NUCLEAR ENERGY INSTITUTE

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June 15, 2000

Mr. Christopher I. Grimes
Chief, License Renewal and Standardization Branch
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

**SUBJECT:** Comments on Draft Standard Review Plan for the Review of License Renewal Applications for Nuclear Power Plants

**PROJECT NUMBER:** 690

Dear Mr. Grimes:

Enclosed are comments on Chapter 4 of the April 21, 2000 draft Standard Review Plan for the Review of License Renewal Applications for Nuclear Power Plants. In addition to our comments, the enclosure includes a line-in line-out version of the existing standard review plan to reflect our comments and a clean copy of the standard review plan to reflect how it reads with our comments incorporated.

Please note that in previous comments on the Generic Aging lessons Learned (GALL) report we recommended removing Time Limited Aging Analyses (TLAA) from GALL and moving them to the standard review plan. Consistent with that recommendation the enclosed comments reflect the incorporation of TLLAs currently identified in the GALL, into the standard review plan

We look forward to discussing the enclosed comments with the NRC staff. Please contact me to establish a meeting date.

Sincerely,

Douglas J. Walters

Douglas J. Walters

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Enclosures

c: Mr. Sam Lee
Mr. P.T. Kuo

# General Comments

**General Comments on the Standard Review Plan**
**Chapter 4 – Time-Limited Aging Analyses**

**Use of the GALL report and the Standard Review Plan for TLAAs:**

1. Time-limited aging analyses (TLAA) should only be addressed in the Standard Review Plan (SRP). Sufficient detail for TLAAs is provided in each section of Chapter 4 of the SRP such that a discussion in the GALL report is not required. Detailed comments from the technical review of the GALL report has been transferred to the detailed comments of the SRP as applicable. Note that each TLAA identified in the GALL report can be binned against one of the Categories identified in the attached table. Refer to Note 3 of the table.

2. Related to the February 3, 2000 letter from the NRC on the use of the GALL report and the SRP, the section on the treatment of the GALL report should be revised. Per the previous comment, the applicant would not reference the GALL report for TLAAs. Since the GALL report identified that every TLAA required 'further evaluation', that feature of the GALL report is not implemented. A plant specific evaluation is required and the SRP can provide the necessary guidance to do the review.

3. In the case that Option iii (manage the effects of aging) is selected, the licensee will need to identify a program. EQ represents the only previously evaluated TLAA program. The evaluation of this program has been added to the SRP as a basis for comparison by the licensee. If the licensee asserts that their program is bounded by this evaluation, then no additional review by the NRC is required. For any other program identified for Option iii, the reviewer will need to evaluate the adequacy of the licensee program. However, TLAA programs do not always fit the 10 criteria model unless they are typical mitigation or inspection types of activities. A basis for evaluation of these programs has been provided in our detailed comments.

**General Comments on Section 4.1:**

4. Please refer to the attached Table. NEI 95-10, the SRP and the GALL report each identify different TLAAs. In order to achieve consistency, the table presents a proposal to provide alignment. Conforming changes to NEI 95-10 would also be made. Conforming changes to the GALL report would not be required based on comment 1 above.

5. Section 4.1 should clarify that the list of TLAAs in the application is a summary list. A detailed listing of each calculation by number will not be provided.

6. In Section 4.1.3, the paragraph starting "The reviewer should use…" leads the reviewer to look at analyses from a few sources such as SERs or picked at random.

In fact, the TLAAs will be specific to the NSSS vendor and AE of record. Since TLAAs must meet the six criteria to be a valid TLAA, the reviewer should look at NSSS/AE analyses included in the CLB where it is likely that all of these criteria will be met. The reviewer should be cautioned that not every aging effect will have a TLAA. However, aging effects in general will be handled from other branches of engineering. The licensee's methodology for determining TLAAs could also provide the reviewer with a good starting point for understanding calculations that were not identified as TLAAs. This could be facilitated by an on-site review of the licensee's documentation. Specific language has been proposed to better direct the reviewer to identify calculations for review including calculations not identified by the licensee.

7. Pursuant to comment 6 above, Tables 4.1-2 and 4.1-3 may not be required. Their purpose was to help direct the reviewer in finding calculations that were not identified by the licensee in their application. Since better direction based on CLB documentation and TLAA methodology will be proposed, these tables no longer would be required. In fact, using these tables may lead a reviewer to question areas that are not relevant for the licensee's plant.

8. Other wording changes are recommended for Section 4.1. They have been included in a proposed revision to the document.

**General Comments on the FSAR Supplement:**

**9.** The FSAR supplement example should be revised. The implementation schedule should not be included in the FSAR. Licensees will make commitments for an implementation schedule elsewhere in the application. These commitments will be tracked internally by the licensee using their existing Commitment Tracking System.

**10. The content and level of detail of the FSAR supplement needs to be discussed further with the NRC.** The FSAR supplement should be revised to indicate the type of statements that need to appear <u>somewhere</u> in the FSAR. In some cases the licensee may choose to reflect license renewal commitments where the TLAA is already discussed in their FSAR. In other cases, the licensee may choose to discuss these commitments in a separate table of the FSAR. Direction to the reviewer should be aimed at assuring the FSAR statements are consistent with both of the license conditions imposed on Oconee and likely on future applicants as well. One deals with changes being made pursuant to 50.59. The other deals with future inspections prior to the renewal period.

**General Comments on Other Sections of the SRP:**

11. The SRP consistently refers to plant-specific calculations. The actual TLAA calculations may be generic and bound a specific plant. The reanalysis may be performed on a generic basis and incorporated by reference in a plant specific application. Specific conforming changes in Chapter 4 of the SRP have been provided.

12. The reactor vessel surveillance program and the tendon prestress surveillance program are not TLAAs because they are not a calculations. They have been deleted from Sections 4.2 and 4.5 respectively.

13. References should be specific to the Section in which they appear. Conforming changes have been identified.

14. Section 3 and Section 6 each deal with fatigue issues. Section 6 specifically deals with the Containment liner. Clarification has been incorporated to carefully divide fatigue scopes between Sections 3 and 6.

15. **GSI-190 needs to be addressed further with the NRC.** Environmental Fatigue may not be a TLAA. If so, then environmental fatigue should be addressed in Chapter 3.2 Reactor Coolant System. Conforming changes need to be made to Section 4.3 once an accepted approach is identified.

16. Section 4.4 on EQ has been revised substantially to reflect the recent discussions on Chapter VI of the GALL report related to EQ.

17. Clarification on how to address tendon prestressing has been provided consistent with comments previously identified for the GALL report.

18. Additional detailed technical comments are summarized in the proposed revision document for TLAAs.

**Review of the Time-Limited Aging Analysis Topics**
**Addressed in NEI 95-10, GALL, SRP**

| Topic | NEI 95-10 | SRP Sect. | SRP Table | GALL | Proposed | Notes |
|---|---|---|---|---|---|---|
| Metal Fatigue | X | 4.3 | 4.1-2 | 107 | 4.3 | |
| Reactor Vessel Embrittlement | X | 4.2 | 4.1-2 | 3 | 4.2 | |
| Environmental Qualification (EQ) | X | 4.4 | 4.1-2 | 1 | 4.4 | |
| Concrete Containment Tendon Prestress | X | 4.5 | 4.1-2 | 2 | 4.5 | |
| High Density Neutron Poisons (Boraflex) | X | - | 4.1-2* | - | - | *Not included in the SOC |
| Metal Corrosion Allowance | X | - | 4.1-2 | - | - | This is not a TLAA |
| Inservice Flaw Growth Analysis | X | - | 4.1-2 | - | - | Note 5 |
| Inservice Ctmt Corrosion Anal. | X | - | 4.1-2 | - | - | This is not a TLAA |
| HELB Fatigue | X | - | 4.1-2 | - | - | Note 5 |
| Void Swelling | - | - | - | 27 | - | This is not a TLAA |
| Elastomers for Vent Ducts | - | - | - | 4 | - | This is not a TLAA |
| Fire Protection Sealants | - | - | - | 4 | - | This is not a TLAA |
| Underclad Cracking | - | - | 4.1-3 | - | - | Note 5 |
| MS to AFW Pipe Fatigue | - | - | 4.1-3 | - | - | Note 5 |
| MS Valve Operating Cycles | - | - | 4.1-3 | - | - | Note 5 |
| RCP Flywheel Fatigue | - | - | 4.1-3 | - | - | Note 5 |
| Polar Crane Fatigue | - | - | 4.1-3 | - | - | Note 5 |
| Reactor Internals Analyses | - | - | 4.1-3 | - | - | Note 5 |
| Leak Before Break | - | - | 4.1-3 | - | - | Note 5 |
| Containment Liner Plate/Penet. Fatigue | - | 4.6 | 4.1-3 | - | 4.6 | |
| Ctmt Penet. Press. Cycles | - | - | 4.1-3 | - | - | Include in Section 4.6 |
| Other TLAAs | - | 4.8 | - | - | 4.7 | |

Notes:
(1) The NEI 95-10 items are identified in Table 5.1-2.
(2) The Standard Review Plan Items are identified in Tables 4.1-2,3.
(3) The GALL numbers indicate the number of times the word TLAA is invoked within each of the stated categories. This demonstrates that each of the GALL TLAAs is addressed by an SRP section or it is not a TLAA at all.
(4) The proposed column reflects items that only items 4.2-4.7 apply. Tables 4.1-2 and 4.1-3 would be deleted.
(5) These TLAAs are subsets of either the fatigue or vessel integrity TLAA sections. Per the general comments, Tables 4.1-2,3 are not required.

Line-In Line-Out

## 4.1 IDENTIFICATION OF TIME-LIMITED AGING ANALYSES

**Review Responsibilities**

**Primary** - Branch responsible for materials and chemical engineering
**Secondary** - Other branches responsible for engineering, as appropriate

### 4.1.1 Areas of Review

This review plan section addresses the identification of time-limited aging analyses (TLAAs). There are certain ~~plant-specific~~ safety analyses which may have been based on an explicitly assumed 40-year plant life (for example, aspects of the reactor vessel design). Pursuant to 10 CFR 54.21(c)(1), a license renewal applicant is required to provide a list of TLAAs, as defined in 10 CFR 54.3. The area relating to the identification of TLAAs is reviewed. The listing of TLAAs should provide sufficient detail to identify the type of calculations and the specific TLAA. A listing of specific calculation numbers is not required.

~~TLAA requirements may have evolved and are plant-specific.~~ As indicated in 10 CFR 54.30, the adequacy of the plant's current licensing basis (CLB), which includes TLAAs, is not an area of review. Potential concerns or enhancements regarding the CLB is to be addressed under the backfit rule (10 CFR 50.109) and are separate from the license renewal process.

In addition, pursuant to 10 CFR 54.21(c)(2), an applicant must provide a list of plant-specific exemptions that are based on TLAAs. However, the initial license renewal applicants have found no such exemptions for their plants.

~~An applicant has the flexibility to determine the set of analyses for which an evaluation is performed, provided that this set encompasses the TLAAs for which the Commission has determined an evaluation is required. Therefore, the reviewer should not review all analyses that the applicant has identified as TLAAs, because i~~It is an applicant's option to include more analyses than those required by 10 CFR 54.21(c)(1). The staff should focus its review to confirm that the applicant did not omit any TLAAs, as defined in 10 CFR 54.3.

### 4.1.2 Acceptance Criteria

The acceptance criteria for the areas of review described in Subsection 4.1.1 of this review plan section define acceptable methods for meeting the requirements of the Commission's regulations in 10 CFR 54-21(c)(1). The staff should find no omission of TLAAs, as defined in 10 CFR 54.3, from the applicant's list.

Pursuant to 10 CFR 54.3, TLAAs are those licensee calculations and analyses that:

1. Involve systems, structures, and components within the scope of license renewal, as delineated in 10 CFR 54.4(a);

2. Consider the effects of aging;

3. Involve time-limited assumptions defined by the current operating term, for example, 40 years;

4. Were determined to be relevant by the licensee in making a safety determination;

5. Involve conclusions or provide the basis for conclusions related to the capability of the system, structure, and component to perform its intended functions, as delineated in 10 CFR 54.4(b); and

6. Are contained or incorporated by reference in the CLB.

### 4.1.3 Review Procedures

For each area of review described in Subsection 4.1.1 of this review plan section, the following review procedures are followed:

The reviewer verifies that the TLAAs not identified by the applicant -don't meet at least one of the following criteria
(Ref. 1).

1. Involve systems, structures, and components within the scope of license renewal, as delineated in 10 CFR 54.4(a). Chapter 2 of this standard review plan provides staff review guidance on the scoping and screening methodology, plant level and various system level scoping results.

2. Consider the effects of aging. The effects of aging include, but are not limited to: loss of material, loss of toughness, loss of prestress, settlement, cracking, and loss of dielectric properties.

3. Involve time-limited assumptions defined by the current operating term, for example, 40 years. The defined operating term should be explicit in the analysis. Simply asserting that a component is designed for a service life or plant life is not sufficient. The assertion should be supported by a calculation or analysis that explicitly includes a time limit.

4. Were determined to be relevant by the licensee in making a safety determination. Relevancy is a determination that the applicant should make based on a review of the information available. A calculation or analysis is relevant if it can be shown to have direct bearing on the action taken as a result of the analysis performed. Analyses are also relevant if they provide the basis for a licensee's safety determination and, in the absence of the analyses, the licensee may have reached a different safety conclusion.

5. Show capability of the system, structure, and component to perform its intended functions, as delineated. Involve conclusions or provide the basis for conclusions related to the 10 CFR 54.4(b). Analyses that do not affect the intended functions of systems, structures, and components are not TLAAs.

6. Are contained or incorporated by reference in the CLB. Plant specific documents contained or incorporated by reference in the CLB include, but are not limited to: FSAR, NRC safety evaluation reports (SERs), Technical Specifications, the fire protection plan/hazards analyses, correspondence to and from the NRC, quality assurance (QA) plan, and topical reports included as reference to the FSAR or correspondence to the NRC. Calculations and analyses that are not in the CLB or not incorporated by reference are not TLAAs. When the code of record is mentioned in the FSAR, for particular groups of structures or components, reference material includes all calculations required by that code of record for those structures and components.

TLAAs that need to be addressed are not necessarily those analyses that have been previously reviewed or approved by the Commission. The following examples illustrate TLAAs that need to be addressed and were not previously reviewed and approved by the Commission:

- The FSAR states that the design complies with a certain national code and standard. A review of the code and standard reveals that a TLAA is required. The actual calculation was performed by the licensee to meet code and standard requirements, the specific calculation was not referenced in the FSAR, and the NRC had not reviewed the calculation.

- In response to a generic letter, a licensee submitted a letter to the NRC committing to perform a TLAA that would address the concern in the generic letter. The NRC had not documented a review of the licensee's response and had not reviewed the actual analysis.

The following examples illustrate analyses that are not TLAAs and need not be addressed under 10 CFR 54.21(c):

- Population projections (Section 2.1.3 of NUREG-0800) (Ref. 2).

- Cost-benefit analyses for plant modifications.

- Analysis with time-limited assumptions defined short of the current operating term of the plant, for example, an analysis for a component based on a service life that would not reach the end of the current operating term.

The number and type of TLAAs vary depending on the plant-specific CLB. All six criteria of TLAAs in 10 CFR 54.3 (and repeated in Subsection 4.1.2 of this review plan section) must be satisfied to conclude that a calculation or analysis is a TLAA. Table 4.1-1 provides examples of how these six criteria may be applied (Ref. 1). ~~Table 4.1-2 provides a list of potential TLAAs (Ref. 1). Table 4.1-3 provides a list of other plant-specific TLAAs that have been identified by the initial license renewal applicants. Table 4.1-2 and 4.1-3 provide examples of analyses that potentially could be TLAAs for a particular plant. However, TLAAs are plant-specific and depend on an applicant's CLB. It is not expected that all applicants would identify all the analyses in these tables as TLAAs for their plants. Also, an applicant may have specific TLAAs for its plant that is not shown in these tables.~~

The reviewer should use the plant Updated Final Safety Analysis Report (UFSAR) and other CLB documents, such as staff SERs, in performing the review. The reviewer should select analyses that the applicant did not identify as TLAAs that are likely to meet the six criteria identified above. Sections 4.2 through 4.6 identify typical types of TLAAs for most plants. Information on the licensee's methodology for identifying TLAAs may also be useful in identifying calculations that did not meet the six criteria. ~~The reviewer may select analyses based on the information in Tables 4.1-2 and 4.1-3 of this review plan section because these analyses have been identified as TLAAs for some plants. In addition, the reviewer may select analyses that are not shown in these tables.~~

Aging effects that may typically be a TLAA for most plants, may not be a TLAA for a specific plant. In these cases, the aging effect may simply be addressed as part of the aging management review. The plant-specific application should direct the reviewer from the TLAA

section to the appropriate Chapter 3 section for the description and demonstration of how the aging effect is being or will be managed.

There are staff members from other branches of engineering reviewing the application in their assigned areas separate from the identification of TLAAs. However, they may come across situations where they may have a question on why the applicant did not identify certain analyses within their areas of review as TLAAs. Should this be the case, the reviewer should coordinate the question resolution with these other staff members and determine whether these analyses should be included as TLAAs.

Should an applicant identify a TLAA, which is also a basis for a plant-specific exemption granted pursuant to 10 CFR 50.12 and the exemption is in effect, the reviewer verifies that the applicant has also identified that exemption pursuant to 10 CFR 54.21(c)(2). However, the initial license renewal applicants have found no such exemptions for their plants.

The reviewer should find no omission by the applicant to make the staff finding that there is reasonable assurance that the applicant has identified the TLAAs for its plant.

### 4.1.4 Evaluation Findings

The reviewer verifies that sufficient and adequate information has been provided to satisfy the provisions of this review plan section and that the staff evaluation supports conclusions of the following type, to be included in the staffs safety evaluation report, as appropriate.

> The staff concludes that the applicant has provided a list of acceptable TLAAs as defined in 10 CFR 54.3 and that no 10 CFR 50.12 exemptions have been granted on the basis of a TLAA as defined in 10 CFR 54.3.

### 4.1.5 Implementation

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

### 4.1.6 References


1. NEI 95-10, Revision 1, "Industry Guideline for Implementing the Requirements of 10 CFR Part 54 – The License Renewal Rule," Nuclear Energy Institute, January 2000.

2. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports Nuclear Power Plants," July 1981.

**Table 4.1-1. Identification of Potential Time-Limited Aging Analyses and Basis for Disposition**

| Example | Disposition |
|---|---|
| NRC correspondence requests a utility to justify that unacceptable cumulative wear did not occur during the design life of control rods | Does not qualify as a TLAA because the design life of control rods is less than 40 years. Therefore, does not meet criterion (3) of the TLAA definition in 10 CFR 54.3. |
| Maximum wind speed of 100 mph is expected to occur once per 50 years. | Not a TLAA. Does not involve an aging effect. |
| Correspondence from the utility to the NRC states that the membrane on the containment basemat is certified by the vendor to last for 40 years. | This example does not meet criterion (4) of the TLAA definition in 10 CFR 54.3 and therefore is not considered a TLAA. The membrane was not credited in any safety evaluation. |
| Fatigue usage factor for the pressurizer surge line was determined not to be an issue for the current license period in response to NRC Bulletin 88-11. | This example is a TLAA because it meets all 6 criteria in the definition of TLAA in 10 CFR 54.3. The utility's fatigue design basis relies on assumptions related to 40 year operating life for this component. |
| Containment tendon lift-off forces are calculated for the 40-year life of the plant. This data is used during Technical Specification surveillance for comparing measured to predicted lift-off forces. | This example is a TLAA because it meets all 6 criteria of the TLAA definition in 10 CFR 54.3. The lift-off force curves are limited to 40-year values currently and are needed to perform a required Technical Specification surveillance. |

~~Table 4.1-2. Potential Time-Limited Aging Analyses~~

| |
|---|
| ~~Fatigue~~ |
| ~~Reactor vessel neutron embrittlement~~ |
| ~~Environmental aging (Environmental qualification)~~ |
| ~~Loss of prestress in concrete containment tendons~~ |
| ~~High density neutron poisons (e.g., Boraflex) of spent fuel racks~~ |
| ~~Metal corrosion allowance~~ |
| ~~Inservice flaw growth analyses that demonstrate structure integrity for 40 years~~ |
| ~~Inservice local metal containment corrosion analyses~~ |
| ~~High-energy line-break postulation based on fatigue "cumulative usage factor"~~ |

~~**Table 4.1-3. Additional Examples of Plant-Specific TLAAs as Identified by the Initial License Renewal Applicants**~~

| |
|---|
| ~~Intergranular separation in the heat-affected zone (HAZ) of reactor vessel low-alloy steel under austenitic stainless steel cladding.~~<br>~~Low-temperature overpressure protection (LTOP) analyses.~~ |
| ~~Fatigue analysis for the main steam supply lines to the turbine-driven auxiliary feedwater pumps.~~ |
| ~~Main steam isolation valves operating cycles.~~ |
| ~~Fatigue analysis of the reactor coolant pump flywheel.~~ |
| ~~Fatigue analysis of polar crane.~~ |
| ~~Flow-induced vibration endurance limit, transient cycle count assumptions, and ductility reduction of fracture toughness for the reactor vessel internals.~~ |
| ~~Leak before break.~~ |
| ~~Fatigue analysis for the containment liner plate.~~ |
| ~~Containment penetration pressurization cycles.~~ |
| ~~Reactor vessel circumferential weld inspection relief (BWR).~~ |

## 4.2 Reactor Vessel Neutron Embrittlement

**Review Responsibilities**

**Primary**- Branch responsible for materials and chemical engineering
**Secondary** - Branch responsible for reactor systems

### 4.2.1 Areas of Review

The fracture toughness of ferritic steel in the reactor vessel beltline region of light-water nuclear power reactors is reduced during plant service by neutron irradiation. Areas of review to ensure that the reactor vessel has adequate fracture toughness to prevent brittle failure during normal and off-normal operating conditions are (1) upper-shelf energy, ~~(2) surveillance program,~~ (~~3~~2) pressurized thermal shock (PTS) for pressurized water reactors (PWRs), (~~4~~3) heat-up and cool-down (pressure-temperature limits) curves, and (~~5~~4) boiling water reactor (BWR) Vessel and Internals Project (VIP) VIP-05 analysis for elimination of circumferential weld inspection ~~for BWRs~~.

The adequacy of the upper-shelf energy analyses ~~and surveillance programs~~ for light-water reactors, the PTS analyses for pressurized water reactors (PWRs), and the heat-up and cool-down (pressure-temperature limits) curves are reviewed for the period of extended operation.

The branch responsible for reactor systems should review neutron fluence and dosimetry information in the application.

### 4.2.2 Acceptance Criteria

The acceptance criteria for the areas of review described in Subsection 4.2.1 of this review plan section define acceptable methods for meeting the requirements of the Commission's regulations in 10 CFR 54.21(c)(1).

#### 4.2.2.1 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 reactor vessel neutron embrittlement depending on the applicant's choice, i.e., 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

##### 4.2.2.1.1 Upper-Shelf Energy

Paragraph IV.A.1 in Appendix G (Ref. 1) to 10 CFR Part 50 requires that the reactor vessel beltline materials must have a Charpy upper-shelf energy of no less than 68 J (50 ft-lb) throughout the life of the reactor vessel unless otherwise approved by the NRC.

#### 4.2.2.1.1.1 10 CFR 54.21 (c)(1)(i)

The existing upper-shelf energy analysis remains valid during the period of extended operation because the neutron fluence projected to the end of the period of extended operation is bounded by the fluence assumed in the existing analysis.

#### 4.2.2.1.1.2 10 CFR 54.21(c)(1)(ii)

The upper-shelf energy is re-evaluated to ~~cover~~ consider the period of extended operation in accordance with Appendix G to 10 CFR Part 50.

#### 4.2.2.1.1.3 10 CFR 54.21(c)(1)(iii)

Acceptance criteria under 10 CFR 54.21(c)(1)(iii) have yet to be developed and will be evaluated on a case-by-case basis to ensure that the aging effects will be managed such that the intended function(s) will be maintained during the period of extended operation.

#### ~~4.2.2.1.2 Surveillance Program~~

The RV Surveillance program does not meet all six of the criteria for TLAAs contained in 54.3. The surveillance program is an administrative program that has established when capsules are to be withdrawn from the RV. The timing is based on ASTM E 185 guidance for projected fluence levels. The surveillance program does not consider the effects of aging, the effect considered is fluence; the program does not involve a time-limit established by the current term - the time-limit is established by projected and actual fluence. The Appendix H vessel surveillance program was not identified as a TLAA at either CCNPP or Oconee. In an RAI subsequent to the submission of the CCNPP LRA, the NRC asked BGE to justify not identifying the surveillance program as a TLAA. (This issue does not appear to have been raised for the Oconee LRA.) BGE answered simply that no calculations or analyses meeting the definition of a TLAA were identified for this issue. In subsequent discussions between BGE and the NRC, it was agreed that extension of the program into the period of extended operation would constitute an aging management program modification issue and not a TLAA. No further mention of this issue (as a TLAA) was made in the SER for the CCNPP LRA. Even though this item is not considered a TLAA, the program must be evaluated (as a modified credited aging management program) to determine if it can be extended through the period of extended operation. Specifically, it must be determined that surveillance capsules are available to provide an additional twenty years of coverage, or capsule information must be available through another source. Recommend removing this issue from the SRP. Staff review of the capsule surveillance program is more appropriately handled during the AMR of the RV as part of the IPA process.

~~Appendix H (Ref. 2) to 10 CFR Part 50 requires the reactor vessel materials surveillance program to meet the American Society for Testing and Materials (ASTM) E 185 Standard (Ref. 3). However, the surveillance program in ASTM E 185 is based on plant operation during the current license term, and additional surveillance capsules may be needed for the period of extended operation. Alternatively, an integrated surveillance program for the period of extended operation may be considered for a set of reactors that have similar design and operating features in accordance with Paragraph II.C of Appendix H to 10 CFR Part 50. Additional surveillance capsules may be needed for the period of extended operation for this alternative also.~~

~~4.2.2.1.2.1 10 CFR 54.21(c)(1)(i)~~

~~Not applicable. As discussed above, the specified surveillance program does not address the period of extended operation.~~

~~4.2.2.1.2.2 10 CFR 54.21(c)(1)(ii)~~

~~An applicant may provide additional surveillance capsules in its surveillance program.~~

~~Specific acceptance criteria for the surveillance program during the period of extended operation have yet to be developed and will be evaluated on a case-by-case basis.~~

~~4.2.2.1.2.3 10 CFR 54.21(c)(1)(iii)~~

~~The existing reactor vessel material surveillance program should be evaluated for sufficient material data and dosimetry to monitor irradiation embrittlement at the end of the period of extended operation and need for operating restrictions (that is, inlet temperature, neutron spectrum, and flux). If surveillance capsules are not withdrawn during the period of extended operation, operating restrictions should be established to ensure the plant is operated within the environment of the surveillance capsules.~~

### 4.2.2.1.~~3~~2 Pressurized Thermal Shock (for PWRs)

For PWRs, 10 CFR 50.61 (Ref. 4) requires the "reference temperature $RT_{PTS}$" for reactor vessel beltline materials to be less than the "PTS screening criteria" at the expiration date of the operating license unless otherwise approved by NRC. The "PTS screening criteria" are 132°C (270°F) for plates, forgings, and axial weld materials, or 149°C(300°F) for circumferential weld materials. The regulations require updating of the pressurized thermal shock assessment upon a request for a change in the expiration date of a facility's operating license. Therefore, the $RT_{PTS}$ value must be calculated for the effective full power years (EFPY) corresponding to the renewal period. ~~reactor life extension period of 48 effective full power years (EFPY).~~

#### 4.2.2.1.~~3~~2.1 10 CFR 54.21(c)(1)(i)

The existing PTS analysis remains valid during the period of extended operation because the neutron fluence projected to the end of the period of extended operation is bounded by the fluence assumed in the existing analysis.

#### 4.2.2.1.~~3~~2.2 10 CFR 54.21(c)(1)(ii)

The PTS analysis is reevaluated to ~~cover~~ consider the period of extended operation in accordance with 10 CFR 50.61. An analysis is performed in accordance with Regulatory Guide 1.154 (Ref. 5) if the "PTS screening criteria' in 10 CFR 50.61 are exceeded during the period of extended operation.

#### 4.2.2.1.~~3~~2.3 10 CFR 54.21(c)(1)(iii)

Acceptance criteria under 10 CFR 54.21(c)(1)(iii) have yet to be developed and will be evaluated on a case-by-case basis to ensure that the aging effects will be managed such that the intended function(s) will be maintained during the period of extended operation.

#### 4.2.2.1.4~~2~~3 Pressure-temperature (P-T) limits

10 CFR Part 50, Appendix G (Ref. 1) requires that heatup and cooldown of the reactor pressure vessel be accomplished within established pressure-temperature (P-T) limits. These limits specify the maximum allowable pressure as a function of reactor coolant temperature. As the reactor pressure vessel becomes embrittled and its fracture toughness is reduced, the allowable pressure is reduced~~. Operation of the reactor coolant system is also limited by the net positive suction curves for the reactor coolant pumps. These curves specify the minimum pressure required to operate the reactor coolant pumps. Therefore, in order to heatup and cooldown, the reactor coolant temperature and pressure must be maintained within an operating window established between the Appendix G P-T limits and the net positive suction curves.~~

#### 4.2.2.1.4~~2~~3.1 10 CFR 54.21 (c)(1)(i)

The existing P-T limits are valid during the period of extended operation because the neutron fluence projected to the end of the period of extended operation is bounded by the fluence assumed in the existing analysis.

#### 4.2.2.1.4~~2~~3.2 10 CFR 54.21(c)(1)(ii)

The P-T limits are re-evaluated to ~~cover~~ consider the period of extended operation in accordance with Appendix G to 10 CFR Part 50 (Ref. 1).

#### 4.2.2.1.4~~2~~3.3 10 CFR 54.21(c)(1)(iii)

~~An operating window should exist between the P-T limits and the net positive suction curves at the end of the period of extended operation. Appendix G to 10 CFR Part 50 requirements will require periodic update of the P-T limits.~~Not applicable. Updated P-T limits for the period of extended operation must be available prior to entering the period of extended operation. (It is not necessary to implement P-T limits to carry the RV through 60 years at the time of application. The updated limits must merely be available prior to the period of extended operation

#### 4.2.2.1.~~5~~4 Elimination of Circumferential Weld Inspection (for BWRs)

Some BWRs have an approved technical alternative eliminating ~~been granted relief from~~ the reactor vessel circumferential shell weld inspections for the current license term because they satisfy the limiting conditional failure probability for the circumferential welds at the expiration of the current license based on BWRVIP 05 and the extent of neutron embrittlement (Refs. 6-8). An applicant for such a BWR may provide justification to extend this relief into the period of extended operation. The staff is currently reviewing BWRVIP-74, which addresses license renewal (Ref. 9). If approved by the staff, BWRVIP-74 may provide the basis for granting such relief.

### 4.2.2.2 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 ~~aging effects are managed in the period of extended operation~~the TLAAs have been dispositioned for the period of extended operation.

### 4.2.3 Review Procedures

For each area of review described in Subsection 4.2.1 of this review plan section, the following review procedures are followed:

#### 4.2.3.1 Time-Limited Aging Analysis

For reactor vessel neutron embrittlement, the review procedures, depending on the applicant's choice, i.e., 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

##### 4.2.3.1.1 Upper-Shelf Energy

###### 4.2.3.1.1.1 10 CFR 54.21(c)(1)(i)

The projected neutron fluence at the end of the period of extended operation is reviewed to verify that it is bounded by the fluence assumed in the existing upper-shelf energy analysis.

###### 4.2.3.1.1.2 10 CFR 54.21(c)(1)(ii)

The documented results of the revised upper-shelf energy analysis based on the projected neutron fluence at the end of the period of extended operation is reviewed for compliance with Appendix G to 10 CFR Part 50. An applicant may use Regulatory Guide 1.99, Rev. 2 (Ref. 10), to project upper-shelf energy to the end of the period of extended operation. An applicant may also use Appendix K of Section XI of the ASME Code (Ref. 11) for evaluating upper-shelf energy. The staff should review the applicant's methodology for this evaluation.

###### 4.2.3.1.1.3 10 CFR 54.21(c)(1)(iii)

The applicant's proposal to demonstrate that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation will be reviewed on a case-by-case basis.

~~**4.2.3.1.2 Surveillance Program**~~

~~**4.2.3.1.2.1 10 CFR 54.21(c)(1)(i)**~~

~~This option is not applicable.~~

~~**4.2.3.1.2.2 10 CFR 54.21(c)(1)(ii)**~~

~~The surveillance program is reviewed for its adequacy during the period of extended operation on a case-by-case basis. If an applicant proposes an integrated surveillance program for the period of extended operation for a set of reactors that have similar design and operating features, the proposal is reviewed for compliance with Paragraph II.C of Appendix H to 10 CFR Part 50.~~

~~**4.2.3.1.2.3 10 CFR 54.21(c)(1)(iii)** (Ref. 12)~~

~~1. An applicant may project the extent of reactor vessel embrittlement for upper-shelf energy and pressure-temperature limits for 60 years in accordance with Regulatory Guide 1.99, Rev. 2, "Radiation Embrittlement of Reactor Vessel Materials." When using Regulatory Guide 1.99, Rev. 2, an applicant has a choice of the following:~~

~~**(a) Neutron Embrittlement Using Chemistry Tables**~~

~~An applicant may use the tables in Regulatory Guide 1.99, Rev. 2, to project the extent of reactor vessel neutron embrittlement for the period of extended operation. This is described as Regulatory Position 1 in the Regulatory Guide.~~

~~(b) Neutron Embrittlement Using Surveillance Data~~

~~When credible surveillance data are available, the extent of reactor vessel neutron embrittlement for the period of extended operation may be projected according to Regulatory Position 2 in Regulatory Guide 1.99, rev. 2. The credible data could be collected during the current operating term. The applicant may have a plant-specific program or an integrated surveillance program during the period of extended operation to collect additional data.~~

~~2. For an applicant that determines embrittlement using the Regulatory Guide 1.99 tables [see item 1(a) above], the applicant should use the applicable limitations in Regulatory Position 1.3 of the regulatory guide.~~

~~3. For an applicant that determines embrittlement using surveillance data [see item 1(b) above], the applicant should define the applicable bounds of the data, such as cold leg operating temperature and neutron fluence. These bounds should be specific for the referenced surveillance data and would be more restrictive than the bounds for the Regulatory Guide in item 2 above. For example, the plant-specific data could be collected within a smaller temperature range than that in the regulatory guide.~~

~~4. All pulled and tested capsules, unless previously discarded, should be placed in storage. (Note: These specimens are saved for future reconstitution use, in case the surveillance program needs to be re-established.)~~

~~5. If an applicant has a surveillance program which consists of capsules with a projected fluence of less than the 60-year fluence at the end of 40 years, at least one capsule should remain in the reactor vessel and should be tested during the period of extended operation. The applicant should either delay withdrawal of their last capsule or withdraw a standby capsule during the period of extended operation to monitor the effects of long-term exposure to neutron irradiation.~~

~~6. If an applicant has surveillance program which consists of capsules with a projected fluence exceeding the 60-year fluence at the end of 40 years, the applicant should pull these capsules when they reach the 60-year fluence and test one capsule to meet the requirements of ASTM E185 and place the remaining capsules in storage without testing. Any changes in anticipation of additional renewals, however, should be discussed with the staff.~~

~~7. Applicants without in-vessel capsules should have alternative dosimetry to monitor neutron fluence during the period of extended operation, as part of the aging management program for reactor vessel neutron embrittlement.~~

~~8. The reactor vessel monitoring program should include that, when future plant operations exceed the limitations or bounds in item 2 or 3 above (as applicable) such as operating at a lower cold leg temperature or higher fluence, the impact of plant operation changes regarding the extent of reactor vessel embrittlement will be evaluated and the NRC will be notified. For an applicant without capsules in their reactor vessel, the applicant could propose re-establishing the reactor vessel surveillance program to assess the extent of embrittlement. This program may consist of (1) capsules from item 6 above; (2) reconstitution of specimens from item 4 above; and/or (3) capsules made from any available archival materials. This program could be plant-specific program or an integrated surveillance program.~~

**4.2.3.1.~~3~~2 Pressurized Thermal Shock (for PWRs)**

**4.2.3.1.~~3~~2.1 10 CFR 54.21(c)(1)(i)**

The documented results of the projected neutron fluence at the end of the period of extended operation is reviewed to verify that it is bounded by the fluence assumed in the existing PTS analysis.

**4.2.3.1.~~3~~2.2 10 CFR 54.21(c)(1)(ii)**

The documented results of the revised PTS analysis based on the projected neutron fluence at the end of the period of extended operation is reviewed for compliance with 10 CFR 50.61. There are two methodologies from 10 CFR 50.61 that can be used in the PTS analysis based on the projected neutron fluence at the end of the period of extended operation. $RT_{NDT}$ is the reference temperature (subscript NDT means nil-ductility temperature) used as an indexing parameter to determine the fracture toughness and the amount of embrittlement of a material. $RT_{PTS}$ is the reference temperature used in the PTS analysis and is related to $RT_{NDT}$ at the end of life.

The first methodology does not rely on plant-specific surveillance data to calculate delta $RT_{NDT}$ (i.e., the mean value of the adjustment or shift in reference temperature caused by irradiation). The delta $RT_{NDT}$ is determined by multiplying a chemistry factor from the tables in 10 CFR 50.61 by a fluence factor calculated from the neutron flux using an equation.

The second methodology relies on plant-specific surveillance data to determine the delta $RT_{NDT}$. In this methodology, two or more sets of surveillance data are needed. Surveillance data consists of a measured delta $RT_{NDT}$ for a corresponding neutron fluence. 10 CFR 50.61 specifies a procedure and a criterion for determining whether the surveillance data are credible, e.g., the difference in the predicted value and the measured value for delta $RT_{NDT}$ must be less than 28°F for weld metal for the surveillance data to be defined as credible. When a credible surveillance data set exists, the chemistry factor determined from the surveillance data can be used in lieu of the values in the table in 10 CFR 50.61 and the standard deviation of the increase in the $RT_{NDT}$ can be reduced from 28°F to 14°F for welds.

If the "PTS screening criteria" in 10 CFR 50.61 are exceeded during the period of extended operation, an analysis based on Regulatory Guide 1.154 is reviewed.

#### 4.2.3.1.~~3~~2.3 10 CFR 54.21(c)(1)(iii)

The applicant's proposal to demonstrate that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation will be reviewed on a case-by-case basis. If the projected reference temperature exceeds the screening criterion established in 10 CFR 50.61, the licensee is required to implement such flux reduction programs as are reasonably practicable to avoid exceeding the screening criterion. The schedule for implementation of such programs may take into account the schedule and anticipated approval by the Director, NRR, of detailed plant-specific analyses to demonstrate acceptable risk with $RT_{PTS}$ above the screening limit. If the licensee cannot avoid exceeding the screening criteria by using a flux reduction program, it must submit a safety analysis to determine what actions are necessary to prevent potential failure of the reactor vessel. 10 CFR 50.61 also permits the licensee to perform a thermal annealing treatment to recover fracture toughness, subject to the requirements of 10 CFR 50.66.

#### 4.2.3.1.4~~2~~3 Pressure-temperature (P-T) limits

#### 4.2.3.1.4~~2~~3.1 10 CFR 54.21(c)(1)(i)

The documented results of the projected neutron fluence at the end of the period of extended operation is reviewed to verify that it is bounded by the embrittlement assumed in the existing P-T limit analysis.

#### 4.2.3.1.4~~2~~3.2 10 CFR 54.21(c)(1)(ii)

The documented results of the revised P-T limit analysis based on the projected reduction in fracture toughness at the end of the period of extended operation is reviewed for compliance with 10 CFR Part 50, Appendix G.

#### 4.2.3.1.4~~2~~3.3 10 CFR 54.21(c)(1)(iii)

~~In order to heatup and cooldown, the reactor coolant temperature and pressure must be maintained within an operating window established between the Appendix G P-T limits and the net positive suction curves. The reviewer verifies that the applicant has provided information to indicate that such an operating window should exist and is sufficient to conduct heatups and cooldowns at the end of the period of extended operation. Appendix G to 10 CFR Part 50 requires periodic update of P-T limits based on projected embrittlement and data from material surveillance program. Thus, the applicant's surveillance program will provide data to update the P-T limits and will manage the reduction in fracture toughness.~~Not applicable.

#### 4.2.3.1.~~5~~4 Elimination of Circumferential Weld Inspection (for BWRs)

~~Some BWRs have been granted relief from the reactor vessel circumferential shell weld inspections for the current license term because they satisfy the limiting conditional failure probability for the circumferential welds at the expiration of the current license based on BWRVIP-05 and the extent of neutron embrittlement (Refs. 6-8). An applicant for such a BWR may provide justification to extend this relief into the period of extended operation. The staff is currently reviewing BWRVIP-74 which supercedes BWRVIP-05 and addresses license renewal (Ref. 9). If approved by the staff, BWRVIP-74 may provide the basis for granting such relief.~~

When available, an applicant may reference the approved BWRVIP-74 as its basis for requesting the continuation of the relief to the end of the period of extended operation. The staff should review to ensure that the applicant's plant is bounded by the BWRVIP-74 analysis and that the applicant has committed to actions that are the basis for the staff approval of BWRVIP 74.

#### 4.2.3.2 FSAR Supplement

The reviewer verifies that the applicant has provided a FSAR supplement on the summary description of the evaluation of the reactor vessel neutron embrittlement TLAA. Table 4.2-1 of this review plan section contains examples of acceptable FSAR supplement information for this TLAA. The reviewer verifies that the applicant has provided a FSAR supplement ~~using a format similar~~with information equivalent to that in Table 4.2-1.

### 4.2.4 Evaluation Findings

The reviewer verifies that sufficient and adequate information has been provided 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 evaluation concludes that the applicant has provided an acceptable demonstration, pursuant to 10 CFR 54.21(c)(1), that, for the reactor vessel neutron embrittlement TLAA, (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 reactor vessel neutron embrittlement TLAA evaluation for the period of extended operation.

### 4.2.5 IMPLEMENTATION

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

### 4.2.6 References


1. 10 CFR Part 50 Appendix G, "Fracture Toughness Requirements."

~~2. 10 CFR Part 50, Appendix H, "Reactor Vessel Material Surveillance Program Requirements."~~

~~3. ASTM E 185, "Standard Practice of Conducting Surveillance Tests for Light-Water Cooled Nuclear Power Reactor Vessels," American Society for Testing and Materials, 1982.~~

4. 10 CFR 50.61, "Fracture Toughness Requirements for Protection Against Pressurized Thermal Shock Events."

5. Regulatory Guide 1.154, "Format and Content of Plant-Specific Pressurized Thermal Shock Safety Analysis Reports for Pressurized Water Reactors," January 1987.

6. BWRVIP-05, "BWR Vessel and Internals Project, BWR Reactor Pressure Vessel Shell Weld Inspection Recommendations (BWRVIP-05)," Boiling Water Reactor Owners Group, September 28, 1995.

7. Letter to Carl Terry of Niagara Mohawk Power Company, from Gus C. Lainas of NRC, dated July 28, 1998.

8. Generic Letter 98-05, "Boiling Water Reactor Licensees Use of the BWRVIP-05 Report to Request Relief from Augmented Examination Requirements on Reactor Pressure Vessel Circumferential Shell Welds," Nuclear Regulatory Commission, November 10, 1998.

9. BWRVIP-74, "BWR Reactor Pressure Vessel Inspection and Flaw Evaluation Guidelines," Boiling Water Reactor Owners Group.

10. Regulatory Guide 1.99 Rev. 2, "Radiation Embrittlement of Reactor Vessel Materials," May, 1988.

11. Appendix K of ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components."

~~12. Letter from C. I. Grimes (NRC) to D. J. Walters (NEI), License Renewal Issue No. 98-0085, "Reactor Vessel Surveillance Program," dated Dec 3, 1999.~~

**Table 4.2-1. Examples of FSAR Supplement for Reactor Vessel Neutron Embrittlement TLAA Evaluation**

| TLAA | Description of Evaluation | ~~Implementation Schedule~~ |
|---|---|---|
| Upper-shelf energy | Paragraph IV.A.1 in Appendix G to 10 CFR Part 50 requires that the reactor vessel beltline materials must have Charpy upper-shelf energy of no less than 50 ft-lb throughout the life of the reactor vessel unless otherwise approved by the NRC. The upper-shelf energy has been determined to exceed 50 ft-lb to the end of the period of extended operation. | ~~Completed~~ |
| ~~Surveillance program~~ | ~~Irradiating and testing of metallurgical samples are used to monitor the progress of neutron embrittlement as a function of neutron fluence. The current program is in accordance with ASTM E 185. The program consists of 6 capsules in each unit, with 2 capsules tested, 3 capsules to be tested, and one standby capsule. The withdrawal schedule will be revised to provide data at neutron fluence equal to or greater than the projected peak fluence at the end of the license renewal period.~~<br><br>~~If the last capsule is withdrawn before year 55, will establish reactor vessel neutron environment conditions applicable to the surveillance data. If the plant operates outside of the limits established by these conditions, will inform the NRC and determine the impact of the condition on reactor vessel integrity.~~<br><br>~~If the last capsule is withdrawn before year 55, will install neutron dosimetry to permit tacking of the fluence to the reactor vessel.~~ | ~~The surveillance capsule withdrawal schedule will be revised by....~~ |
| Pressurized thermal shock (for PWRs) | For PWRs, 10 CFR 50.61 requires the "reference temperature $RT_{PTS}$" for reactor vessel beltline materials be less that the "PTS screening criteria" at the expiration date of the operating license unless otherwise approved by the NRC. The "PTS screening criteria" are 270 $^0$F for plates, forgings, and axial weld materials, or 300 $^0$F for circumferential weld materials. The "reference temperature" has been determined to be less than the "PTS screening criteria" at the end of the period of extended operation. | ~~Completed~~ |
| Pressure-temperature (P-T) limits | Appendix G to 10 CFR Part 50 requires that heatup and cooldown of the reactor pressure vessel be accomplished within established P-T limits. These limits specify the maximum allowable pressure as a function of | ~~Update as required by Appendix G to 10 CFR Part 50~~ |

| | | |
|---|---|---|
| | reactor coolant temperature. As the reactor pressure vessel becomes embrittled and its fracture toughness is reduced, the allowable pressure is reduced. Appendix G to 10 CFR Part 50 requires periodic update of P-T limits based on projected embrittlement and data from material surveillance program. The P-T limits will be updated to consider the period of extended operation. | |
| Elimination of circum-ferential weld inspection (for BWRs) | NRC has granted relief from the reactor vessel circumferential shell weld inspections, because the plant has been demonstrated to meet BWRVIP-74 as approved by the NRC. | ~~Completed~~ |

Open Item – These examples need to be revised to reflect the General Comments on the FSAR Supplement that have been provided separately. General Comments 9 and 10 apply.

## 4.3 ~~4.3~~ METAL FATIGUE

*Note: SRP 4.3 has been revised to be similar to the wording in SRP 4.6 in the same locations.*

### REVIEW RESPONSIBILITIES

**Primary**- Branch responsible for mechanical engineering
**Secondary**- None

### 4.3.I AREAS OF REVIEW

A metal component subjected to cyclic loading at loads less than the static design load may fail because of fatigue. Metal fatigue of these components may have been evaluated based on an assumed number of transients or cycles for the current operating term. The validity of such metal fatigue analysis is reviewed for the period of extended operation. The metal fatigue analysis review includes, as appropriate, a review of inservice flaw growth analyses, reactor vessel underclad cracking analyses, reactor vessel internals fatigue analyses, postulated high energy line break locations and leak-before-break.

The adequacy of the fatigue analyses of the containment liner plates (including welded joints), penetration sleeves, dissimilar metal welds, and penetration bellows is reviewed separately following the guidance in Section 4.6, "Containment Liner Plate and Penetrations Fatigue Analysis" of this standard review plan.

For some plants, fatigue may not be addressed by a TLAA. In these cases, the applicant will address fatigue issues in Chapter 3.

#### 4.3.1.1 Time-Limited Aging Analysis

Metal components may be designed or analyzed based on guidance in the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code or the American National Standards Institute (ANSI) requirements. These codes contain explicit metal fatigue or cyclic considerations based on time-limited aging analyses.

##### 4.3.1.1.1 ASME Section III, Class 1

ASME Class 1 components, which include core support structures, are analyzed for metal fatigue. ASME Section III (Ref. 1) requires a fatigue analysis for Class 1 components considering all transient loads based on the anticipated number of transients. A Section III Class 1 fatigue analysis requires the calculation of the "cumulative usage factor" (CUF) based on the fatigue properties of the materials and the expected fatigue service of the component. The ASME Code limits the CUF to a value of less than unity for acceptable fatigue design. The fatigue resistance of these components during the period of extended operation is an area of review.

##### 4.3.1.1.2 ANSI B31.1

ANSI B31.1 (Ref. 2) does not require an explicit fatigue analysis. It specifies allowable stress levels based on the number of anticipated thermal cycles. ANSI B31.1 applies only to piping.

The specific allowable stress reductions due to thermal cycles are listed in Table 4.3-1. For example, the allowable stress would be reduced by a factor of 1.0, that is, no reduction, for piping that is not expected to experience more than 7,000 thermal cycles during plant service but would be reduced to half of the maximum allowable static stress for 100,000 or more thermal cycles. The fatigue resistance of these components during the period of extended operation is an area of review.

#### 4.3.1.1.3 Other Evaluations Based on CUF

The codes also contain metal fatigue analysis requirements based on a CUF calculation [the 1969 edition of ANSI B31.7 (Ref. 3) for Class 1 piping, ~~ASME NC-3200 vessels, ASME NE-3200 Class MC components, and metal bellows designed to ASME NC-3649.4(e)(3), ND-3649.4(e)(3), or NE-3366.2(e)(3)].~~ For these components, the discussion relating to ASME Section III, Class 1 in Subsection 4.3.1.1.1 of this review plan section applies.

#### 4.3.1.1.4 ASME Section III, Class 2 and 3

ASME Section III, Class 2 and 3 piping cyclic design requirements are similar to those for ANSI B31.1. The discussion relating to B31.1 in Subsection 4.3.1.1.2 of this review plan section applies.

### 4.3.1.2 Generic Safety Issue

The fatigue design criteria for nuclear power plant components has changed as the industry consensus codes and standards have evolved. The fatigue design criteria for a specific component depend on the version of the design code that applied to that component, that is, the code of record. There is a concern that the effects of the reactor coolant environment on the fatigue life of component was not adequately addressed by the code of record.

The Commission has decided that the adequacy of the code of record relating to metal fatigue is a potential safety issue to be addressed by the current regulatory process for operating reactors (Refs. 4 and 5). The effects of fatigue for the initial 40-year ~~initial~~ reactor license period were studied and resolved under Generic Safety Issue (GSI)-78, "Monitoring of Fatigue Transient Limits for Reactor Coolant System," and GSI-166, "Adequacy of Fatigue Life of Metal Components" (Ref. 6). GSI-78 addressed whether fatigue monitoring was necessary at operating plants. As part of the resolution of GSI-166, an assessment was made of the significance of the more recent fatigue test data on the fatigue life of a sample of components in plants were Code fatigue design analysis had been performed. The efforts on fatigue life estimation and ongoing issues under GSI-78 and GSI-166 for 40-year plant life were addressed separately under a staff generic task action plan (Refs. 7 and 8). The staff documented its completion of the fatigue action plan in SECY-95-245 (Ref. 9).

SECY-95-245 was based on a study described in NUREG/CR-6260, "Application of NUREG/CR-5999 Interim Fatigue Curves to Selected Nuclear Power Plant Components" (Ref. 10). In NUREG/CR-6260, sample locations in the plant with high fatigue usage were evaluated. Conservatisms in the original fatigue calculations, such as actual cycles versus assumed cycles, were removed and the fatigue usage was recalculated using a fatigue curve considering the effects of the environment. The staff found that most of the locations would have a CUF of less

than the ASME Code limit of 1.0 for 40 years. On the basis of the component assessments, supplemented by a 40-year risk study, the staff concluded that a backfit of the environmental fatigue data to operating plants could not be justified. However, because the staff was less certain that sufficient excessive conservatisms in the original fatigue calculations could be removed to account for an additional 20 years of operation for renewal, the staff recommended in SECY-95-245 that the samples in NUREG/CR-6260 should be evaluated considering environmental effects for license renewal. GSI-190, "Fatigue Evaluation of Metal Components for 60-year Plant Life," was established to address the residual concerns of GSI-78 and GSI-166 regarding the environmental effects on fatigue on pressure boundary components for 60-years of plant operation.

The scope of GSI-190 included design basis fatigue transients, studying the probability of fatigue failure and its effect on core damage frequency (CDF) of selected metal components for 60-year plant life. The study showed that some components have cumulative probabilities of crack initiation and through-wall growth that approach unity within the 40- and 60-year period. The maximum failure rate (through-wall cracks per year) was in the range of $10^{-2}$ per year, and those failures were generally associated with high cumulative usage factor locations and components with thinner walls, i.e., pipes more vulnerable to through-wall cracks. In most cases, the leakage from these through-wall cracks is small and not likely to lead to core damage. Based on the results of probabilistic analyses, along with the sensitivity studies performed, the interactions with the industry (NEI and EPRI), and different approaches available to the licensees to manage the effects of aging, it was concluded that no generic regulatory action is required, and that GSI-190 is resolved (Ref. 11). However, the calculations supporting resolution of this issue, which included consideration of environmental effects, and the nature of age-related degradation indicate the potential for an increase in the frequency of pipe leaks as plants continue to operate. Thus, the staff concluded that licensees must address the effects of coolant environment on component fatigue life as aging management programs are formulated in support of license renewal.

One method acceptable to the staff of satisfying this recommendation is to assess the impact of the reactor coolant environment on a sample of critical components. These critical components should include, as a minimum, those components selected in NUREG/CR–6260 (Ref. 10). 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 for carbon and low–alloy steels are contained in NUREG/CR–6583 (Ref. 12) and those for austenitic stainless steels are contained in NUREG/CR–5704 (Ref. 13).

An applicant may also chose to address the effects of coolant environment on component fatigue life by an aging management program.

An applicant's consideration of the effects of coolant environment on component fatigue life for license renewal is an area of review.

Open Item – Section 4.3.1.2 needs to be revised to reflect the recent discussions between the industry and NRC staff on the topic of GSI-190. The current accepted approach to the resolution of GSI-190 is the reanalysis of certain existing fatigue calculations. In the future, an accepted approach may be along the lines of enhanced or augmented inspection of certain locations in an aging management program. Consideration should be given to relocation of the GSI-190 discussion to SRP 3.2, Reactor Coolant System. Conforming changes should also be made to SRP Sections 4.3.2.1.1 and 4.3.3.1.1.

#### 4.3.1.3 FSAR Supplement

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.

### 4.3.2 ACCEPTANCE CRITERIA

The acceptance criteria for the areas of review described in Subsection 4.3.1 of this review plan section define acceptable methods for meeting the requirements of the Commission's regulations in 10 CFR 54.21(c)(1).

4.3.2.1 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 metal fatigue are:

#### 4.3.2.1.1 ASME Section III, Class 1

For components designed or analyzed to ASME Class 1 requirements, the acceptance criteria, depending on the applicant's choice, that is, 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

##### 4.3.2.1.1.1 10 CFR 54.21(c)(1)(i)

The existing CUF calculations remain valid because the number of assumed transients ~~would~~ will not be exceeded during the period of extended operation. The effects of coolant environment on component fatigue life (GSI-190) are included within the existing CUF calculations.

##### 4.3.2.1.1.2 10 CFR 54.21(c)(1)(ii)

The CUF calculations have been re-evaluated based on an increased number of assumed transients to bound the period of extended operation. The resulting CUF remains less than unity as required by the code during the period of extended operation. The effects of coolant environment on component fatigue life (GSI-190) are included within the re-evaluated CUF calculations.

##### 4.3.2.1.1.3 10 CFR 54.21(c)(1)(iii)

The effects of aging on the intended function(s) will be adequately managed for the period of extended operation. The component could be replaced and the CUF for the replacement will be less than unity during the period of extended operation. The effects of coolant environment on component fatigue life (GSI-190) are included within the proposed aging management program.

~~Alternative acceptance criteria under 10 CFR 54.21(c)(1)(iii) have yet to be developed and will be evaluated on a case-by-case basis to ensure that the aging effects will be managed such that the intended functions(s) will be maintained during the period of extended operation.~~ Alternative aging management program provided by the applicant will be evaluated on a case-by-case basis to ensure that the aging effects will be managed such that the intended functions(s) will be maintained during the period of extended operation.

#### 4.3.2.1.2 ANSI B31.1

For piping designed or analyzed to B31.1 requirements, the acceptance criteria, depending on the applicant's choice, that is, 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

##### 4.3.2.1.2.1 10 CFR 54.21(c)(1)(i)

The existing allowable stresses remain valid because the number of assumed thermal cycles would not be exceeded during the period of extended operation.

##### 4.3.2.1.2.2 10 CFR 54.21(c)(1)(ii)

The allowable stresses have been re-evaluated based on an increased number of assumed thermal cycles and Table 4.3-1 to bound the period of extended operation. The resulting allowable stresses remain sufficient as required by the code during the period of extended operation.

##### 4.3.2.1.2.3 10 CFR 54.21(c)(1)(iii)

The effects of aging on the intended function(s) will be adequately managed for the period of extended operation. The component could be replaced and the allowable stresses for the replacement will be sufficient as required by the code during the period of extended operation.

Alternative acceptance criteria under 10 CFR 54.21(c)(1)(iii) have yet to be developed and will be evaluated on a case-by-case basis to ensure that the aging effects will be managed such that the intended functions(s) will be maintained during the period of extended operation.

#### 4.3.2.1.3 Other Evaluations Based on CUF

The acceptance criteria in Subsection 4.3.2.1.1 of this review plan section apply.

#### 4.3.2.1.4 ASME Section III, Class 2 and 3

The acceptance criteria in Subsection 4.3.2.1.2 of this review plan section apply.

~~4.3.2.2 Generic Safety Issue~~

~~The staff recommendation for the closure of GSI–190 is contained in a December 26, 1999, memorandum from Ashok Thadani to William Travers (Ref. 11). The staff recommended that licensees address the effects of the coolant environment on component fatigue life as aging management programs are formulated in support of license renewal. One method acceptable to the staff of satisfying this recommendation is to assess the impact of the reactor coolant environment on a sample of critical components. These critical components should include, as a minimum, those components selected in NUREG/CR–6260 (Ref. 10). 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 for carbon and low–alloy steels are contained in NUREG/CR–6583 (Ref. 12) and those for austenitic stainless steels are contained in NUREG/CR–5704 (Ref. 13).~~

#### 4.3.2.~~3~~2 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 ~~aging effects are managed in the period of extended operation.~~the TLAA has been properly dispositioned~~.~~ for the period of extended operation.

### 4.3.3 REVIEW PROCEDURES

For each area of review described in Subsection 4.3.1 of this review plan section, the following review procedures are followed:

4.3.3.1 Time-Limited Aging Analysis

#### 4.3.3.1.1 ASME Section III, Class 1

For components designed or analyzed to ASME Class 1 requirements, the review procedures, depending on the applicant's choice, that is, 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

##### 4.3.3.1.1.1 10 CFR 54.21(c)(1)(i)

~~A list of the assumed transients used in the existing CUF calculations for the current operating term and operating transient experience is reviewed to ensure that the number of assumed transients would not be exceeded during the period of extended operation.~~ The number of assumed transients used in the existing CUF calculations for the current operating term is compared to an evaluation of the number of operating transients experienced to date as extrapolated to 60 years of operation. The comparison confirms that the number of transients in the existing analyses will not be exceeded during the period of extended operation.

The reviewer verifies that the effects of coolant environment on component fatigue life (GSI-190) are included within the existing CUF calculations.

##### 4.3.3.1.1.2 10 CFR 54.21(c)(1)(ii)

A list of the increased number of assumed transients projected to the end of the period of extended operation and operating transient experience is reviewed to ensure that the transient projection is adequate. The revised CUF calculations based on the projected number of assumed transients are reviewed to ensure that the CUF remains less than unity at the end of the period of extended operation.

The code of record should be used for the re-evaluation, or the applicant may update to a later code edition pursuant to 10 CFR 50.55a. In the latter case, the reviewer verifies that the requirements in 10 CFR 50.55a are met.

The reviewer verifies that the effects of coolant environment on component fatigue life (GSI-190) are included within the revised CUF calculations.

#### 4.3.3.1.1.3 10 CFR 54.21(c)(1)(iii)

The applicant's proposed program to ensure that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation is reviewed. ~~If the applicant proposed component replacement before its CUF exceeds unity, the reviewer verifies that the CUF for the replacement will remain less than unity during the period of extended operation.~~ The proposed program should include corrective actions such as component reanalysis, transient re-classification, more sophisticated monitoring, repair or replacement.

The reviewer verifies that the effects of coolant environment on component fatigue life (GSI-190) are being addressed within the applicant's proposed aging management program.

Other applicant proposed programs will be reviewed on a case-by-case basis.

#### 4.3.3.1.2 ANSI B31.1

For piping designed or analyzed to ANSI B31.1 requirements, the review procedures, depending on the applicant's choice, that is, 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

#### 4.3.3.1.2.1 10 CFR 54.21(c)(1)(i)

~~A list~~The documented results -of the assumed thermal cycles used in the existing allowable stress determination and operating cyclic experience is reviewed to ensure that the number of assumed thermal cycles would not be exceeded during the period of extended operation.

#### 4.3.3.1.2.2 10 CFR 54.21(c)(1)(ii)

~~A list~~The documented results of the increased number of assumed thermal cycles projected to the end of the period of extended operation and operating cyclic experience is reviewed to ensure that the thermal cycle projection is adequate. The revised allowable stresses based on the projected number of assumed thermal cycles and Table 4.3-1 are reviewed to ensure that they remain sufficient as required by the code during the period of extended operation.

The code of record should be used for the re-evaluation or the applicant may update to a later code edition pursuant to 10 CFR 50.55a. In the latter case, the reviewer verifies that the requirements in 10 CFR 50.55a are met.

#### 4.3.3.1.2.3 10 CFR 54.21(c)(1)(iii)

The applicant's proposed program to ensure that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation is reviewed. If the applicant proposed component replacement before it exceeds the assumed thermal cycles, the reviewer verifies that the allowable stresses for the replacement will remain sufficient as required by the code during the period of extended operation. Other applicant-proposed programs will be reviewed on a case-by-case basis.

#### 4.3.3.1.3 Other Evaluations Based on CUF

The review procedures in Subsection 4.3.3.1.1 of this review plan section apply.

#### 4.3.3.1.4 ASME Section III, Class 2 and 3

The review procedures in Subsection 4.3.3.1.2 of this review plan section apply.

~~4.3.3.2 Generic Safety Issue~~

~~The reviewer verifies that the applicant has addressed the staff recommendation for the closure of GSI–190 contained in a December 26, 1999, memorandum from Ashok Thadani to William Travers (Ref. 11). The reviewer verifies that the applicant has addressed the effects of the coolant environment on component fatigue life as aging management programs are formulated in support of license renewal. If an applicant has chosen to assess the impact of the reactor coolant environment on a sample of critical components, the reviewer verifies the following:~~

~~1. The critical components include, as a minimum, those components selected in NUREG/CR–6260 (Ref. 10).~~

~~2. The sample of critical components have been evaluated by applying environmental correction factors to the existing ASME Code fatigue analyses.~~

~~3. Formulas for calculating the environmental life correction factors are those contained in NUREG/CR–6583 (Ref. 12) for carbon and low–alloy steels, and in NUREG/CR–5704 (Ref. 13) for austenitic stainless steels.~~

~~An applicant may also choose to manage the effects of aging due to environmental fatigue. In this case the reviewer verifies that the activity for managing the effects of aging is consistent with the guidance provided in Appendix A of this review plan.~~

#### 4.3.3.3~~2~~ FSAR Supplement

The reviewer verifies that the applicant has provided a FSAR supplement on the summary description of the evaluation of the metal fatigue TLAA. Table 4.3-2 of this review plan section contains examples of acceptable FSAR supplement information for this TLAA. The reviewer

verifies that the applicant has provided a FSAR supplement ~~using a format similar~~ with information equivalent to that in Table 4.3-2.

### 4.3.4 EVALUATION FINDINGS

The reviewer verifies that sufficient and adequate information has been provided 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 evaluation concludes that the applicant has provided an acceptable demonstration, pursuant to 10 CFR 54.21(c)(1), that, for the metal fatigue TLAA, (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 metal fatigue TLAA evaluation for the period of extended operation.

### 4.3.5 IMPLEMENTATION

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

### 4.3.6 REFERENCES


1. ASME Boiler and Pressure Vessel Code, Section III, "Rules for Construction of Nuclear Power Plant Components," American Society of Mechanical Engineers.

2. ANSI/ASME B31.1, "Power Piping," American National Standards Institute.

3. ANSI/ASME B31.7-1969, "Nuclear Power Piping," American National Standards Institute.

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

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

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

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

8. SECY-94-191, "Fatigue Design of Metal Components," July 26, 1994.

9. SECY-95-245, "Completion of The Fatigue Action Plan," September 25, 1995.

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

11. Letter from Ashok C. Thadani of the Office of Nuclear Regulatory Research to William D. Travers, Executive Director of Operations, dated December 26, 1999.

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

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

**Table 4.3-1. Stress Range Reduction Factors**

| Number of Equivalent Full Temperature Cycles | Stress Range Reduction Factor |
|---|---|
| 7,000 and less | 1.0 |
| 7,000 to 14,000 | 0.9 |
| 14,000 to 22,000 | 0.8 |
| 22,000 to 45,000 | 0.7 |
| 45,000 to 100,000 | 0.6 |
| 100,000 and over | 0.5 |

**Table 4.3-2. Examples of FSAR Supplement for Metal Fatigue TLAA Evaluation**

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

| TLAA | Description of Evaluation | ~~Implementation Schedule~~ |
|---|---|---|
| Metal Fatigue | The existing CUF evaluation has been determined to remain valid because the number of assumed cyclic loads would not be exceeded during the period of extended operation.<br><br>The effects of coolant environment on reactor coolant system component fatigue life (GSI-190) are included within the existing calculations. | ~~Completed~~ |

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

| TLAA | Description of Evaluation | ~~Implementation Schedule~~ |
|---|---|---|
| Metal Fatigue | The CUF calculations have been re-evaluated based on an increased number of assumed cyclic loads to include the period of extended operation and the revised CUF will not exceed unity during the period of extended operation.<br><br>The effects of coolant environment on reactor coolant system component fatigue life (GSI-190) are included within the revised calculations. | ~~Completed~~ |

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

| TLAA | Description of Evaluation | ~~Implementation Schedule~~ |
|---|---|---|
| Metal Fatigu | In order not to exceed the design limit on fatigue usage and the number of design cycles, the aging management program monitors and tracks the number of critical thermal and pressure test transients, and monitors the cycles for the selected reactor coolant system components.<br><br>~~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. 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.~~<br>The effects of coolant environment on reactor coolant system component fatigue life (GSI-190) are addressed by the aging management program. | ~~Evaluation will be completed by...~~ |

Open Item – These examples need to be revised to reflect the General Comments on the FSAR Supplement that have been provided separately.

## 4.4 Environmental Qualification (EQ) of Electric Equipment

*Note: This revised version of SRP 4.4 incorporates material that has previously been provided to the NRC by NEI as part of industry comments on the electrical portion of the GALL report. Specifically, the material contained in proposed Section X of the GALL and dated April 19, 2000, "Evaluation of Electrical Components Included in the Plant's Environmental Qualification (EQ) Program" has been incorporated into this revision of SRP 4.4.*

Review Responsibilities

**Primary** - Branch responsible for electrical engineering
**Secondary** - None

### 4.4.1 Areas of Review

~~Electric equipment important to safety that is environmentally qualified is required to remain functional during normal plant operation and during and following design basis events to ensure safe operation, achieve and maintain safe shutdown, or prevent or mitigate accidents. Environmental qualification (EQ) of this equipment has been demonstrated by testing, analysis in combination with partial type test data, and/or operating experience with identical or similar equipment for the current operating term. The validity of EQ for this equipment is reviewed for the period of extended operation.~~

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 (i.e., 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

~~Specific requirements pertaining to qualification of certain electric equipment important to safety are contained in 10 CFR 50.49, "Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants." Regulatory Guide 1.89, Rev. 1, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants," (Ref. 1) supports 10 CFR 50.49. The EQ rule (10 CFR 50.49) is based on 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 codes and standards contain explicit EQ considerations based on time-limited aging analyses.~~

All operating plants must meet the requirements of § 50.49 for certain electrical components important-to-safety. § 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. § 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. § 50.49(e) also requires component replacement or refurbishment prior to the end of designated life unless additional life is established through ongoing qualification. § 50.49(f) establishes four methods of demonstrating qualification for aging and accident conditions. §§ 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*; June 1979, NUREG-0588, *Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment;* July 1981 and Regulatory Guide 1.89, Rev. 1, *Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants*, June 1984. Compliance with § 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 § 50.49(f) qualification methods. As required by § 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.

~~**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**

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. Specific issues being addressed in this research are presented in NUREG/CR-6384. Once this generic issue is resolved, guidance will be provided as to the impact on license renewal. In the interim, NRC letter dated June 2, 1998, "*Guidance on Addressing GSI-168 for License Renewal*," (C. Grimes, NRC to D.

Walters, NEI) provides guidance on addressing GSI-168 in license renewal applications. It states that until the generic issue is resolved, "*...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.*"

~~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.~~

~~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 (depending 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 qualifies the component through 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 extend the qualification of the component through the period of extended operation. 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**, Table 4.4-2.

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

~~The effects of aging on the intended function(s) will be adequately managed for the period of extended operation. The equipment could be replaced prior to reaching the end of its qualified life. The EQ process is considered an aging management program for license renewal.~~ Option (iii) is used in cases (a) where the aging evaluation does not extend the qualification into or extends the qualification into but not through, the period of extended operation or (b) where aging management actions such as periodic maintenance, inspection, testing or parts replacement are required to maintain the qualification through the period of extended operation. In light of this option, EQ programs, which implement the requirements of § 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. The evaluation and technical basis for EQ programs as acceptable aging management programs is provided in the **EQ Program Evaluation and Technical Basis**, Table 4.4-1. 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**, Table 4.4-2.

#### ~~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. 14)~~

*Note: Section 4.4.2.2 is no longer needed because of the discussion contained in 4.4.1.2.*

#### 4.4.2.~~3~~2 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 ~~aging effects are managed in the period of extended operation.~~the TLAA has been properly dispositioned for the period of extended operation..

### 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 bounds the period of extended operation.

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

The results of extending the qualification for the period of extended operation will be reviewed. The qualification methods include testing, analysis, operating experience or combinations thereof. For reanalysis, the reviewer verifies that an applicant has addressed 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. ~~(Ref. 15)~~

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

The applicant's EQ process will be reviewed to ensure that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation because the equipment will be replaced prior to reaching the end of its qualified life. Replacement equipment must be qualified in accordance with the provisions of 10 CFR 50.49. For reanalysis, the reviewer verifies that an applicant has addressed 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. ~~(Ref. 15)~~

The applicant may state that the environmental qualification program described in Table 4.4-1 is applicable to its plant. The reviewer verifies that the applicant has identified the environmental qualification program in its application. 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.14).~~

*Note: Section 4.4.3.2 is no longer needed because of the discussion contained in 4.4.1.2. Furthermore, it is inappropriate to place a requirement for an applicant action ( i.e., applicant should monitor updates to NUREG-0933 ) in the review procedure section of the SRP.*

#### 4.4.3.~~3~~2 FSAR Supplement

The reviewer verifies that the applicant has provided a FSAR supplement on the summary description of the evaluation of EQ Electric Equipment TLAA. Table 4.4-3~~1~~ 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 ~~using a format similar~~with information equivalent to that in Table 4.4-3~~1~~.

### 4.4.4 Evaluation of Findings

The reviewer verifies that sufficient and adequate information has been provided 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 evaluation concludes that the applicant has provided an acceptable demonstration, pursuant to 10 CFR 54.2 (c)(1), that, for the EQ of Electric Equipment, (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. Letter from Christopher I. Grimes (NRC) to Doug Walters (NEI), " Guidance on addressing GSI-168 for license renewal", dated June 2, 1998.

15. ~~NUREG-xxxx, "Generic Aging Lessons Learned (GALL)," U.S. Nuclear Regulatory Commission, XXXX.~~

**Table 4.4-1 Environmental Qualification (EQ) Program 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:*** § 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 (e.g., 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:*** § 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:*** § 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:*** § 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. § 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 § 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 § 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 § 50.49 provides evidence that the component will perform its intended functions during accident conditions after experiencing the effects of in-service aging.

## Table 4.4-2 Environmental Qualification Reanalysis Attributes

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 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 (i.e., 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 (i.e., 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 conservatisms in the component service conditions (e.g., 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 & Corrective Actions:*** The reanalysis of an aging evaluation shall 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 (i.e., sufficient time is available to refurbish, replace or requalify the component if the reanalysis is unsuccessful).

**Table 4.4-3~~1~~. 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 bound 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 extended to ~~cover~~consider 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~~ |

Open Item – These examples need to be revised to reflect the General Comments on the FSAR Supplement that have been provided separately.

## 4.5 CONCRETE CONTAINMENT TENDON PRESTRESS

**Review Responsibilities**

**Primary** - Branch responsible for structural engineering
**Secondary** - None

### 4.5.1 Areas of Review

The prestressing ~~forces~~ tendons in prestressed concrete containments lose their prestressing forces with time due to creep and shrinkage of concrete, and relaxation of the prestressing steel. During the design phase, engineers estimate these losses to arrive at the predicted prestressing forces at the end of operating life (Refs. 1 and 2), normally forty years. ~~The experiences with the trend of prestressing forces indicate that the prestressing tendons lose their prestressing forces at a rate higher than estimated (Ref. 3). Thus, it is necessary to perform time limited aging analysis (TLAA) for the extended period of operation.~~ These end of life prestressing force Predicted Lower Limits (PLL) must be above certain design Minimum Required Values (MRV). Curves developed from these calculations/analyses are used to evaluate prestressing force measurements taken on the tendons during surveillances required by Reg. Guide 1.35 and/or ASME Section XI, Subsection IWL. Because the calculations/analyses for the prediction of the loss of prestressing forces are performed for a period of time based on the original operating term, and must be extended to ~~cover~~consider the period of extended operation, they constitute a TLAA.

The actual surveillance testing (including the evaluation of test results) for the prestressing of the containment tendons constitutes an aging management activity that must be evaluated as part of the IPA process but does not involve a TLAA , because the conduct of testing is not based on time-limited assumptions based on the current operating term. Testing periodicities are established by regulatory requirements at intervals much shorter than the current operating term, and test results are not compared to the 40 year values, but to the values that correspond to the time of the collection of the data.. ~~The adequacy of the prestressing forces in prestressed concrete containments is reviewed for the period of extended operation.~~

### 4.5.2 Acceptance Criteria

The acceptance criterion for the TLAA described in Subsection 4.5.1 of this review plan section ~~are~~ is as follows:

~~The trend lines of the actually measured prestressing forces in each group of tendons to remain above the predicted lower limits (PLL) (Ref. 2) for the period of extended operation.~~ The design calculations/analyses predicting the prestressing losses must already consider or must be projected to consider the period of extended operation. The PLL curves must be shown to remain above the MRV for the period of extended operation.

#### 4.5.2.1 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.

Accordingly, the specific options for satisfying the acceptance criterion are:

#### 4.5.2.1.1 10 CFR 54.21(c)(1)(i)

The existing prestressing force evaluation remains valid because ~~(1)~~the existing calculations/analyses regarding the predicted losses of the prestressing force ~~are less than the predicted losses as evidenced from the trend lines constructed from the recent inspection, (2) the period of evaluation~~ covnsiderers the period of extended operation~~, and (3) the trend lines of the measured prestressing forces remain above the predicted lower limit (PLL) for each group of tendons for the period of extended operation~~. (As the requirements of Reg Guide 1.35 and ASME Section XI, Subsection IWL are based on a forty year operating cycle, it is likely that existing PLL curves will not account for the period of extended operation, and that option (ii) will apply.)

#### 4.5.2.1.2 10 CFR 54.21(c)(1)(ii)

~~An applicant may utilize this option as follows:~~

The calculations/analyses regarding the predicted losses of the prestressing force ~~predicted lower limits (PLLs) of prestressing forces for each group of tendons developed for 40 years period of operation should be~~are ~~extended~~ projected to 60 years. ~~The applicant should demonstrate that the trend lines of the measured prestressing forces will stay above the PLLs and the minimum required prestressing force value (MRV) in the CLB for each group of tendons during the period of extended operation (Ref. 4). If this cannot be done, the applicant should develop a systematic plan for retensioning selected tendons so that the trend lines will remain above the PLLs for each group of tendons during the period of extended operation, or perform a reanalysis of containment to demonstrate design adequacy.~~

#### 4.5.2.1.3 10 CFR 54.21(c)(1)(iii)

This option is not applicable for this TLAA. The calculations/analyses pertaining to the predicted loss of prestressing losses must be extended to ~~cover~~consider the period of extended operation to satisfy the requirements of Reg. Guide 1.35 and/or ASME Section XI, Subsection IWL. An aging management activity may not be substituted for this action.
~~In this option, an applicant should develop an aging managing program incorporating the ten elements: (1) scope of program, (2) preventive actions, (3) parameters monitored and inspected, (4) detection of aging effects, (5) monitoring and trending, (6) acceptance criteria, (7) corrective actions, (8) confirmation process, (9) administrative controls, and (10) operating experience as described in the Branch Technical Position XX of this standard review plan, and address the following attributes:~~

~~(a) The tendon prestressing forces are monitored in accordance with ASME Section XI, Subsection IWL (Ref. 5), examination category L-B, "Unbonded Post-Tension System" and 10 CFR 50.55a(b)(2)(ix)(B) (Ref. 6);~~

~~(b) The trend lines of the measured prestressing forces should be developed for the period of extended operation. The applicant should demonstrate that the trend lines stay above the predicted lower limit (PLL) prestressing forces for each group of tendons during the period of extended operation;~~

~~(c) If the trend lines cross the PLLs at any time, corrective actions should be taken which include either systematic retensioning to ensure the adequacy of tendon forces or a reanalysis of containment to demonstrate design adequacy;~~

~~(d) The program should incorporate any plant operating experience, as well as operating experience at other plants as applicable to tendon force monitoring.~~

#### 4.5.2.2 FSAR Supplement

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

The description of the time-limited aging analyses for the period of extended operation in the FSAR supplement should provide 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 and the basis for determining that ~~aging and time-dependent effects are managed during the period of extended operation~~the TLAA has been properly dispositioned.

### 4.5.3 Review Procedures

For each area of review described in Subsection 4.5.1 of this review plan section, the following review procedures are followed:

#### 4.5.3.1 Time-Limited Aging Analysis

For a concrete containment prestressing tendon system ~~that has been evaluated and determined to be acceptable for continued service to the end of the current operating term~~, the review procedures, depending on the applicant's choice, i.e., 10 CFR 54.21(c)(1)(i), or (ii)~~, or (iii)~~, are:

##### 4.5.3.1.1 10 CFR 54.21(c)(1)(i)

~~The results of a recent inspection to measure the amount of prestress loss are reviewed to ensure that the reduction of prestressing force is less than the predicted losses in the existing analysis.~~ The reviewer verifies that the ~~trend line of~~ documented results of the calculations/analyses for the ~~measured~~ predicted prestressing force ~~when plotted on the predicted prestressing force curve shows that the existing analysis~~losses ~~will cover~~ considers the period of extended operation.

##### 4.5.3.1.2 10 CFR 54.21(c)(1)(ii)

~~The reviewer reviews the trend lines of the measured prestressing forces to ensure that individual tendon lift-off forces (rather than average lift-off forces of the tendon group) are considered in the regression analysis as discussed in IN 99-10 (Ref. 3). The reviewer verifies that the trend lines will stay above the predicted lower limit (PLL) prestressing forces for each~~

~~group of tendons during the period of extended operation. If the trend lines fall below the PLL during the period of extended operation, the reviewer verifies that the applicant has a systematic plan for retensioning the tendons to ensure that the trend lines will remain above the PLL for each group of tendons during the period of extended operation. If the applicant chooses to reanalyze the containment, the reviewer verifies that the design adequacy is maintained in the period of extended operation.~~ The reviewer verifies that the documented results of the calculations/analyses for the predicted prestressing force losses have been or will be extended to ~~cover~~consider the period of extended operation.

#### 4.5.3.1.3 10 CFR 54.21(c)(1)(iii)

~~The reviewer verifies that the aging managing program developed by the applicant addresses attributes (a) to (d) listed in Subsection 4.5.2.1.3 of this review plan section.~~ Not applicable

### 4.5.3.2 FSAR Supplement

The reviewer verifies that the applicant has provided a FSAR supplement on the description of the evaluation of the tendon prestress TLAA. Table 4.5-1 of this review plan section contains examples of acceptable FSAR supplement information for this TLAA. The reviewer verifies that the applicant has provided a FSAR supplement ~~using a format~~with information equivalent ~~similar~~ to that in Table 4.5-1.

## 4.5.4 Evaluation Findings

The reviewer verifies that sufficient and adequate information has been provided 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~~),~~) or (ii)~~, or (iii), to be included in the staff's safety evaluation report~~:

> The staff evaluation concludes that the applicant has provided an acceptable demonstration ~~or an aging management program~~, pursuant to 10 CFR 54.21(c)(1), that, for the concrete containment tendon prestress TLAA, (i) the analyses remain valid for the period of extended operation, or (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 description of the concrete containment tendon prestress TLAA evaluation for the period of extended operation.

## 4.5.5 Implementation

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

## 4.5.6 References


1. Regulatory Guide 1.35, Rev. 3, "Inspection of Ungrouted Tendons in Prestressed Concrete Containments," July 1990.

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

~~3. NRC Information Notice 99-10, "Degradation of Prestressing Tendon Systems in Prestressed Concrete Containments," April 1999.~~

~~4. NUREG/CR-XX, "Generic Aging Lessons Learned (GALL)," XXXX.~~

~~5~~3. ASME Boiler and Pressure Vessel Code, Section XI, "Rules for In-Service Inspection of Nuclear Power Plant Components," American Society of Mechanical Engineers, 1989; including Appendix VII, "Qualification of Nondestructive Examination Personnel for Ultrasonic Examination," and Appendix VIII (1989 Addenda), "Performance Demonstration for Ultrasonic Examination Systems," Subsection IWE (1992 Edition with 1992 Addenda), "Requirements for Class MC and Metallic Liners of Class CC Components of Light-Water Cooled Plants," and Subsection IWL (1992 Edition with 1992 Addenda), "Requirements for Class CC Concrete Components of Light-Water Cooled Plants."

~~6~~4. Codes of Federal Regulations: 10 CFR 50.55a, "Codes and Standards."

**Table 4.5-1. Examples of FSAR Supplement for Concrete Containment Tendon Prestress TLAA Evaluation**

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

| TLAA | Description of Evaluation | ~~Implementation Schedule~~ |
|---|---|---|
| Concrete Containment Tendon Prestress | The prestressing tendons are used to impart compressive forces in the prestressed concrete containments to resist the internal pressure inside the containment that would be generated in the event of a LOCA. The prestressing forces generated by the tendons diminish over time due to losses in prestressing force in the tendons and the surrounding concrete. The predicted prestressing force ~~evaluation has~~calculations/analyses have been determined to remain valid to the end of the period of extended operation. The PLL curves are shown to remain above the MRV for the period of extended operation.~~, and the trend lines of the measured prestressing forces will stay above the predicted lower limits for each group of tendons to the end of the period of extended operation~~. | ~~Completed~~ |

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

| TLAA | Description of Evaluation | ~~Implementation Schedule~~ |
|---|---|---|
| Concrete Containment Tendon Prestress | The prestressing tendons are used to impart compressive forces in the prestressed concrete containments to resist the internal pressure inside the containment that would be generated in the event of a LOCA. The prestressing forces generated by the tendons diminish over time due to losses in prestressing force in the tendons and the surrounding concrete. The predicted prestressing force calculations/analyses have been projected to the end of the period of extended operation. The PLL curves have been shown to remain above the MRV for the period of extended operation.~~The prestressing forces have been re-evaluated and that the trend lines of the measured prestressing forces will stay above the predicted lower limits for each group of tendons to the end of the period of extended operation.~~ | ~~Completed~~~~Completed prior to the period of extended operation~~ |

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

| ~~TLAA~~ | ~~Description of Evaluation~~ | ~~Implementation Schedule~~ |
|---|---|---|
| ~~Concrete Containment Tendon Prestress~~ | ~~The prestressing tendons are used to impart compressive forces in the prestressed concrete containments to resist the internal pressure inside the containment that would be generated in the event of a LOCA. The prestressing forces generated by the tendons diminish over time due to losses of prestressing force in the tendons and the surrounding concrete. The aging management program developed to monitor the prestressing force should ensure that, during each inspection, the trend lines of the measured prestressing forces show that they meet the requirements of 10 CFR 50.55a(b)(2)(ix)(B). If the trend lines cross the predicted lower limits corrective actions will be taken. The program will also incorporate any plant-specific and industry operating experience.~~ | ~~Program will be implemented by...~~ |

Open Item – These examples need to be revised to reflect the General Comments on the FSAR Supplement that have been provided separately. General Comments -9 and 10 apply.

## 4.6 CONTAINMENT LINER PLATE AND PENETRATIONS FATIGUE ANALYSIS

*Note: SRP 4.6 has been revised to be similar to the wording in SRP 4.3 in the same locations.*

### Review Responsibilities

**Primary** - Branch responsible for structural engineering
**Secondary** - Branch responsible for mechanical engineering

### 4.6.1 Areas of Review

The interior surface of a concrete containment structure is lined with thin metallic plates to provide a leak tight barrier against the uncontrolled release of radioactivity to the environment as required by 10 CFR Part 50. ~~The thickness of the liner plates is generally between 6.2 mm (1/4 in) and 9.5 mm (3/8 in).~~ The liner plates are attached to the concrete containment wall by means of stud anchors or structural rolled shapes or both. The design process assumes that the liner plates do not carry loads. However, normal loads, such as from concrete shrinkage, creep and thermal changes, imposed on the concrete containment structure are transferred to the liner plates through the anchorage system. Internal pressure and temperature loads are directly applied to the liner plates. Thus, under design-base conditions, the liner plates could experience significant strains. Fatigue of the liner plates is considered in the design based on an assumed number of loading cycles for the current operating term. The cyclic loads include reactor building interior temperature varying during the heatup and cooldown of the reactor coolant system, loss-of-coolant accident, annual outdoor temperature variations, thermal loads due to the high energy containment penetration piping lines, such as steam and feedwater lines, seismic loads, and pressurization due to periodic Type A integrated leak rate tests.

High energy piping penetrations and fuel transfer canal in some plants are equipped with bellow assemblies. These are designed to accommodate relative movements between the containment wall (including the liner) and the adjoining structures. The penetrations have sleeves (up to 10 feet in length, with a 2 to 3-inch annulus around the piping) to penetrate the concrete containment wall and allow movement of the piping system. Dissimilar metal welds connect the piping penetrations to the bellows to provide leaktight penetrations. The containment liner plates, penetration sleeves (including dissimilar metal welds), and penetration bellows ~~are Class 1 components. They~~ are generally designed in accordance with requirements of ASME Section III ~~which requires a fatigue analysis based on an assumed number of load cycles~~. If the code of record requires a fatigue analysis, then ~~T~~this fatigue analysis ~~is~~may be a Time-Limited Aging Analysis (TLAA) and must be evaluated in accordance with 10 CFR 54.21(c)(1) to ensure that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

For some plants, liner fatigue may not be addressed by a TLAA. In these cases, the applicant will address fatigue issues in Chapter 3.

The adequacy of the fatigue analyses of the containment liner plates (including welded joints), penetration sleeves, dissimilar metal welds, and penetration bellows is reviewed in this review plan section for the period of extended operation.

The fatigue analyses of pressure boundary welds of the high energy containment penetration piping lines are reviewed separately following the guidance in Section 4.3, "Metal Fatigue" of this standard review plan.

#### 4.6.1.1 Time-Limited Aging Analysis

The containment liner plates (including welded joints), penetration sleeves, dissimilar metal welds, and penetration bellows are generally designed and/or analyzed in accordance with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code requirements. The ASME code contains explicit metal fatigue or cyclic considerations based on time-limited aging analyses. Specific requirements are contained in the design code of reference for each plant.

##### 4.6.1.1.1 ASME Section III, Class 1

~~ASME Class II, III, or MC components, such as containment liner plates, penetration sleeves, dissimilar metal welds, and penetration bellows, are analyzed for metal fatigue.~~ ASME Section III, Division 2, "Code for Concrete Reactor Vessel and Containments, Subsection CC, Concrete Containment" (Ref. 1) requires a fatigue analysis for liner plates considering all cyclic loads, and is based on the anticipated number of cycles. A Section III Class 1 fatigue analysis requires the calculation of the "cumulative usage factor" (CUF) based on the fatigue properties of the materials and the expected fatigue service of the component. The ASME Code limits the CUF to a value of less than unity for acceptable fatigue design. The fatigue resistance of the liner plate, ~~liner weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows~~ during the period of extended operation is an area of review.

##### 4.6.1.1.2 ASME Section III, Class 2, 3

ASME Class 2, 3 or MC components, such as containment liner plates, penetration sleeves, dissimilar metal welds, and penetration bellows, are analyzed for metal fatigue. The fatigue resistance of the liner plate, liner weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows during the period of extended operation is an area of review.

##### 4.6.1.1.3~~2~~ Other Evaluations Based on CUF

Other evaluations also contain metal fatigue analysis requirements based on a CUF calculation such as metal bellows designed to ASME NC-3649.4(e)(3), ND-3649.4(e)(3), or NE-3366.2(e)(3). For these cases, the discussion relating to ASME Section III, Class 1 in Subsection 4.6.1.1.1 of this review plan section applies.

#### 4.6.1.2 FSAR Supplement

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.

### 4.6.2 Acceptance Criteria

The acceptance criteria for the areas of review described in Subsection 4.6.1 of this review plan section define acceptable methods for meeting the requirements of the Commission's

regulations in 10 CFR 54.21(c)(1).

#### 4.6.2.1 Time-Limited Aging Analysis

Pursuant to 10 CFR 54.21(c)(1), 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 fatigue of containment liner plates, liner plate weld joints, dissimilar metal welds, penetration sleeves, and penetration bellows are:

#### 4.6.2.1.1 ASME Section III, Class 1

For containment liner plates~~, liner plate weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows~~ designed or analyzed to ASME Class 1 requirements, the acceptance criteria, depending on the applicant's choice of 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

##### 4.6.2.1.1.1 10 CFR 54.21(c)(1)(i)

The existing CUF calculations remain valid because the number of assumed cyclic loads ~~during the period of extended operation would not exceed the ones considered for the current licensing basis.~~will not be exceeded during the period of extended operation.

##### 4.6.2.1.1.2 10 CFR 54.21(c)(1)(ii)

Current license basis fatigue analysis, per ASME Code, Section III, were conducted for a 40 years life. The CUF calculations should be re-evaluated based on an increased number of assumed cyclic loads to include the period of extended operation. All cyclic loads considered in the original fatigue analyses (including Type A and Type B leak rate tests) should be reevaluated and revised as necessary. ~~(Ref. 2).~~ The revised analysis should show that the CUF will not exceed unity as required by the ASME code during the period of extended operation.

##### 4.6.2.1.1.3 10 CFR 54.21(c)(1)(iii)

The effects of aging on the intended function(s) will be adequately managed for the period of extended operation. The component could be replaced and the CUF for the replacement will be less than unity during the period of extended operation.

Alternative aging management program provided by the applicant will be evaluated on a case-by-case basis to ensure that the aging effects will be managed such that the intended functions(s) will be maintained during the period of extended operation. In cases where a mitigation or inspection program is proposed, ~~T~~the aging management program ~~will~~ may be evaluated against the ten elements described in Branch Technical Position RLSB-1, Appendix A.1 of this standard review plan.

#### 4.6.2.1.2 ASME Section III, Class 2, 3

ASME Class 2, 3 or MC components, such as containment liner plates, penetration sleeves, dissimilar metal welds, and penetration bellows designed or analyzed to ASME Section III, Class 2 or 3, the acceptance criteria, depending on the applicant's choice, that is 10 CFR 54.21(c)(1)(I), (ii), or (iii), are:

**4.6.2.1.2.1 10 CFR 54.21(c)(1)(i)**

The existing allowable stresses remain valid because the number of assumed thermal cycles would not be exceeded during the period of extended operation.

**4.6.2.1.2.2 10 CFR 54.21(c)(1)(ii)**

The allowable stresses have been re-evaluated based on an increased number of assumed thermal cycles to bound the period of extended operation. The resulting allowable stresses remain sufficient as required by the code during the period of extended operation.

**4.6.2.1.2.3 10 CFR 54.21(c)(1)(iii)**

The effects of aging on the intended function(s) will be adequately managed for the period of extended operation. The component could be replaced and the allowable stresses for the replacement will be sufficient as required by the code during the period of extended operation.

Alternative acceptance criteria under 10 CFR 54.21(c)(1)(iii) have yet to be developed and will be evaluated on a case-by-case basis to ensure that the aging effects will be managed such that the intended functions(s) will be maintained during the period of extended operation.

**4.6.2.1.3~~2~~ Other Evaluations Based on CUF**

The acceptance criteria in Subsection 4.6.2.1.2~~1~~ of this review plan section apply.

**4.6.2.2 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 ~~or 10 CFR 50.90.~~. The description should contain information associated with the time-limited aging analysis regarding the basis for determining that ~~aging effects are managed during the period of extended operation~~the TLAA has been properly dispositioned.

**4.6.3 Review Procedures**

For each area of review described in Subsection 4.6.1 of this review plan section, the following review procedures are followed:

**4.6.3.1 Time-Limited Aging Analysis**

#### 4.6.3.1.1 ASME Section III, Class 1

For containment liner plates~~, liner weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows,~~ designed or analyzed to ASME Class 1 requirements, the review procedures, depending on the applicant's choice of 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

##### 4.6.3.1.1.1 10 CFR 54.2l(c)(1)(i)

~~A list of the assumed cyclic loads used in the existing CUF calculations for the current operating term and operating transient experience is reviewed to ensure that the number of cyclic loads assumed in the current licensing basis would not be exceeded during the period of extended operation.~~ The number of assumed transients used in the existing CUF calculations for the current operating term is compared to the number of operating transients experienced to date as extrapolated to 60 years of operation. The comparison confirms that the number of transients in the existing analyses will not be exceeded during the period of extended operation.

##### 4.6.3.1.1.2 10 CFR 54.21(c)(1)(ii)

A list of the increased number of assumed cyclic loads projected to the end of the period of extended operation and operating transient experience is reviewed to ensure that the cyclic load projection is adequate. ~~The basis of the determination of the maximum expected load cycles for 60 years operation is reviewed.~~ The revised CUF calculations based on the projected number of assumed cyclic loads are reviewed to ensure that the CUF remains less than unity at the end of the period of extended operation.

The code of record should be used for the re-evaluation, or the applicant may update to a later code edition pursuant to 10 CFR 50.55a. In the latter case, the reviewer verifies that the requirements in 10 CFR 50.55a are met.

##### 4.6.3.1.1.3 10 CFR 54.2l(c)(1)(iii)

The applicant's proposed aging management program to ensure that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation is reviewed. If the applicant proposed component replacement before its CUF exceeds unity, the reviewer verifies that the CUF for the replacement will remain less than unity during the period of extended operation.

Other applicant proposed programs will be reviewed on a case-by-case basis.

#### 4.6.3.1.2 ASME Section III, Class 2, 3

ASME Class 2, 3 or MC components, such as containment liner plates, penetration sleeves, dissimilar metal welds, and penetration bellows designed or analyzed to ASME Section III, Class 2 or 3, the review procedures, depending on the applicant's choice, that is 10 CFR 54.21(c)(1)(l), (ii), or (iii), are:

##### 4.6.3.1.2.1 10 CFR 54.21(c)(1)(ii)

The results of the ~~A list of the~~ assumed thermal cycles evaluation used in the existing allowable stress determination and operating cyclic experience is reviewed to ensure that the number of assumed thermal cycles would not be exceeded during the period of extended operation.

#### 4.6.3.1.2.2 10 CFR 54.21(c)(1)(ii)

The results of the evaluation for the~~A list of the~~ increased number of assumed thermal cycles projected to the end of the period of extended operation and operating cyclic experience is reviewed to ensure that the thermal cycle projection is adequate. The revised allowable stresses based on the projected number of assumed thermal cycles are reviewed to ensure that they remain sufficient as required by the code during the period of extended operation.

The code of record should be used for the re-evaluation or the applicant may update to a later code edition pursuant to 10 CFR 50.55a. In the latter case, the reviewer verifies that the requirements in 10 CFR 50.55a are met.

#### 4.6.3.1.2.3 10 CFR 54.21(c)(1)(iii)

The applicant's proposed program to ensure that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation is reviewed. If the applicant proposed component replacement before it exceeds the assumed thermal cycles, the reviewer verifies that the allowable stresses for the replacement will remain sufficient as required by the code during the period of extended operation. Other applicant-proposed programs will be reviewed on a case-by-case basis.

#### 4.6.3.1.3~~2~~ Other Evaluations Based on CUF

The review procedures in Subsection 4.6.3.1 of this review plan section apply.

### 4.6.3.2 FSAR Supplement

The reviewer verifies that the applicant has provided a FSAR supplement on the summary description of the evaluation of the containment liner plate and penetrations fatigue TLAA. Table 4.6-1 of this review plan section contains examples of acceptable FSAR supplement information for this TLAA. The reviewer verifies that the applicant has provided a FSAR supplement ~~using a format similar~~with information equivalent to that in Table 4.6-1.

## 4.6.4 Evaluation Findings

The reviewer verifies that sufficient and adequate information has been provided to satisfy the provisions of this standard 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 evaluation concludes that the applicant has provided an acceptable demonstration, pursuant to 10 CFR 54.21(c)(1), that for the containment liner plate and penetrations fatigue TLAA, (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 containment liner plate and penetrations fatigue TLAA evaluation for the period of extended operation.

### 4.6.5 Implementation

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

### 4.5.6 4.6.6 References


1. ASME Boiler and Pressure Vessel Code, Section III, Division 2, "Code for Concrete Reactor Vessels and Containments, Subsection CC, Concrete Containment," American Society of Mechanical Engineers, New York, New York, 1989 Edition.

~~2.NUREG-XXXX, "Generic Aging Lessons Learned (GALL)," XXXX.~~

**Table 4.6-1. Examples of FSAR Supplement for Containment Liner Plate and Penetrations Fatigue TLAA Evaluation**

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

| TLAA | Description of Evaluation | ~~Implementation Schedule~~ |
|---|---|---|
| Containment liner plate and penetrations fatigue | The containment liner plates, liner weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows provide a leak tight barrier. A Section III Class 1 fatigue analysis limits the "Cumulative Usage Factor" (CUF) to a value of less than unity for acceptable fatigue design. The existing CUF evaluation has been determined to remain valid because the number of assumed cyclic loads would not be exceeded during the period of extended operation. | ~~Completed~~ |

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

| TLAA | Description of Evaluation | ~~Implementation Schedule~~ |
|---|---|---|
| Containment liner plate and penetrations fatigue | The containment liner plates, liner weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows provide a leak tight barrier. A Section III Class 1 fatigue analysis limits the CUF to a value of less than unity for acceptable fatigue design. The CUF calculations have been re-evaluated based on an increased number of assumed cyclic loads to include the period of extended operation and the revised CUF will not exceed unity during the period of extended operation. | ~~Completed~~ |

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

| TLAA | Description of Evaluation | ~~Implementation Schedule~~ |
|---|---|---|
| Containment liner plate and penetrations fatigue | The containment liner plates, liner weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows provide a leak tight barrier. A Section III Class 1 fatigue analysis limits the CUF to a value of less than unity for acceptable fatigue design. The component will be replaced and the CUF for the replacement will be shown to be less than unity during the period of extended operation. | ~~Program will be implemented by...~~ |

Note: All containment components need not meet the same requirement. It is likely that the liner plate and the bellows may be evaluated per 10CFR54.21(c)(1)(i), while high energy penetrations may be evaluated per 10CFR54.21(c)(1)(ii).

Open Item – These examples need to be revised to reflect the General Comments on the FSAR Supplement that have been provided separately.

## 4.~~8~~7 OTHER PLANT-SPECIFIC TIME LIMITED AGING ANALESES

Review Responsibilities

**Primary** - Branch responsible for engineering
**Secondary** – Other branches responsible for systems, as appropriate

### 4.~~8~~7.1 Areas of Review

There are certain ~~plant-specific~~ safety analyses which may have been based on an explicitly assumed 40-year plant life (for example, aspects of the reactor vessel design). Pursuant to 10 CFR 54.21(c), a license renewal applicant is required to evaluate time-limited aging analyses (TLAAs). The definition of TLAAs is provided in 10 CFR 54.3 and Section 4.1of this standard review plan.

~~TLAA requirements may have evolved and are plant-specific.~~ The adequacy of the plant's current licensing basis (CLB), which includes TLAAs, is not an area of review. Potential concerns or enhancements regarding the CLB are to be addressed under the backfit rule (10 CFR 50.109) and are separate from the license renewal process.

License renewal reviews focus on the period of extended operation. Pursuant to 10 CFR 54.30, if the reviews show that the TLAAs are not sufficient to provide reasonable assurance during the current license term that licensed activities will be conducted in accordance with the CLB, the licensee is required to take measures under its current license to ensure that the intended function of those structures or components will be maintained in accordance with the CLB throughout the term of the current license. The adequacy of the measures for the term of the current license is not an area of review for license renewal.

Pursuant to 10 CFR 54.21(c), an applicant must provide a listing of TLAAs and plant-specific exemptions that are based on TLAAs. The staff reviews the applicant's identification of TLAAs and exemptions that are based on TLAAs separately following the guidance in Section 4.1 of this standard review plan.

Based on lessons learned in the review of the initial license renewal applications, the staff has developed review procedures for the evaluation of certain TLAAs. If an applicant identifies these TLAAs as applicable to its plant, the staff reviews them separately following the guidance in Sections 4.2 through 4.~~7~~6 of this standard review plan. The staff reviews other TLAAs that are identified by the applicant following the generic guidance in this review plan section. The staff from branches responsible for systems may be requested to assist in the review, as appropriate.

The following areas relating to a TLAA are reviewed:

#### 4.~~8~~7.1.1 Time-Limited Aging Analysis

The evaluation of the TLAA for the period of extended operation is reviewed.

#### 4.~~8~~7.1.2 FSAR Supplement

The FSAR supplement summarizing the evaluation of the TLAA for the period of extended operation in accordance with 10 CFR 54.21(d) is reviewed.

### 4.~~8~~7.2 Acceptance Criteria

The acceptance criteria for the areas of review described in Subsection 4.8.1 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.~~8~~7.2.1 Time-Limited Aging Analysis

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

(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.

#### 4.~~8~~7.~~4~~.2.2 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 provides appropriate description such that later changes can be controlled by 10 CFR 50.59. The description should contain information associated with the TLAAs regarding the basis for determining that ~~aging effects are managed~~ the TLAAs have been dispositioned for ~~in~~ the period of extended operation.

### 4.~~8~~7.3 Review Procedures

The requirement of TLAAs captures, for renewal review, certain ~~plant-specific~~ aging analyses that are explicitly based on the duration of the current operating license of the plant. The concern is that these aging analyses do not ~~cover~~consider the period of extended operation. Unless these analyses are evaluated, there is no assurance that the systems, structures, and components addressed by these analyses can perform their intended function(s) during the period of extended operation.

For each area of review described in Subsection 4.8.1 of this review plan section, the following review procedures are followed:

#### 4.~~8~~7.3.1 Time-Limited Aging Analysis

For the TLAA identified, the review procedures depending on the applicant's choice, that is, 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

##### 4.~~8~~7.3.1.1 10 CFR 54.21(c)(1)(i)

Justification provided by the applicant is reviewed to verify that the existing analyses are valid for the period of extended operation. The existing analyses should be shown to be bounding even during the period of extended operation.

An applicant should describe the TLAA with respect to the objectives of the analysis, conditions, and assumptions used in the analysis, acceptance criteria, relevant aging effects, and intended function(s). The applicant should show that (1) the conditions and assumptions used in the analysis already address the relevant aging effects for the period of extended operation, and (2) acceptance criteria are maintained to provide reasonable assurance that the intended function(s) is maintained for renewal. Thus, no reanalysis is necessary for renewal.

In some instances the applicant may identify activities to be performed to verify the assumption basis of the calculation such as cycle counting. An evaluation of that activity should be provided by the applicant. The reviewer should assure that the applicant's activity is sufficient to confirm the calculation assumptions for the 60 year period.

If the TLAA has to be modified or recalculated to extend the period of evaluation to ~~cover~~consider the period of extended operation, the re-evaluation should be addressed under 10 CFR 54.21(c)(1)(ii).

**4.~~8~~7.3.1.2 10 CFR 54.21(c)(1)(ii)**

The documented results of the revised analyses are reviewed to verify that the period of evaluation of the analyses is extended such that they are valid for the period of extended operation, for example, 60 years. The applicable analysis technique can be the one that is in effect in the plant's CLB at the time of renewal application.

An applicant may recalculate the TLAA using a 60 year period to show that the TLAA acceptance criteria continue to be satisfied for the period of extended operation. The applicant may also revise the TLAA by recognizing and re-evaluating any overly conservative conditions and assumptions. Examples include relaxing overly conservative assumptions in the original analysis, using new or refined analytical techniques, and performing the analysis using a 60 year period. The applicant shall document the results of the reanalysis to show that it is satisfactory for the 60 year period. The analysis itself does not need to be reviewed.

As applicable, the plant's code of record should be used for the re-evaluation or the applicant may update to a later code edition pursuant to 10 CFR 50.55a. In the latter case, the reviewer verifies that the requirements in 10 CFR 50.55a are met.

In some cases the applicant may identify activities to be performed to verify the assumption basis of the calculation such as cycle counting. An evaluation of that activity should be provided by the applicant. The reviewer should assure that the applicant's activity is sufficient to confirm the calculation assumptions for the 60 year period.

**4.~~8~~7.3.1.3 10 CFR 54.21(c)(1)(iii)**

Under this option, an applicant would propose to manage the aging effects associated with the TLAA by an aging management program, in the same manner as the integrated plant assessment (IPA) in 10 CFR 54.21(a)(3). The reviewer reviews the applicant's aging management program to verify that the effects of aging on the intended function(s) will be adequately managed consistent with the CLB for the period of extended operation.

An applicant should identify the structures and components associated with the TLAA. The TLAA should be described with respect to the objectives of the analysis, conditions, and

assumptions used in the analysis, acceptance criteria, relevant aging effects and intended function(s). In cases where a mitigation or inspection program is proposed, ~~T~~the reviewer may use the guidance provided in Branch Technical Position RLSB-1 of this standard review plan to ensure that the effects of aging on the structure and component intended function(s) are adequately managed for the period of extended operation.

### 4.~~8~~7.3.2 FSAR Supplement

The reviewer verifies that the applicant has provided a FSAR supplement on the description of the evaluation of the TLAA. The summary description of the evaluation of TLAA for the period of extended operation in the FSAR supplement is reviewed to verify that it provides an appropriate description such that later changes can be controlled by 10 CFR 50.59. The description should contain information that the TLAAs have been dispositioned for the period of extended operation.~~associated with the TLAA regarding the basis for determining that aging effects are managed in the period of extended operation.~~ Sections 4.2 through 4.~~7~~6 of this standard review plan contain~~s~~ examples of acceptable FSAR supplement information for TLAA evaluation.

### 4.~~8~~7.4 Evaluation Findings

The reviewer verifies that sufficient and adequate information has been provided 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 evaluation concludes that the applicant has provided an acceptable demonstration, pursuant to 10 CFR 54.21(c)(1), that, for the (name of specific) TLAA, (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 this TLAA evaluation for the period of extended operation.

### 4.~~8~~7.5 Implementation

Except in those cases in which the applicant proposes an acceptable alternative method, the method described herein will be used by the staff in its evaluation of conformance with Commission regulation.

### 4.~~8~~7.6 References

None.

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## 4.1 IDENTIFICATION OF TIME-LIMITED AGING ANALYSES

**Review Responsibilities**

**Primary** - Branch responsible for materials and chemical engineering
**Secondary** - Other branches responsible for engineering, as appropriate

### 4.1.1 Areas of Review

This review plan section addresses the identification of time-limited aging analyses (TLAAs). There are certain safety analyses which may have been based on an explicitly assumed 40-year plant life (for example, aspects of the reactor vessel design). Pursuant to 10 CFR 54.21(c)(1), a license renewal applicant is required to provide a list of TLAAs, as defined in 10 CFR 54.3. The area relating to the identification of TLAAs is reviewed. The listing of TLAAs should provide sufficient detail to identify the type of calculations and the specific TLAA. A listing of specific calculation numbers is not required.

As indicated in 10 CFR 54.30, the adequacy of the plant's current licensing basis (CLB), which includes TLAAs, is not an area of review. Potential concerns or enhancements regarding the CLB is to be addressed under the backfit rule (10 CFR 50.109) and are separate from the license renewal process.

In addition, pursuant to 10 CFR 54.21(c)(2), an applicant must provide a list of plant-specific exemptions that are based on TLAAs. However, the initial license renewal applicants have found no such exemptions for their plants.

It is an applicant's option to include more analyses than those required by 10 CFR 54.21(c)(1). The staff should focus its review to confirm that the applicant did not omit any TLAAs, as defined in 10 CFR 54.3.

### 4.1.2 Acceptance Criteria

The acceptance criteria for the areas of review described in Subsection 4.1.1 of this review plan section define acceptable methods for meeting the requirements of the Commission's regulations in 10 CFR 54-21(c)(1). The staff should find no omission of TLAAs, as defined in 10 CFR 54.3, from the applicant's list.

Pursuant to 10 CFR 54.3, TLAAs are those licensee calculations and analyses that:

1. Involve systems, structures, and components within the scope of license renewal, as delineated in 10 CFR 54.4(a);

2. Consider the effects of aging;

3. Involve time-limited assumptions defined by the current operating term, for example, 40 years;

4. Were determined to be relevant by the licensee in making a safety determination;

5. Involve conclusions or provide the basis for conclusions related to the capability of the system, structure, and component to perform its intended functions, as delineated in 10 CFR 54.4(b); and

6. Are contained or incorporated by reference in the CLB.

### 4.1.3 Review Procedures

For each area of review described in Subsection 4.1.1 of this review plan section, the following review procedures are followed:

The reviewer verifies that the TLAAs not identified by the applicant don't meet at least one of the following criteria
(Ref. 1).

1. Involve systems, structures, and components within the scope of license renewal, as delineated in 10 CFR 54.4(a). Chapter 2 of this standard review plan provides staff review guidance on the scoping and screening methodology, plant level and various system level scoping results.

2. Consider the effects of aging. The effects of aging include, but are not limited to: loss of material, loss of toughness, loss of prestress, settlement, cracking, and loss of dielectric properties.

3. Involve time-limited assumptions defined by the current operating term, for example, 40 years. The defined operating term should be explicit in the analysis. Simply asserting that a component is designed for a service life or plant life is not sufficient. The assertion should be supported by a calculation or analysis that explicitly includes a time limit.

4. Were determined to be relevant by the licensee in making a safety determination. Relevancy is a determination that the applicant should make based on a review of the information available. A calculation or analysis is relevant if it can be shown to have direct bearing on the action taken as a result of the analysis performed. Analyses are also relevant if they provide the basis for a licensee's safety determination and, in the absence of the analyses, the licensee may have reached a different safety conclusion.

5. Show capability of the system, structure, and component to perform its intended functions, as delineated. Involve conclusions or provide the basis for conclusions related to the 10 CFR 54.4(b). Analyses that do not affect the intended functions of systems, structures, and components are not TLAAs.

6. Are contained or incorporated by reference in the CLB. Plant specific documents contained or incorporated by reference in the CLB include, but are not limited to: FSAR, NRC safety evaluation reports (SERs), Technical Specifications, the fire protection plan/hazards analyses, correspondence to and from the NRC, quality assurance (QA) plan, and topical reports included as reference to the FSAR or correspondence to the NRC. Calculations and analyses that are not in the CLB or not incorporated by reference are not TLAAs. When the code of record is mentioned in the FSAR, for particular groups of structures or components, reference material includes all calculations required by that code of record for those structures and components.

TLAAs that need to be addressed are not necessarily those analyses that have been previously reviewed or approved by the Commission. The following examples illustrate TLAAs that need to be addressed and were not previously reviewed and approved by the Commission:

- The FSAR states that the design complies with a certain national code and standard. A review of the code and standard reveals that a TLAA is required. The actual calculation was performed by the licensee to meet code and standard requirements, the specific calculation was not referenced in the FSAR, and the NRC had not reviewed the calculation.

- In response to a generic letter, a licensee submitted a letter to the NRC committing to perform a TLAA that would address the concern in the generic letter. The NRC had not documented a review of the licensee's response and had not reviewed the actual analysis.

The following examples illustrate analyses that are not TLAAs and need not be addressed under 10 CFR 54.21(c):

- Population projections (Section 2.1.3 of NUREG-0800) (Ref. 2).

- Cost-benefit analyses for plant modifications.

- Analysis with time-limited assumptions defined short of the current operating term of the plant, for example, an analysis for a component based on a service life that would not reach the end of the current operating term.

The number and type of TLAAs vary depending on the plant-specific CLB. All six criteria of TLAAs in 10 CFR 54.3 (and repeated in Subsection 4.1.2 of this review plan section) must be satisfied to conclude that a calculation or analysis is a TLAA. Table 4.1-1 provides examples of how these six criteria may be applied (Ref. 1).

The reviewer should use the plant Updated Final Safety Analysis Report (UFSAR) and other CLB documents, such as staff SERs, in performing the review. The reviewer should select analyses that the applicant did not identify as TLAAs that are likely to meet the six criteria identified above. Sections 4.2 through 4.6 identify typical types of TLAAs for most plants. Information on the licensee's methodology for identifying TLAAs may also be useful in identifying calculations that did not meet the six criteria.

Aging effects that may typically be a TLAA for most plants, may not be a TLAA for a specific plant. In these cases, the aging effect may simply be addressed as part of the aging management review. The plant-specific application should direct the reviewer from the TLAA section to the appropriate Chapter 3 section for the description and demonstration of how the aging effect is being or will be managed.

There are staff members from other branches of engineering reviewing the application in their assigned areas separate from the identification of TLAAs. However, they may come across situations where they may have a question on why the applicant did not identify certain analyses within their areas of review as TLAAs. Should this be the case, the reviewer should coordinate the question resolution with these other staff members and determine whether these analyses should be included as TLAAs.

Should an applicant identify a TLAA, which is also a basis for a plant-specific exemption granted pursuant to 10 CFR 50.12 and the exemption is in effect, the reviewer verifies that the applicant has also identified that exemption pursuant to 10 CFR 54.21(c)(2). However, the initial license renewal applicants have found no such exemptions for their plants.

The reviewer should find no omission by the applicant to make the staff finding that there is reasonable assurance that the applicant has identified the TLAAs for its plant.

### 4.1.4 Evaluation Findings

The reviewer verifies that sufficient and adequate information has been provided to satisfy the provisions of this review plan section and that the staff evaluation supports conclusions of the following type, to be included in the staffs safety evaluation report, as appropriate.

> The staff concludes that the applicant has provided a list of acceptable TLAAs as defined in 10 CFR 54.3 and that no 10 CFR 50.12 exemptions have been granted on the basis of a TLAA as defined in 10 CFR 54.3.

### 4.1.5 Implementation

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

### 4.1.6 References


1. NEI 95-10, Revision 1, "Industry Guideline for Implementing the Requirements of 10 CFR Part 54 – The License Renewal Rule," Nuclear Energy Institute, January 2000.

2. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports Nuclear Power Plants," July 1981.

**Table 4.1-1. Identification of Potential Time-Limited Aging Analyses and Basis for Disposition**

| Example | Disposition |
|---|---|
| NRC correspondence requests a utility to justify that unacceptable cumulative wear did not occur during the design life of control rods | Does not qualify as a TLAA because the design life of control rods is less than 40 years. Therefore, does not meet criterion (3) of the TLAA definition in 10 CFR 54.3. |
| Maximum wind speed of 100 mph is expected to occur once per 50 years. | Not a TLAA. Does not involve an aging effect. |
| Correspondence from the utility to the NRC states that the membrane on the containment basemat is certified by the vendor to last for 40 years. | This example does not meet criterion (4) of the TLAA definition in 10 CFR 54.3 and therefore is not considered a TLAA. The membrane was not credited in any safety evaluation. |
| Fatigue usage factor for the pressurizer surge line was determined not to be an issue for the current license period in response to NRC Bulletin 88-11. | This example is a TLAA because it meets all 6 criteria in the definition of TLAA in 10 CFR 54.3. The utility's fatigue design basis relies on assumptions related to 40 year operating life for this component. |
| Containment tendon lift-off forces are calculated for the 40-year life of the plant. This data is used during Technical Specification surveillance for comparing measured to predicted lift-off forces. | This example is a TLAA because it meets all 6 criteria of the TLAA definition in 10 CFR 54.3. The lift-off force curves are limited to 40-year values currently and are needed to perform a required Technical Specification surveillance. |

## 4.2 Reactor Vessel Neutron Embrittlement

**Review Responsibilities**

**Primary**- Branch responsible for materials and chemical engineering
**Secondary** - Branch responsible for reactor systems

### 4.2.1 Areas of Review

The fracture toughness of ferritic steel in the reactor vessel beltline region of light-water nuclear power reactors is reduced during plant service by neutron irradiation. Areas of review to ensure that the reactor vessel has adequate fracture toughness to prevent brittle failure during normal and off-normal operating conditions are (1) upper-shelf energy, (2) pressurized thermal shock (PTS) for pressurized water reactors (PWRs), (3) heat-up and cool-down (pressure-temperature limits) curves, and (4) boiling water reactor (BWR) Vessel and Internals Project (VIP) VIP-05 analysis for elimination of circumferential weld inspection.

The adequacy of the upper-shelf energy analyses for light-water reactors, the PTS analyses for pressurized water reactors (PWRs), and the heat-up and cool-down (pressure-temperature limits) curves are reviewed for the period of extended operation.

The branch responsible for reactor systems should review neutron fluence and dosimetry information in the application.

### 4.2.2 Acceptance Criteria

The acceptance criteria for the areas of review described in Subsection 4.2.1 of this review plan section define acceptable methods for meeting the requirements of the Commission's regulations in 10 CFR 54.21(c)(1).

#### 4.2.2.1 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 reactor vessel neutron embrittlement depending on the applicant's choice, i.e., 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

##### 4.2.2.1.1 Upper-Shelf Energy

Paragraph IV.A.1 in Appendix G (Ref. 1) to 10 CFR Part 50 requires that the reactor vessel beltline materials must have a Charpy upper-shelf energy of no less than 68 J (50 ft-lb) throughout the life of the reactor vessel unless otherwise approved by the NRC.

#### 4.2.2.1.1.1 10 CFR 54.21 (c)(1)(i)

The existing upper-shelf energy analysis remains valid during the period of extended operation because the neutron fluence projected to the end of the period of extended operation is bounded by the fluence assumed in the existing analysis.

#### 4.2.2.1.1.2 10 CFR 54.21(c)(1)(ii)

The upper-shelf energy is re-evaluated to consider the period of extended operation in accordance with Appendix G to 10 CFR Part 50.

#### 4.2.2.1.1.3 10 CFR 54.21(c)(1)(iii)

Acceptance criteria under 10 CFR 54.21(c)(1)(iii) have yet to be developed and will be evaluated on a case-by-case basis to ensure that the aging effects will be managed such that the intended function(s) will be maintained during the period of extended operation.

### 4.2.2.1.2 Pressurized Thermal Shock (for PWRs)

For PWRs, 10 CFR 50.61 (Ref. 4) requires the "reference temperature $RT_{PTS}$" for reactor vessel beltline materials to be less than the "PTS screening criteria" at the expiration date of the operating license unless otherwise approved by NRC. The "PTS screening criteria" are 132°C (270°F) for plates, forgings, and axial weld materials, or 149°C(300°F) for circumferential weld materials. The regulations require updating of the pressurized thermal shock assessment upon a request for a change in the expiration date of a facility's operating license. Therefore, the $RT_{PTS}$ value must be calculated for the effective full power years (EFPY) corresponding to the renewal period.

#### 4.2.2.1.2.1 10 CFR 54.21(c)(1)(i)

The existing PTS analysis remains valid during the period of extended operation because the neutron fluence projected to the end of the period of extended operation is bounded by the fluence assumed in the existing analysis.

#### 4.2.2.1.2.2 10 CFR 54.21(c)(1)(ii)

The PTS analysis is reevaluated to consider the period of extended operation in accordance with 10 CFR 50.61. An analysis is performed in accordance with Regulatory Guide 1.154 (Ref. 5) if the "PTS screening criteria' in 10 CFR 50.61 are exceeded during the period of extended operation.

#### 4.2.2.1.2.3 10 CFR 54.21(c)(1)(iii)

Acceptance criteria under 10 CFR 54.21(c)(1)(iii) have yet to be developed and will be evaluated on a case-by-case basis to ensure that the aging effects will be managed such that the intended function(s) will be maintained during the period of extended operation.

### 4.2.2.1.3 Pressure-temperature (P-T) limits

10 CFR Part 50, Appendix G (Ref. 1) requires that heatup and cooldown of the reactor pressure vessel be accomplished within established pressure-temperature (P-T) limits. These limits

specify the maximum allowable pressure as a function of reactor coolant temperature. As the reactor pressure vessel becomes embrittled and its fracture toughness is reduced, the allowable pressure is reduced

**4.2.2.1.3.1 10 CFR 54.21 (c)(1)(i)**

The existing P-T limits are valid during the period of extended operation because the neutron fluence projected to the end of the period of extended operation is bounded by the fluence assumed in the existing analysis.

**4.2.2.1.3.2 10 CFR 54.21(c)(1)(ii)**

The P-T limits are re-evaluated to consider the period of extended operation in accordance with Appendix G to 10 CFR Part 50 (Ref. 1).

**4.2.2.1.3.3 10 CFR 54.21(c)(1)(iii)**

Not applicable. Updated P-T limits for the period of extended operation must be available prior to entering the period of extended operation. (It is not necessary to implement P-T limits to carry the RV through 60 years at the time of application. The updated limits must merely be available prior to the period of extended operation

**4.2.2.1.4 Elimination of Circumferential Weld Inspection (for BWRs)**

Some BWRs have an approved technical alternative eliminating the reactor vessel circumferential shell weld inspections for the current license term because they satisfy the limiting conditional failure probability for the circumferential welds at the expiration of the current license based on BWRVIP 05 and the extent of neutron embrittlement (Refs. 6-8). An applicant for such a BWR may provide justification to extend this relief into the period of extended operation. The staff is currently reviewing BWRVIP-74, which addresses license renewal (Ref. 9). If approved by the staff, BWRVIP-74 may provide the basis for granting such relief.

**4.2.2.2 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 TLAAs have been dispositioned for the period of extended operation.

**4.2.3 Review Procedures**

For each area of review described in Subsection 4.2.1 of this review plan section, the following review procedures are followed:

**4.2.3.1 Time-Limited Aging Analysis**

For reactor vessel neutron embrittlement, the review procedures, depending on the applicant's choice, i.e., 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

#### 4.2.3.1.1 Upper-Shelf Energy

##### 4.2.3.1.1.1 10 CFR 54.21(c)(1)(i)

The projected neutron fluence at the end of the period of extended operation is reviewed to verify that it is bounded by the fluence assumed in the existing upper-shelf energy analysis.

##### 4.2.3.1.1.2 10 CFR 54.21(c)(1)(ii)

The documented results of the revised upper-shelf energy analysis based on the projected neutron fluence at the end of the period of extended operation is reviewed for compliance with Appendix G to 10 CFR Part 50. An applicant may use Regulatory Guide 1.99, Rev. 2 (Ref. 10), to project upper-shelf energy to the end of the period of extended operation. An applicant may also use Appendix K of Section XI of the ASME Code (Ref. 11) for evaluating upper-shelf energy. The staff should review the applicant's methodology for this evaluation.

##### 4.2.3.1.1.3 10 CFR 54.21(c)(1)(iii)

The applicant's proposal to demonstrate that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation will be reviewed on a case-by-case basis.

#### 4.2.3.1.2 Pressurized Thermal Shock (for PWRs)

##### 4.2.3.1.2.1 10 CFR 54.21(c)(1)(i)

The documented results of the projected neutron fluence at the end of the period of extended operation is reviewed to verify that it is bounded by the fluence assumed in the existing PTS analysis.

##### 4.2.3.1.2.2 10 CFR 54.21(c)(1)(ii)

The documented results of the revised PTS analysis based on the projected neutron fluence at the end of the period of extended operation is reviewed for compliance with 10 CFR 50.61. There are two methodologies from 10 CFR 50.61 that can be used in the PTS analysis based on the projected neutron fluence at the end of the period of extended operation. $RT_{NDT}$ is the reference temperature (subscript NDT means nil-ductility temperature) used as an indexing parameter to determine the fracture toughness and the amount of embrittlement of a material. $RT_{PTS}$ is the reference temperature used in the PTS analysis and is related to $RT_{NDT}$ at the end of life.

The first methodology does not rely on plant-specific surveillance data to calculate delta $RT_{NDT}$ (i.e., the mean value of the adjustment or shift in reference temperature caused by irradiation). The delta $RT_{NDT}$ is determined by multiplying a chemistry factor from the tables in 10 CFR 50.61 by a fluence factor calculated from the neutron flux using an equation.

The second methodology relies on plant-specific surveillance data to determine the delta $RT_{NDT}$. In this methodology, two or more sets of surveillance data are needed. Surveillance data consists of a measured delta $RT_{NDT}$ for a corresponding neutron fluence. 10 CFR 50.61 specifies a procedure and a criterion for determining whether the surveillance data are credible,

e.g., the difference in the predicted value and the measured value for delta $RT_{NDT}$ must be less than 28°F for weld metal for the surveillance data to be defined as credible. When a credible surveillance data set exists, the chemistry factor determined from the surveillance data can be used in lieu of the values in the table in 10 CFR 50.61 and the standard deviation of the increase in the $RT_{NDT}$ can be reduced from 28°F to 14°F for welds.

If the "PTS screening criteria" in 10 CFR 50.61 are exceeded during the period of extended operation, an analysis based on Regulatory Guide 1.154 is reviewed.

#### 4.2.3.1.2.3 10 CFR 54.21(c)(1)(iii)

The applicant's proposal to demonstrate that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation will be reviewed on a case-by-case basis. If the projected reference temperature exceeds the screening criterion established in 10 CFR 50.61, the licensee is required to implement such flux reduction programs as are reasonably practicable to avoid exceeding the screening criterion. The schedule for implementation of such programs may take into account the schedule and anticipated approval by the Director, NRR, of detailed plant-specific analyses to demonstrate acceptable risk with $RT_{PTS}$ above the screening limit. If the licensee cannot avoid exceeding the screening criteria by using a flux reduction program, it must submit a safety analysis to determine what actions are necessary to prevent potential failure of the reactor vessel. 10 CFR 50.61 also permits the licensee to perform a thermal annealing treatment to recover fracture toughness, subject to the requirements of 10 CFR 50.66.

### 4.2.3.1.3 Pressure-temperature (P-T) limits

#### 4.2.3.1.3.1 10 CFR 54.21(c)(1)(i)

The documented results of the projected neutron fluence at the end of the period of extended operation is reviewed to verify that it is bounded by the embrittlement assumed in the existing P-T limit analysis.

#### 4.2.3.1.3.2 10 CFR 54.21(c)(1)(ii)

The documented results of the revised P-T limit analysis based on the projected reduction in fracture toughness at the end of the period of extended operation is reviewed for compliance with 10 CFR Part 50, Appendix G.

#### 4.2.3.1.3.3 10 CFR 54.21(c)(1)(iii)

Not applicable.

### 4.2.3.1.4 Elimination of Circumferential Weld Inspection (for BWRs)

When available, an applicant may reference the approved BWRVIP-74 as its basis for requesting the continuation of the relief to the end of the period of extended operation. The staff should review to ensure that the applicant's plant is bounded by the BWRVIP-74 analysis and that the applicant has committed to actions that are the basis for the staff approval of BWRVIP 74.

#### 4.2.3.2 FSAR Supplement

The reviewer verifies that the applicant has provided a FSAR supplement on the summary description of the evaluation of the reactor vessel neutron embrittlement TLAA. Table 4.2-1 of this review plan section 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 4.2-1.

### 4.2.4 Evaluation Findings

The reviewer verifies that sufficient and adequate information has been provided 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 evaluation concludes that the applicant has provided an acceptable demonstration, pursuant to 10 CFR 54.21(c)(1), that, for the reactor vessel neutron embrittlement TLAA, (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 reactor vessel neutron embrittlement TLAA evaluation for the period of extended operation.

### 4.2.5 IMPLEMENTATION

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

### 4.2.6 References


1. 10 CFR Part 50 Appendix G, "Fracture Toughness Requirements."

2. 10 CFR 50.61, "Fracture Toughness Requirements for Protection Against Pressurized Thermal Shock Events."

3. Regulatory Guide 1.154, "Format and Content of Plant-Specific Pressurized Thermal Shock Safety Analysis Reports for Pressurized Water Reactors," January 1987.

4. BWRVIP-05, "BWR Vessel and Internals Project, BWR Reactor Pressure Vessel Shell Weld Inspection Recommendations (BWRVIP-05)," Boiling Water Reactor Owners Group, September 28, 1995.

5. Letter to Carl Terry of Niagara Mohawk Power Company, from Gus C. Lainas of NRC, dated July 28, 1998.

6. Generic Letter 98-05, "Boiling Water Reactor Licensees Use of the BWRVIP-05 Report to Request Relief from Augmented Examination Requirements on Reactor Pressure Vessel Circumferential Shell Welds," Nuclear Regulatory Commission, November 10, 1998.

7. BWRVIP-74, "BWR Reactor Pressure Vessel Inspection and Flaw Evaluation Guidelines," Boiling Water Reactor Owners Group.

8. Regulatory Guide 1.99 Rev. 2, "Radiation Embrittlement of Reactor Vessel Materials," May, 1988.

9. Appendix K of ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components."

**Table 4.2-1. Examples of FSAR Supplement for Reactor Vessel Neutron Embrittlement TLAA Evaluation**

| TLAA | Description of Evaluation | |
|---|---|---|
| Upper-shelf energy | Paragraph IV.A.1 in Appendix G to 10 CFR Part 50 requires that the reactor vessel beltline materials must have Charpy upper-shelf energy of no less than 50 ft-lb throughout the life of the reactor vessel unless otherwise approved by the NRC. The upper-shelf energy has been determined to exceed 50 ft-lb to the end of the period of extended operation. | |
| | | |
| Pressurized thermal shock (for PWRs) | For PWRs, 10 CFR 50.61 requires the "reference temperature $RT_{PTS}$" for reactor vessel beltline materials be less that the "PTS screening criteria" at the expiration date of the operating license unless otherwise approved by the NRC. The "PTS screening criteria" are 270 $^0$F for plates, forgings, and axial weld materials, or 300 $^0$F for circumferential weld materials. The "reference temperature" has been determined to be less than the "PTS screening criteria" at the end of the period of extended operation. | |
| Pressure-temperature (P-T) limits | Appendix G to 10 CFR Part 50 requires that heatup and cooldown of the reactor pressure vessel be accomplished within established P-T limits. These limits specify the maximum allowable pressure as a function of reactor coolant temperature. As the reactor pressure vessel becomes embrittled and its fracture toughness is reduced, the allowable pressure is reduced. Appendix G to 10 CFR Part 50 requires periodic update of P-T limits based on projected embrittlement and data from material surveillance program. The P-T limits will be updated to consider the period of extended operation. | |
| Elimination of circum-ferential weld inspection (for BWRs) | NRC has granted relief from the reactor vessel circumferential shell weld inspections, because the plant has been demonstrated to meet BWRVIP-74 as approved by the NRC. | |

## 4.3 METAL FATIGUE

**Review Responsibilities**

**Primary**- Branch responsible for mechanical engineering
**Secondary**- None

### 4.3.I AREAS OF REVIEW

A metal component subjected to cyclic loading at loads less than the static design load may fail because of fatigue. Metal fatigue of these components may have been evaluated based on an assumed number of transients or cycles for the current operating term. The validity of such metal fatigue analysis is reviewed for the period of extended operation. The metal fatigue analysis review includes, as appropriate, a review of inservice flaw growth analyses, reactor vessel underclad cracking analyses, reactor vessel internals fatigue analyses, postulated high energy line break locations and leak-before-break.

The adequacy of the fatigue analyses of the containment liner plates (including welded joints), penetration sleeves, dissimilar metal welds, and penetration bellows is reviewed separately following the guidance in Section 4.6, "Containment Liner Plate and Penetrations Fatigue Analysis" of this standard review plan.

For some plants, fatigue may not be addressed by a TLAA. In these cases, the applicant will address fatigue issues in Chapter 3.

#### 4.3.1.1 Time-Limited Aging Analysis

Metal components may be designed or analyzed based on guidance in the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code or the American National Standards Institute (ANSI) requirements. These codes contain explicit metal fatigue or cyclic considerations based on time-limited aging analyses.

##### 4.3.1.1.1 ASME Section III, Class 1

ASME Class 1 components, which include core support structures, are analyzed for metal fatigue. ASME Section III (Ref. 1) requires a fatigue analysis for Class 1 components considering all transient loads based on the anticipated number of transients. A Section III Class 1 fatigue analysis requires the calculation of the "cumulative usage factor" (CUF) based on the fatigue properties of the materials and the expected fatigue service of the component. The ASME Code limits the CUF to a value of less than unity for acceptable fatigue design. The fatigue resistance of these components during the period of extended operation is an area of review.

##### 4.3.1.1.2 ANSI B31.1

ANSI B31.1 (Ref. 2) does not require an explicit fatigue analysis. It specifies allowable stress levels based on the number of anticipated thermal cycles. ANSI B31.1 applies only to piping. The specific allowable stress reductions due to thermal cycles are listed in Table 4.3-1. For example, the allowable stress would be reduced by a factor of 1.0, that is, no reduction, for piping that is not expected to experience more than 7,000 thermal cycles during plant service

but would be reduced to half of the maximum allowable static stress for 100,000 or more thermal cycles. The fatigue resistance of these components during the period of extended operation is an area of review.

#### 4.3.1.1.3 Other Evaluations Based on CUF

The codes also contain metal fatigue analysis requirements based on a CUF calculation [the 1969 edition of ANSI B31.7 (Ref. 3) for Class 1 piping, For these components, the discussion relating to ASME Section III, Class 1 in Subsection 4.3.1.1.1 of this review plan section applies.

#### 4.3.1.1.4 ASME Section III, Class 2 and 3

ASME Section III, Class 2 and 3 piping cyclic design requirements are similar to those for ANSI B31.1. The discussion relating to B31.1 in Subsection 4.3.1.1.2 of this review plan section applies.

### 4.3.1.2 Generic Safety Issue

The fatigue design criteria for nuclear power plant components has changed as the industry consensus codes and standards have evolved. The fatigue design criteria for a specific component depend on the version of the design code that applied to that component, that is, the code of record. There is a concern that the effects of the reactor coolant environment on the fatigue life of component was not adequately addressed by the code of record.

The Commission has decided that the adequacy of the code of record relating to metal fatigue is a potential safety issue to be addressed by the current regulatory process for operating reactors (Refs. 4 and 5). The effects of fatigue for the initial 40-year reactor license period were studied and resolved under Generic Safety Issue (GSI)-78, "Monitoring of Fatigue Transient Limits for Reactor Coolant System," and GSI-166, "Adequacy of Fatigue Life of Metal Components" (Ref. 6). GSI-78 addressed whether fatigue monitoring was necessary at operating plants. As part of the resolution of GSI-166, an assessment was made of the significance of the more recent fatigue test data on the fatigue life of a sample of components in plants were Code fatigue design analysis had been performed. The efforts on fatigue life estimation and ongoing issues under GSI-78 and GSI-166 for 40-year plant life were addressed separately under a staff generic task action plan (Refs. 7 and 8). The staff documented its completion of the fatigue action plan in SECY-95-245 (Ref. 9).

SECY-95-245 was based on a study described in NUREG/CR-6260, "Application of NUREG/CR-5999 Interim Fatigue Curves to Selected Nuclear Power Plant Components" (Ref. 10). In NUREG/CR-6260, sample locations in the plant with high fatigue usage were evaluated. Conservatisms in the original fatigue calculations, such as actual cycles versus assumed cycles, were removed and the fatigue usage was recalculated using a fatigue curve considering the effects of the environment. The staff found that most of the locations would have a CUF of less than the ASME Code limit of 1.0 for 40 years. On the basis of the component assessments, supplemented by a 40-year risk study, the staff concluded that a backfit of the environmental fatigue data to operating plants could not be justified. However, because the staff was less certain that sufficient excessive conservatisms in the original fatigue calculations could be removed to account for an additional 20 years of operation for renewal, the staff recommended in SECY-95-245 that the samples in NUREG/CR-6260 should be evaluated considering environmental effects for license renewal. GSI-190, "Fatigue Evaluation of Metal Components for 60-year Plant Life," was established to address the residual concerns of GSI-78 and GSI-166

regarding the environmental effects on fatigue on pressure boundary components for 60-years of plant operation.

The scope of GSI-190 included design basis fatigue transients, studying the probability of fatigue failure and its effect on core damage frequency (CDF) of selected metal components for 60-year plant life. The study showed that some components have cumulative probabilities of crack initiation and through-wall growth that approach unity within the 40- and 60-year period. The maximum failure rate (through-wall cracks per year) was in the range of $10^{-2}$ per year, and those failures were generally associated with high cumulative usage factor locations and components with thinner walls, i.e., pipes more vulnerable to through-wall cracks. In most cases, the leakage from these through-wall cracks is small and not likely to lead to core damage. Based on the results of probabilistic analyses, along with the sensitivity studies performed, the interactions with the industry (NEI and EPRI), and different approaches available to the licensees to manage the effects of aging, it was concluded that no generic regulatory action is required, and that GSI-190 is resolved (Ref. 11). However, the calculations supporting resolution of this issue, which included consideration of environmental effects, and the nature of age-related degradation indicate the potential for an increase in the frequency of pipe leaks as plants continue to operate. Thus, the staff concluded that licensees must address the effects of coolant environment on component fatigue life as aging management programs are formulated in support of license renewal.

One method acceptable to the staff of satisfying this recommendation is to assess the impact of the reactor coolant environment on a sample of critical components. These critical components should include, as a minimum, those components selected in NUREG/CR–6260 (Ref. 10). 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 for carbon and low–alloy steels are contained in NUREG/CR–6583 (Ref. 12) and those for austenitic stainless steels are contained in NUREG/CR–5704 (Ref. 13).

An applicant may also chose to address the effects of coolant environment on component fatigue life by an aging management program.

An applicant's consideration of the effects of coolant environment on component fatigue life for license renewal is an area of review.

#### 4.3.1.3 FSAR Supplement

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.

### 4.3.2 ACCEPTANCE CRITERIA

The acceptance criteria for the areas of review described in Subsection 4.3.1 of this review plan section define acceptable methods for meeting the requirements of the Commission's regulations in 10 CFR 54.21(c)(1).

#### 4.3.2.1 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 metal fatigue are:

#### 4.3.2.1.1 ASME Section III, Class 1

For components designed or analyzed to ASME Class 1 requirements, the acceptance criteria, depending on the applicant's choice, that is, 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

##### 4.3.2.1.1.1 10 CFR 54.21(c)(1)(i)

The existing CUF calculations remain valid because the number of assumed transients will not be exceeded during the period of extended operation. The effects of coolant environment on component fatigue life (GSI-190) are included within the existing CUF calculations.

##### 4.3.2.1.1.2 10 CFR 54.21(c)(1)(ii)

The CUF calculations have been re-evaluated based on an increased number of assumed transients to bound the period of extended operation. The resulting CUF remains less than unity as required by the code during the period of extended operation. The effects of coolant environment on component fatigue life (GSI-190) are included within the re-evaluated CUF calculations.

##### 4.3.2.1.1.3 10 CFR 54.21(c)(1)(iii)

The effects of aging on the intended function(s) will be adequately managed for the period of extended operation. The component could be replaced and the CUF for the replacement will be less than unity during the period of extended operation. The effects of coolant environment on component fatigue life (GSI-190) are included within the proposed aging management program.

Alternative aging management program provided by the applicant will be evaluated on a case-by-case basis to ensure that the aging effects will be managed such that the intended functions(s) will be maintained during the period of extended operation.

#### 4.3.2.1.2 ANSI B31.1

For piping designed or analyzed to B31.1 requirements, the acceptance criteria, depending on the applicant's choice, that is, 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

##### 4.3.2.1.2.1 10 CFR 54.21(c)(1)(i)

The existing allowable stresses remain valid because the number of assumed thermal cycles would not be exceeded during the period of extended operation.

#### 4.3.2.1.2.2 10 CFR 54.21(c)(1)(ii)

The allowable stresses have been re-evaluated based on an increased number of assumed thermal cycles and Table 4.3-1 to bound the period of extended operation. The resulting allowable stresses remain sufficient as required by the code during the period of extended operation.

#### 4.3.2.1.2.3 10 CFR 54.21(c)(1)(iii)

The effects of aging on the intended function(s) will be adequately managed for the period of extended operation. The component could be replaced and the allowable stresses for the replacement will be sufficient as required by the code during the period of extended operation.

Alternative acceptance criteria under 10 CFR 54.21(c)(1)(iii) have yet to be developed and will be evaluated on a case-by-case basis to ensure that the aging effects will be managed such that the intended functions(s) will be maintained during the period of extended operation.

#### 4.3.2.1.3 Other Evaluations Based on CUF

The acceptance criteria in Subsection 4.3.2.1.1 of this review plan section apply.

#### 4.3.2.1.4 ASME Section III, Class 2 and 3

The acceptance criteria in Subsection 4.3.2.1.2 of this review plan section apply.

### 4.3.2.2 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 TLAA has been properly dispositioned for the period of extended operation.

## 4.3.3 REVIEW PROCEDURES

For each area of review described in Subsection 4.3.1 of this review plan section, the following review procedures are followed:

### 4.3.3.1 Time-Limited Aging Analysis

#### 4.3.3.1.1 ASME Section III, Class 1

For components designed or analyzed to ASME Class 1 requirements, the review procedures, depending on the applicant's choice, that is, 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

#### 4.3.3.1.1.1 10 CFR 54.21(c)(1)(i)

The number of assumed transients used in the existing CUF calculations for the current operating term is compared to an evaluation of the number of operating transients experienced to date as extrapolated to 60 years of operation. The comparison confirms that the number of transients in the existing analyses will not be exceeded during the period of extended operation.

The reviewer verifies that the effects of coolant environment on component fatigue life (GSI-190) are included within the existing CUF calculations.

#### 4.3.3.1.1.2 10 CFR 54.21(c)(1)(ii)

A list of the increased number of assumed transients projected to the end of the period of extended operation and operating transient experience is reviewed to ensure that the transient projection is adequate. The revised CUF calculations based on the projected number of assumed transients are reviewed to ensure that the CUF remains less than unity at the end of the period of extended operation.

The code of record should be used for the re-evaluation, or the applicant may update to a later code edition pursuant to 10 CFR 50.55a. In the latter case, the reviewer verifies that the requirements in 10 CFR 50.55a are met.

The reviewer verifies that the effects of coolant environment on component fatigue life (GSI-190) are included within the revised CUF calculations.

#### 4.3.3.1.1.3 10 CFR 54.21(c)(1)(iii)

The applicant's proposed program to ensure that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation is reviewed. The proposed program should include corrective actions such as component reanalysis, transient re-classification, more sophisticated monitoring, repair or replacement.
The reviewer verifies that the effects of coolant environment on component fatigue life (GSI-190) are being addressed within the applicant's proposed aging management program.

Other applicant proposed programs will be reviewed on a case-by-case basis.

#### 4.3.3.1.2 ANSI B31.1

For piping designed or analyzed to ANSI B31.1 requirements, the review procedures, depending on the applicant's choice, that is, 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

#### 4.3.3.1.2.1 10 CFR 54.21(c)(1)(i)

The documented results of the assumed thermal cycles used in the existing allowable stress determination and operating cyclic experience is reviewed to ensure that the number of assumed thermal cycles would not be exceeded during the period of extended operation.

#### 4.3.3.1.2.2 10 CFR 54.21(c)(1)(ii)

The documented results of the increased number of assumed thermal cycles projected to the end of the period of extended operation and operating cyclic experience is reviewed to ensure that the thermal cycle projection is adequate. The revised allowable stresses based on the

projected number of assumed thermal cycles and Table 4.3-1 are reviewed to ensure that they remain sufficient as required by the code during the period of extended operation.

The code of record should be used for the re-evaluation or the applicant may update to a later code edition pursuant to 10 CFR 50.55a. In the latter case, the reviewer verifies that the requirements in 10 CFR 50.55a are met.

#### 4.3.3.1.2.3 10 CFR 54.21(c)(1)(iii)

The applicant's proposed program to ensure that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation is reviewed. If the applicant proposed component replacement before it exceeds the assumed thermal cycles, the reviewer verifies that the allowable stresses for the replacement will remain sufficient as required by the code during the period of extended operation. Other applicant-proposed programs will be reviewed on a case-by-case basis.

#### 4.3.3.1.3 Other Evaluations Based on CUF

The review procedures in Subsection 4.3.3.1.1 of this review plan section apply.

#### 4.3.3.1.4 ASME Section III, Class 2 and 3

The review procedures in Subsection 4.3.3.1.2 of this review plan section apply.

### 4.3.3.2 FSAR Supplement

The reviewer verifies that the applicant has provided a FSAR supplement on the summary description of the evaluation of the metal fatigue TLAA. Table 4.3-2 of this review plan section 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 4.3-2.

## 4.3.4 EVALUATION FINDINGS

The reviewer verifies that sufficient and adequate information has been provided 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 evaluation concludes that the applicant has provided an acceptable demonstration, pursuant to 10 CFR 54.21(c)(1), that, for the metal fatigue TLAA, (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 metal fatigue TLAA evaluation for the period of extended operation.

## 4.3.5 IMPLEMENTATION

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

### 4.3.6 REFERENCES


1. ASME Boiler and Pressure Vessel Code, Section III, "Rules for Construction of Nuclear Power Plant Components," American Society of Mechanical Engineers.

2. ANSI/ASME B31.1, "Power Piping," American National Standards Institute.

3. ANSI/ASME B31.7-1969, "Nuclear Power Piping," American National Standards Institute.

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

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

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

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

8. SECY-94-191, "Fatigue Design of Metal Components," July 26, 1994.

9. SECY-95-245, "Completion of The Fatigue Action Plan," September 25, 1995.

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

11. Letter from Ashok C. Thadani of the Office of Nuclear Regulatory Research to William D. Travers, Executive Director of Operations, dated December 26, 1999.

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

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

**Table 4.3-1. Stress Range Reduction Factors**

| Number of Equivalent Full Temperature Cycles | Stress Range Reduction Factor |
|---|---|
| 7,000 and less | 1.0 |
| 7,000 to 14,000 | 0.9 |
| 14,000 to 22,000 | 0.8 |
| 22,000 to 45,000 | 0.7 |
| 45,000 to 100,000 | 0.6 |
| 100,000 and over | 0.5 |

**Table 4.3-2. Examples of FSAR Supplement for Metal Fatigue TLAA Evaluation**

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

| TLAA | Description of Evaluation | |
|---|---|---|
| Metal Fatigue | The existing CUF evaluation has been determined to remain valid because the number of assumed cyclic loads would not be exceeded during the period of extended operation.<br><br>The effects of coolant environment on reactor coolant system component fatigue life (GSI-190) are included within the existing calculations. | |

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

| TLAA | Description of Evaluation | |
|---|---|---|
| Metal Fatigue | The CUF calculations have been re-evaluated based on an increased number of assumed cyclic loads to include the period of extended operation and the revised CUF will not exceed unity during the period of extended operation.<br><br>The effects of coolant environment on reactor coolant system component fatigue life (GSI-190) are included within the revised calculations. | |

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

| TLAA | Description of Evaluation | |
|---|---|---|
| Metal Fatigu | In order not to exceed the design limit on fatigue usage and the number of design cycles, the aging management program monitors and tracks the number of critical thermal and pressure test transients, and monitors the cycles for the selected reactor coolant system components.<br><br>The effects of coolant environment on reactor coolant system component fatigue life (GSI-190) are addressed by the aging management program. | |

Open Item – These examples need to be revised to reflect the General Comments on the FSAR Supplement that have been provided separately.

## 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 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 (i.e., 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 § 50.49 for certain electrical components important-to-safety. § 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. § 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. § 50.49(e) also requires component replacement or refurbishment prior to the end of designated life unless additional life is established through ongoing qualification. § 50.49(f) establishes four methods of demonstrating qualification for aging and accident conditions. §§ 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*; June 1979, NUREG-0588, *Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment;* July 1981 and Regulatory Guide 1.89, Rev. 1, *Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants*, June 1984. Compliance with § 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 § 50.49(f) qualification methods. As required by § 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.

#### 4.4.1.2 Generic Safety Issue

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. Specific issues being addressed in this research are presented in NUREG/CR-6384.

Once this generic issue is resolved, guidance will be provided as to the impact on license renewal. In the interim, NRC letter dated June 2, 1998, "*Guidance on Addressing GSI-168 for License Renewal,*" (C. Grimes, NRC to D. Walters, NEI) provides guidance on addressing GSI-168 in license renewal applications. It states that until the generic issue is resolved, "*...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.*"

#### 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 (depending 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)

For option (i), the aging evaluation existing at the time of the renewal application qualifies the component through the period of extended operation and no further evaluation is necessary.

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

For option (ii), a reanalysis of the aging evaluation is performed in order to extend the qualification of the component through the period of extended operation. 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**, Table 4.4-2.

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

Option (iii) is used in cases (a) where the aging evaluation does not extend the qualification into or extends the qualification into but not through, the period of extended operation or (b) where aging management actions such as periodic maintenance, inspection, testing or parts replacement are required to maintain the qualification through the period of extended operation. In light of this option, EQ programs, which implement the requirements of § 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. The evaluation and technical basis for EQ programs as acceptable aging management programs is provided in the **EQ Program Evaluation and Technical Basis**, Table 4.4-1. 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**, Table 4.4-2.

### 4.4.2.2 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 TLAA has been properly dispositioned for the period of extended operation..

## 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 bounds the period of extended operation.

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

The results of extending the qualification for the period of extended operation will be reviewed. The qualification methods include testing, analysis, operating experience or combinations thereof. For reanalysis, the reviewer verifies that an applicant has addressed 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.

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

The applicant's EQ process will be reviewed to ensure that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation because the equipment will be replaced prior to reaching the end of its qualified life. Replacement equipment must be qualified in accordance with the provisions of 10 CFR 50.49. For reanalysis, the reviewer verifies that an applicant has addressed 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.

The applicant may state that the environmental qualification program described in Table 4.4-1 is applicable to its plant. The reviewer verifies that the applicant has identified the environmental qualification program in its application. No further staff evaluation is necessary.

### 4.4.3.2 FSAR Supplement

The reviewer verifies that the applicant has provided a FSAR supplement on the summary description of the evaluation of EQ Electric Equipment TLAA. Table 4.4-3 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 4.4-3.

## 4.4.4 Evaluation of Findings

The reviewer verifies that sufficient and adequate information has been provided 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 evaluation concludes that the applicant has provided an acceptable demonstration, pursuant to 10 CFR 54.2 (c)(1), that, for the EQ of Electric Equipment, (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. 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 (EQ) Program 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:*** § 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 (e.g., 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:*** § 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:*** § 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:*** § 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. § 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 § 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 § 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 § 50.49 provides evidence that the component will perform its intended functions during accident conditions after experiencing the effects of in-service aging.

**Table 4.4-2 Environmental Qualification Reanalysis Attributes**

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 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 (i.e., 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 (i.e., 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 conservatisms in the component service conditions (e.g., 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 & Corrective Actions:*** The reanalysis of an aging evaluation shall 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 (i.e., sufficient time is available to refurbish, replace or requalify the component if the reanalysis is unsuccessful).

**Table 4.4-3. 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 | |
|---|---|---|
| Environmental qualification (EQ) of electric equipment | The original EQ qualified life has been shown to bound the period of extended operation. | |

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

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

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

| TLAA | Description of Evaluation | |
|---|---|---|
| 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. | |

## 4.5 CONCRETE CONTAINMENT TENDON PRESTRESS

**Review Responsibilities**

**Primary** - Branch responsible for structural engineering
**Secondary** - None

### 4.5.1 Areas of Review

The prestressing tendons in prestressed concrete containments lose their prestressing forces with time due to creep and shrinkage of concrete, and relaxation of the prestressing steel. During the design phase, engineers estimate these losses to arrive at the predicted prestressing forces at the end of operating life (Refs. 1 and 2), normally forty years. These end of life prestressing force Predicted Lower Limits (PLL) must be above certain design Minimum Required Values (MRV). Curves developed from these calculations/analyses are used to evaluate prestressing force measurements taken on the tendons during surveillances required by Reg. Guide 1.35 and/or ASME Section XI, Subsection IWL. Because the calculations/analyses for the prediction of the loss of prestressing forces are performed for a period of time based on the original operating term, and must be extended to consider the period of extended operation, they constitute a TLAA.

The actual surveillance testing (including the evaluation of test results) for the prestressing of the containment tendons constitutes an aging management activity that must be evaluated as part of the IPA process but does not involve a TLAA , because the conduct of testing is not based on time-limited assumptions based on the current operating term. Testing periodicities are established by regulatory requirements at intervals much shorter than the current operating term, and test results are not compared to the 40 year values, but to the values that correspond to the time of the collection of the data..

### 4.5.2 Acceptance Criteria

The acceptance criterion for the TLAA described in Subsection 4.5.1 of this review plan section is as follows:

> The design calculations/analyses predicting the prestressing losses must already consider or must be projected to consider the period of extended operation. The PLL curves must be shown to remain above the MRV for the period of extended operation.

#### 4.5.2.1 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.

Accordingly, the specific options for satisfying the acceptance criterion are:

#### 4.5.2.1.1 10 CFR 54.21(c)(1)(i)

The existing prestressing force evaluation remains valid because the existing calculations/analyses regarding the predicted losses of the prestressing force considerer the period of extended operation. (As the requirements of Reg Guide 1.35 and ASME Section XI, Subsection IWL are based on a forty year operating cycle, it is likely that existing PLL curves will not account for the period of extended operation, and that option (ii) will apply.)

#### 4.5.2.1.2 10 CFR 54.21(c)(1)(ii)

The calculations/analyses regarding the predicted losses of the prestressing force are projected to 60 years.

#### 4.5.2.1.3 10 CFR 54.21(c)(1)(iii)

This option is not applicable for this TLAA. The calculations/analyses pertaining to the predicted loss of prestressing losses must be extended to consider the period of extended operation to satisfy the requirements of Reg. Guide 1.35 and/or ASME Section XI, Subsection IWL. An aging management activity may not be substituted for this action.

### 4.5.2.2 FSAR Supplement

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

> The description of the time-limited aging analyses for the period of extended operation in the FSAR supplement should provide 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 and the basis for determining that the TLAA has been properly dispositioned.

### 4.5.3 Review Procedures

For each area of review described in Subsection 4.5.1 of this review plan section, the following review procedures are followed:

### 4.5.3.1 Time-Limited Aging Analysis

For a concrete containment prestressing tendon system, the review procedures, depending on the applicant's choice, i.e., 10 CFR 54.21(c)(1)(i), or (ii), are:

#### 4.5.3.1.1 10 CFR 54.21(c)(1)(i)

The reviewer verifies that the documented results of the calculations/analyses for the predicted prestressing force losses considers the period of extended operation.

#### 4.5.3.1.2 10 CFR 54.21(c)(1)(ii)

The reviewer verifies that the documented results of the calculations/analyses for the predicted prestressing force losses have been or will be extended to consider the period of extended operation.

#### 4.5.3.1.3 10 CFR 54.21(c)(1)(iii)

Not applicable

### 4.5.3.2 FSAR Supplement

The reviewer verifies that the applicant has provided a FSAR supplement on the description of the evaluation of the tendon prestress TLAA. Table 4.5-1 of this review plan section 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 4.5-1.

## 4.5.4 Evaluation Findings

The reviewer verifies that sufficient and adequate information has been provided 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) or (ii):

> The staff evaluation concludes that the applicant has provided an acceptable demonstration, pursuant to 10 CFR 54.21(c)(1), that for the concrete containment tendon prestress TLAA, (i) the analyses remain valid for the period of extended operation, or (ii) the analyses have been projected to the end of the period of extended operation. The staff also concludes that the FSAR supplement contains an appropriate description of the concrete containment tendon prestress TLAA evaluation for the period of extended operation.

## 4.5.5 Implementation

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

## 4.5.6 References


1. Regulatory Guide 1.35, Rev. 3, "Inspection of Ungrouted Tendons in Prestressed Concrete Containments," July 1990.

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

3. ASME Boiler and Pressure Vessel Code, Section XI, "Rules for In-Service Inspection of Nuclear Power Plant Components," American Society of Mechanical Engineers, 1989; including Appendix VII, "Qualification of Nondestructive Examination Personnel for Ultrasonic Examination," and Appendix VIII (1989 Addenda), "Performance Demonstration for Ultrasonic Examination Systems," Subsection IWE (1992 Edition with 1992 Addenda), "Requirements for Class MC and Metallic Liners of Class CC Components of Light-Water Cooled Plants," and Subsection IWL (1992 Edition with 1992 Addenda), "Requirements for

Class CC Concrete Components of Light-Water Cooled Plants."

4. Codes of Federal Regulations: 10 CFR 50.55a, "Codes and Standards."

**Table 4.5-1. Examples of FSAR Supplement for Concrete Containment Tendon Prestress TLAA Evaluation**

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

| TLAA | Description of Evaluation | |
|---|---|---|
| Concrete Containment Tendon Prestress | The prestressing tendons are used to impart compressive forces in the prestressed concrete containments to resist the internal pressure inside the containment that would be generated in the event of a LOCA. The prestressing forces generated by the tendons diminish over time due to losses in prestressing force in the tendons and the surrounding concrete. The predicted prestressing force calculations/analyses have been determined to remain valid to the end of the period of extended operation. The PLL curves are shown to remain above the MRV for the period of extended operation.. | |

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

| TLAA | Description of Evaluation | |
|---|---|---|
| Concrete Containment Tendon Prestress | The prestressing tendons are used to impart compressive forces in the prestressed concrete containments to resist the internal pressure inside the containment that would be generated in the event of a LOCA. The prestressing forces generated by the tendons diminish over time due to losses in prestressing force in the tendons and the surrounding concrete. The predicted prestressing force calculations/analyses have been projected to the end of the period of extended operation. The PLL curves have been shown to remain above the MRV for the period of extended operation. | |

## 4.6 CONTAINMENT LINER PLATE AND PENETRATIONS FATIGUE ANALYSIS

**Review Responsibilities**

**Primary** - Branch responsible for structural engineering
**Secondary** - Branch responsible for mechanical engineering

### 4.6.1 Areas of Review

The interior surface of a concrete containment structure is lined with thin metallic plates to provide a leak tight barrier against the uncontrolled release of radioactivity to the environment as required by 10 CFR Part 50. The liner plates are attached to the concrete containment wall by means of stud anchors or structural rolled shapes or both. The design process assumes that the liner plates do not carry loads. However, normal loads, such as from concrete shrinkage, creep and thermal changes, imposed on the concrete containment structure are transferred to the liner plates through the anchorage system. Internal pressure and temperature loads are directly applied to the liner plates. Thus, under design-base conditions, the liner plates could experience significant strains. Fatigue of the liner plates is considered in the design based on an assumed number of loading cycles for the current operating term. The cyclic loads include reactor building interior temperature varying during the heatup and cooldown of the reactor coolant system, loss-of-coolant accident, annual outdoor temperature variations, thermal loads due to the high energy containment penetration piping lines, such as steam and feedwater lines, seismic loads, and pressurization due to periodic Type A integrated leak rate tests.

High energy piping penetrations and fuel transfer canal in some plants are equipped with bellow assemblies. These are designed to accommodate relative movements between the containment wall (including the liner) and the adjoining structures. The penetrations have sleeves (up to 10 feet in length, with a 2 to 3-inch annulus around the piping) to penetrate the concrete containment wall and allow movement of the piping system. Dissimilar metal welds connect the piping penetrations to the bellows to provide leaktight penetrations. The containment liner plates, penetration sleeves (including dissimilar metal welds), and penetration bellows are generally designed in accordance with requirements of ASME Section III. If the code of record requires a fatigue analysis, then this fatigueanalysis may be a Time-Limited Aging Analysis (TLAA) and must be evaluated in accordance with 10 CFR 54.21(c)(1) to ensure that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

For some plants, liner fatigue may not be addressed by a TLAA. In these cases, the applicant will address fatigue issues in Chapter 3.

The adequacy of the fatigue analyses of the containment liner plates (including welded joints), penetration sleeves, dissimilar metal welds, and penetration bellows is reviewed in this review plan section for the period of extended operation.

The fatigue analyses of pressure boundary welds of the high energy containment penetration piping lines are reviewed separately following the guidance in Section 4.3, "Metal Fatigue" of this standard review plan.

#### 4.6.1.1 Time-Limited Aging Analysis

The containment liner plates (including welded joints), penetration sleeves, dissimilar metal welds, and penetration bellows are generally designed and/or analyzed in accordance with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code requirements. The ASME code contains explicit metal fatigue or cyclic considerations based on time-limited aging analyses. Specific requirements are contained in the design code of reference for each plant.

##### 4.6.1.1.1 ASME Section III, Class 1

ASME Section III, Division 2, "Code for Concrete Reactor Vessel and Containments, Subsection CC, Concrete Containment" (Ref. 1) requires a fatigue analysis for liner plates considering all cyclic loads, and is based on the anticipated number of cycles. A Section III Class 1 fatigue analysis requires the calculation of the "cumulative usage factor" (CUF) based on the fatigue properties of the materials and the expected fatigue service of the component. The ASME Code limits the CUF to a value of less than unity for acceptable fatigue design. The fatigue resistance of the liner plate, during the period of extended operation is an area of review.

##### 4.6.1.1.2 ASME Section III, Class 2, 3

ASME Class 2, 3 or MC components, such as containment liner plates, penetration sleeves, dissimilar metal welds, and penetration bellows, are analyzed for metal fatigue. The fatigue resistance of the liner plate, liner weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows during the period of extended operation is an area of review.

##### 4.6.1.1.3 Other Evaluations Based on CUF

Other evaluations also contain metal fatigue analysis requirements based on a CUF calculation such as metal bellows designed to ASME NC-3649.4(e)(3), ND-3649.4(e)(3), or NE-3366.2(e)(3). For these cases, the discussion relating to ASME Section III, Class 1 in Subsection 4.6.1.1.1 of this review plan section applies.

#### 4.6.1.2 FSAR Supplement

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.

### 4.6.2 Acceptance Criteria

The acceptance criteria for the areas of review described in Subsection 4.6.1 of this review plan section define acceptable methods for meeting the requirements of the Commission's regulations in 10 CFR 54.21(c)(1).

#### 4.6.2.1 Time-Limited Aging Analysis

Pursuant to 10 CFR 54.21(c)(1), 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 fatigue of containment liner plates, liner plate weld joints, dissimilar metal welds, penetration sleeves, and penetration bellows are:

**4.6.2.1.1 ASME Section III, Class 1**

For containment liner plates designed or analyzed to ASME Class 1 requirements, the acceptance criteria, depending on the applicant's choice of 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

**4.6.2.1.1.1 10 CFR 54.21(c)(1)(i)**

The existing CUF calculations remain valid because the number of assumed cyclic loads will not be exceeded during the period of extended operation.

**4.6.2.1.1.2 10 CFR 54.21(c)(1)(ii)**

Current license basis fatigue analysis, per ASME Code, Section III, were conducted for a 40 years life. The CUF calculations should be re-evaluated based on an increased number of assumed cyclic loads to include the period of extended operation. All cyclic loads considered in the original fatigue analyses (including Type A and Type B leak rate tests) should be reevaluated and revised as necessary. The revised analysis should show that the CUF will not exceed unity as required by the ASME code during the period of extended operation.

**4.6.2.1.1.3 10 CFR 54.21(c)(1)(iii)**

The effects of aging on the intended function(s) will be adequately managed for the period of extended operation. The component could be replaced and the CUF for the replacement will be less than unity during the period of extended operation.

Alternative aging management program provided by the applicant will be evaluated on a case-by-case basis to ensure that the aging effects will be managed such that the intended functions(s) will be maintained during the period of extended operation. In cases where a mitigation or inspection program is proposed, the aging management program may be evaluated against the ten elements described in Branch Technical Position RLSB-1, Appendix A.1 of this standard review plan.

**4.6.2.1.2 ASME Section III, Class 2, 3**

ASME Class 2, 3 or MC components, such as containment liner plates, penetration sleeves, dissimilar metal welds, and penetration bellows designed or analyzed to ASME Section III, Class 2 or 3, the acceptance criteria, depending on the applicant's choice, that is 10 CFR 54.21(c)(1)(I), (ii), or (iii), are:

#### 4.6.2.1.2.1 10 CFR 54.21(c)(1)(i)

The existing allowable stresses remain valid because the number of assumed thermal cycles would not be exceeded during the period of extended operation.

#### 4.6.2.1.2.2 10 CFR 54.21(c)(1)(ii)

The allowable stresses have been re-evaluated based on an increased number of assumed thermal cycles to bound the period of extended operation. The resulting allowable stresses remain sufficient as required by the code during the period of extended operation.

#### 4.6.2.1.2.3 10 CFR 54.21(c)(1)(iii)

The effects of aging on the intended function(s) will be adequately managed for the period of extended operation. The component could be replaced and the allowable stresses for the replacement will be sufficient as required by the code during the period of extended operation.

Alternative acceptance criteria under 10 CFR 54.21(c)(1)(iii) have yet to be developed and will be evaluated on a case-by-case basis to ensure that the aging effects will be managed such that the intended functions(s) will be maintained during the period of extended operation.

#### 4.6.2.1.3 Other Evaluations Based on CUF

The acceptance criteria in Subsection 4.6.2.1.2 of this review plan section apply.

### 4.6.2.2 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 ofextended 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 TLAA has been properly dispositioned.

## 4.6.3 Review Procedures

For each area of review described in Subsection 4.6.1 of this review plan section, the following review procedures are followed:

### 4.6.3.1 Time-Limited Aging Analysis

#### 4.6.3.1.1 ASME Section III, Class 1

For containment liner plates designed or analyzed to ASME Class 1 requirements, the review procedures, depending on the applicant's choice of 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

#### 4.6.3.1.1.1 10 CFR 54.2l(c)(1)(i)

The number of assumed transients used in the existing CUF calculations for the current operating term is compared to the number of operating transients experienced to date as

extrapolated to 60 years of operation. The comparison confirms that the number of transients in the existing analyses will not be exceeded during the period of extended operation.

#### 4.6.3.1.1.2 10 CFR 54.21(c)(1)(ii)

A list of the increased number of assumed cyclic loads projected to the end of the period of extended operation and operating transient experience is reviewed to ensure that the cyclic load projection is adequate. The revised CUF calculations based on the projected number of assumed cyclic loads are reviewed to ensure that the CUF remains less than unity at the end of the period of extended operation.

The code of record should be used for the re-evaluation, or the applicant may update to a later code edition pursuant to 10 CFR 50.55a. In the latter case, the reviewer verifies that the requirements in 10 CFR 50.55a are met.

#### 4.6.3.1.1.3 10 CFR 54.2l(c)(1)(iii)

The applicant's proposed aging management program to ensure that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation is reviewed. If the applicant proposed component replacement before its CUF exceeds unity, the reviewer verifies that the CUF for the replacement will remain less than unity during the period of extended operation.

Other applicant proposed programs will be reviewed on a case-by-case basis.

### 4.6.3.1.2 ASME Section III, Class 2, 3

ASME Class 2, 3 or MC components, such as containment liner plates, penetration sleeves, dissimilar metal welds, and penetration bellows designed or analyzed to ASME Section III, Class 2 or 3, the review procedures, depending on the applicant's choice, that is 10 CFR 54.21(c)(1)(l), (ii), or (iii), are:

#### 4.6.3.1.2.1 10 CFR 54.21(c)(1)(i)

The results of the assumed thermal cycles evaluation used in the existing allowable stress determination and operating cyclic experience is reviewed to ensure that the number of assumed thermal cycles would not be exceeded during the period of extended operation.

#### 4.6.3.1.2.2 10 CFR 54.21(c)(1)(ii)

The results of the evaluation for the increased number of assumed thermal cycles projected to the end of the period of extended operation and operating cyclic experience is reviewed to ensure that the thermal cycle projection is adequate. The revised allowable stresses based on the projected number of assumed thermal cycles are reviewed to ensure that they remain sufficient as required by the code during the period of extended operation.

The code of record should be used for the re-evaluation or the applicant may update to a later code edition pursuant to 10 CFR 50.55a. In the latter case, the reviewer verifies that the requirements in 10 CFR 50.55a are met.

#### 4.6.3.1.2.3 10 CFR 54.21(c)(1)(iii)

The applicant's proposed program to ensure that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation is reviewed. If the applicant proposed component replacement before it exceeds the assumed thermal cycles, the reviewer verifies that the allowable stresses for the replacement will remain sufficient as required by the code during the period of extended operation. Other applicant-proposed programs will be reviewed on a case-by-case basis.

#### 4.6.3.1.3 Other Evaluations Based on CUF

The review procedures in Subsection 4.6.3.1 of this review plan section apply.

### 4.6.3.2 FSAR Supplement

The reviewer verifies that the applicant has provided a FSAR supplement on the summary description of the evaluation of the containment liner plate and penetrations fatigue TLAA. Table 4.6-1 of this review plan section 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 4.6-1.

## 4.6.4 Evaluation Findings

The reviewer verifies that sufficient and adequate information has been provided to satisfy the provisions of this standard 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 evaluation concludes that the applicant has provided an acceptable demonstration, pursuant to 10 CFR 54.21(c)(1), that for the containment liner plate and penetrations fatigue TLAA, (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 containment liner plate and penetrations fatigue TLAA evaluation for the period of extended operation.

## 4.6.5 Implementation

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

## 4.5.6 4.6.6 References

1. ASME Boiler and Pressure Vessel Code, Section III, Division 2, "Code for Concrete Reactor Vessels and Containments, Subsection CC, Concrete Containment," American Society of Mechanical Engineers, New York, New York, 1989 Edition.

**Table 4.6-1. Examples of FSAR Supplement for Containment Liner Plate and Penetrations Fatigue TLAA Evaluation**

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

| TLAA | Description of Evaluation | |
|---|---|---|
| Containment liner plate and penetrations fatigue | The containment liner plates, liner weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows provide a leak tight barrier. A Section III Class 1 fatigue analysis limits the "Cumulative Usage Factor" (CUF) to a value of less than unity for acceptable fatigue design. The existing CUF evaluation has been determined to remain valid because the number of assumed cyclic loads would not be exceeded during the period of extended operation. | |

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

| TLAA | Description of Evaluation | |
|---|---|---|
| Containment liner plate and penetrations fatigue | The containment liner plates, liner weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows provide a leak tight barrier. A Section III Class 1 fatigue analysis limits the CUF to a value of less than unity for acceptable fatigue design. The CUF calculations have been re-evaluated based on an increased number of assumed cyclic loads to include the period of extended operation and the revised CUF will not exceed unity during the period of extended operation. | |

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

| TLAA | Description of Evaluation | |
|---|---|---|
| Containment liner plate and penetrations fatigue | The containment liner plates, liner weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows provide a leak tight barrier. A Section III Class 1 fatigue analysis limits the CUF to a value of less than unity for acceptable fatigue design. The component will be replaced and the CUF for the replacement will be shown to be less than unity during the period of extended operation. | |

Note: All containment components need not meet the same requirement. It is likely that the liner plate and the bellows may be evaluated per 10CFR54.21(c)(1)(i), while high energy penetrations may be evaluated per 10CFR54.21(c)(1)(ii).

## 4.7 OTHER PLANT-SPECIFIC TIME LIMITED AGING ANALESES

**Review Responsibilities**

**Primary** - Branch responsible for engineering
**Secondary** – Other branches responsible for systems, as appropriate

### 4.7.1 Areas of Review

There are certain safety analyses which may have been based on an explicitly assumed 40-year plant life (for example, aspects of the reactor vessel design). Pursuant to 10 CFR 54.21(c), a license renewal applicant is required to evaluate time-limited aging analyses (TLAAs). The definition of TLAAs is provided in 10 CFR 54.3 and Section 4.1of this standard review plan.

The adequacy of the plant's current licensing basis (CLB), which includes TLAAs, is not an area of review. Potential concerns or enhancements regarding the CLB are to be addressed under the backfit rule (10 CFR 50.109) and are separate from the license renewal process.

License renewal reviews focus on the period of extended operation. Pursuant to 10 CFR 54.30, if the reviews show that the TLAAs are not sufficient to provide reasonable assurance during the current license term that licensed activities will be conducted in accordance with the CLB, the licensee is required to take measures under its current license to ensure that the intended function of those structures or components will be maintained in accordance with the CLB throughout the term of the current license. The adequacy of the measures for the term of the current license is not an area of review for license renewal.

Pursuant to 10 CFR 54.21(c), an applicant must provide a listing of TLAAs and plant-specific exemptions that are based on TLAAs. The staff reviews the applicant's identification of TLAAs and exemptions that are based on TLAAs separately following the guidance in Section 4.1 of this standard review plan.

Based on lessons learned in the review of the initial license renewal applications, the staff has developed review procedures for the evaluation of certain TLAAs. If an applicant identifies these TLAAs as applicable to its plant, the staff reviews them separately following the guidance in Sections 4.2 through 4.6 of this standard review plan. The staff reviews other TLAAs that are identified by the applicant following the generic guidance in this review plan section. The staff from branches responsible for systems may be requested to assist in the review, as appropriate.

The following areas relating to a TLAA are reviewed:

#### 4.7.1.1 Time-Limited Aging Analysis

The evaluation of the TLAA for the period of extended operation is reviewed.

#### 4.7.1.2 FSAR Supplement

The FSAR supplement summarizing the evaluation of the TLAA for the period of extended operation in accordance with 10 CFR 54.21(d) is reviewed.

### 4.7.2 Acceptance Criteria

The acceptance criteria for the areas of review described in Subsection 4.8.1 of this review plan section define acceptable methods for meeting the requirements of the Commission's regulations in 10 CFR 54.21(c)(1).

#### 4.7.2.1 Time-Limited Aging Analysis

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

(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.

#### 4.7.2.2 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 provides appropriate description such that later changes can be controlled by 10 CFR 50.59. The description should contain information associated with the TLAAs regarding the basis for determining that the TLAAs have been dispositioned for the period of extended operation.

### 4.7.3 Review Procedures

The requirement of TLAAs captures, for renewal review, certain aging analyses that are explicitly based on the duration of the current operating license of the plant. The concern is that these aging analyses do not consider the period of extended operation. Unless these analyses are evaluated, there is no assurance that the systems, structures, and components addressed by these analyses can perform their intended function(s) during the period of extended operation.

For each area of review described in Subsection 4.8.1 of this review plan section, the following review procedures are followed:

#### 4.7.3.1 Time-Limited Aging Analysis

For the TLAA identified, the review procedures depending on the applicant's choice, that is, 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

##### 4.7.3.1.1 10 CFR 54.21(c)(1)(i)

Justification provided by the applicant is reviewed to verify that the existing analyses are valid for the period of extended operation. The existing analyses should be shown to be bounding even during the period of extended operation.

An applicant should describe the TLAA with respect to the objectives of the analysis, conditions, and assumptions used in the analysis, acceptance criteria, relevant aging effects, and intended

function(s). The applicant should show that (1) the conditions and assumptions used in the analysis already address the relevant aging effects for the period of extended operation, and (2) acceptance criteria are maintained to provide reasonable assurance that the intended function(s) is maintained for renewal. Thus, no reanalysis is necessary for renewal.

In some instances the applicant may identify activities to be performed to verify the assumption basis of the calculation such as cycle counting. An evaluation of that activity should be provided by the applicant. The reviewer should assure that the applicant's activity is sufficient to confirm the calculation assumptions for the 60 year period.

If the TLAA has to be modified or recalculated to extend the period of evaluation to consider the period of extended operation, the re-evaluation should be addressed under 10 CFR 54.21(c)(1)(ii).

#### 4.7.3.1.2 10 CFR 54.21(c)(1)(ii)

The documented results of the revised analyses are reviewed to verify that the period of evaluation of the analyses is extended such that they are valid for the period of extended operation, for example, 60 yearsAn applicant may recalculate the TLA. The applicable analysis technique can be the one that is in effect in the plant's CLB at the time of renewal application.

A using a 60 year period to show that the TLAA acceptance criteria continue to be satisfied for the period of extended operation. The applicant may also revise the TLAA by recognizing and re-evaluating any overly conservative conditions and assumptions. Examples include relaxing overly conservative assumptions in the original analysis, using new or refined analytical techniques, and performing the analysis using a 60 year period. The applicant shall document the results of the reanalysis to show that it is satisfactory for the 60 year period. The analysis itself does not need to be reviewed.

As applicable, the plant's code of record should be used for the re-evaluation or the applicant may update to a later code edition pursuant to 10 CFR 50.55a. In the latter case, the reviewer verifies that the requirements in 10 CFR 50.55a are met.

In some cases the applicant may identify activities to be performed to verify the assumption basis of the calculation such as cycle counting. An evaluation of that activity should be provided by the applicant. The reviewer should assure that the applicant's activity is sufficient to confirm the calculation assumptions for the 60 year period.

#### 4.7.3.1.3 10 CFR 54.21(c)(1)(iii)

Under this option, an applicant would propose to manage the aging effects associated with the TLAA by an aging management program, in the same manner as the integrated plant assessment (IPA) in 10 CFR 54.21(a)(3). The reviewer reviews the applicant's aging management program to verify that the effects of aging on the intended function(s) will be adequately managed consistent with the CLB for the period of extended operation.

An applicant should identify the structures and components associated with the TLAA. The TLAA should be described with respect to the objectives of the analysis, conditions, and assumptions used in the analysis, acceptance criteria, relevant aging effects and intended function(s). In cases where a mitigation or inspection program is proposed, the reviewer may use the guidance provided in Branch Technical Position RLSB-1 of this standard review plan to

ensure that the effects of aging on the structure and component intended function(s) are adequately managed for the period of extended operation.

#### 4.7.3.2 FSAR Supplement

The reviewer verifies that the applicant has provided a FSAR supplement on the description of the evaluation of the TLAA. The summary description of the evaluation of TLAA for the period of extended operation in the FSAR supplement is reviewed to verify that it provides an appropriate description such that later changes can be controlled by 10 CFR 50.59. The description should contain information that the TLAAs have been dispositioned for the period of extended operation. Sections 4.2 through 4.6 of this standard review plan contain examples of acceptable FSAR supplement information for TLAA evaluation.

### 4.7.4 Evaluation Findings

The reviewer verifies that sufficient and adequate information has been provided 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 evaluation concludes that the applicant has provided an acceptable demonstration, pursuant to 10 CFR 54.21(c)(1), that, for the (name of specific) TLAA, (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 this TLAA evaluation for the period of extended operation.

### 4.7.5 Implementation

Except in those cases in which the applicant proposes an acceptable alternative method, the method described herein will be used by the staff in its evaluation of conformance with Commission regulation.

### 4.7.6 References

None.

#### 4.6.1.1 Time-Limited Aging Analysis

The containment liner plates (including welded joints), penetration sleeves, dissimilar metal welds, and penetration bellows are generally designed and/or analyzed in accordance with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code requirements. The ASME code contains explicit metal fatigue or cyclic considerations based on time-limited aging analyses. Specific requirements are contained in the design code of reference for each plant.

##### 4.6.1.1.1 ASME Section III, Class 1

ASME Section III, Division 2, "Code for Concrete Reactor Vessel and Containments, Subsection CC, Concrete Containment" (Ref. 1) requires a fatigue analysis for liner plates considering all cyclic loads, and is based on the anticipated number of cycles. A Section III Class 1 fatigue analysis requires the calculation of the "cumulative usage factor" (CUF) based on the fatigue properties of the materials and the expected fatigue service of the component. The ASME Code limits the CUF to a value of less than unity for acceptable fatigue design. The fatigue resistance of the liner plate, during the period of extended operation is an area of review.

##### 4.6.1.1.2 ASME Section III, Class 2, 3

ASME Class 2, 3 or MC components, such as containment liner plates, penetration sleeves, dissimilar metal welds, and penetration bellows, are analyzed for metal fatigue. The fatigue resistance of the liner plate, liner weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows during the period of extended operation is an area of review.

##### 4.6.1.1.3 Other Evaluations Based on CUF

Other evaluations also contain metal fatigue analysis requirements based on a CUF calculation such as metal bellows designed to ASME NC-3649.4(e)(3), ND-3649.4(e)(3), or NE-3366.2(e)(3). For these cases, the discussion relating to ASME Section III, Class 1 in Subsection 4.6.1.1.1 of this review plan section applies.

#### 4.6.1.2 FSAR Supplement

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.

### 4.6.2 Acceptance Criteria

The acceptance criteria for the areas of review described in Subsection 4.6.1 of this review plan section define acceptable methods for meeting the requirements of the Commission's regulations in 10 CFR 54.21(c)(1).

#### 4.6.2.1 Time-Limited Aging Analysis

Pursuant to 10 CFR 54.21(c)(1), 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 fatigue of containment liner plates, liner plate weld joints, dissimilar metal welds, penetration sleeves, and penetration bellows are:

#### 4.6.2.1.1 ASME Section III, Class 1

For containment liner plates designed or analyzed to ASME Class 1 requirements, the acceptance criteria, depending on the applicant's choice of 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

##### 4.6.2.1.1.1 10 CFR 54.21(c)(1)(i)

The existing CUF calculations remain valid because the number of assumed cyclic loads will not be exceeded during the period of extended operation.

##### 4.6.2.1.1.2 10 CFR 54.21(c)(1)(ii)

Current license basis fatigue analysis, per ASME Code, Section III, were conducted for a 40 years life. The CUF calculations should be re-evaluated based on an increased number of assumed cyclic loads to include the period of extended operation. All cyclic loads considered in the original fatigue analyses (including Type A and Type B leak rate tests) should be reevaluated and revised as necessary. The revised analysis should show that the CUF will not exceed unity as required by the ASME code during the period of extended operation.

##### 4.6.2.1.1.3 10 CFR 54.21(c)(1)(iii)

The effects of aging on the intended function(s) will be adequately managed for the period of extended operation. The component could be replaced and the CUF for the replacement will be less than unity during the period of extended operation.

Alternative aging management program provided by the applicant will be evaluated on a case-by-case basis to ensure that the aging effects will be managed such that the intended functions(s) will be maintained during the period of extended operation. In cases where a mitigation or inspection program is proposed, the aging management program may be evaluated against the ten elements described in Branch Technical Position RLSB-1, Appendix A.1 of this standard review plan.

#### 4.6.2.1.2 ASME Section III, Class 2, 3

ASME Class 2, 3 or MC components, such as containment liner plates, penetration sleeves, dissimilar metal welds, and penetration bellows designed or analyzed to ASME Section III, Class 2 or 3, the acceptance criteria, depending on the applicant's choice, that is 10 CFR 54.21(c)(1)(I), (ii), or (iii), are:

#### 4.6.2.1.2.1 10 CFR 54.21(c)(1)(i)

The existing allowable stresses remain valid because the number of assumed thermal cycles would not be exceeded during the period of extended operation.

#### 4.6.2.1.2.2 10 CFR 54.21(c)(1)(ii)

The allowable stresses have been re-evaluated based on an increased number of assumed thermal cycles to bound the period of extended operation. The resulting allowable stresses remain sufficient as required by the code during the period of extended operation.

#### 4.6.2.1.2.3 10 CFR 54.21(c)(1)(iii)

The effects of aging on the intended function(s) will be adequately managed for the period of extended operation. The component could be replaced and the allowable stresses for the replacement will be sufficient as required by the code during the period of extended operation.

Alternative acceptance criteria under 10 CFR 54.21(c)(1)(iii) have yet to be developed and will be evaluated on a case-by-case basis to ensure that the aging effects will be managed such that the intended functions(s) will be maintained during the period of extended operation.

#### 4.6.2.1.3 Other Evaluations Based on CUF

The acceptance criteria in Subsection 4.6.2.1.2 of this review plan section apply.

### 4.6.2.2 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 ofextended 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 TLAA has been properly dispositioned.

## 4.6.3 Review Procedures

For each area of review described in Subsection 4.6.1 of this review plan section, the following review procedures are followed:

### 4.6.3.1 Time-Limited Aging Analysis

#### 4.6.3.1.1 ASME Section III, Class 1

For containment liner plates designed or analyzed to ASME Class 1 requirements, the review procedures, depending on the applicant's choice of 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

#### 4.6.3.1.1.1 10 CFR 54.2l(c)(1)(i)

The number of assumed transients used in the existing CUF calculations for the current operating term is compared to the number of operating transients experienced to date as

extrapolated to 60 years of operation. The comparison confirms that the number of transients in the existing analyses will not be exceeded during the period of extended operation.

#### 4.6.3.1.1.2 10 CFR 54.21(c)(1)(ii)

A list of the increased number of assumed cyclic loads projected to the end of the period of extended operation and operating transient experience is reviewed to ensure that the cyclic load projection is adequate. The revised CUF calculations based on the projected number of assumed cyclic loads are reviewed to ensure that the CUF remains less than unity at the end of the period of extended operation.

The code of record should be used for the re-evaluation, or the applicant may update to a later code edition pursuant to 10 CFR 50.55a. In the latter case, the reviewer verifies that the requirements in 10 CFR 50.55a are met.

#### 4.6.3.1.1.3 10 CFR 54.2l(c)(1)(iii)

The applicant's proposed aging management program to ensure that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation is reviewed. If the applicant proposed component replacement before its CUF exceeds unity, the reviewer verifies that the CUF for the replacement will remain less than unity during the period of extended operation.

Other applicant proposed programs will be reviewed on a case-by-case basis.

### 4.6.3.1.2 ASME Section III, Class 2, 3

ASME Class 2, 3 or MC components, such as containment liner plates, penetration sleeves, dissimilar metal welds, and penetration bellows designed or analyzed to ASME Section III, Class 2 or 3, the review procedures, depending on the applicant's choice, that is 10 CFR 54.21(c)(1)(I), (ii), or (iii), are:

#### 4.6.3.1.2.1 10 CFR 54.21(c)(1)(i)

The results of the assumed thermal cycles evaluation used in the existing allowable stress determination and operating cyclic experience is reviewed to ensure that the number of assumed thermal cycles would not be exceeded during the period of extended operation.

#### 4.6.3.1.2.2 10 CFR 54.21(c)(1)(ii)

The results of the evaluation for the increased number of assumed thermal cycles projected to the end of the period of extended operation and operating cyclic experience is reviewed to ensure that the thermal cycle projection is adequate. The revised allowable stresses based on the projected number of assumed thermal cycles are reviewed to ensure that they remain sufficient as required by the code during the period of extended operation.

The code of record should be used for the re-evaluation or the applicant may update to a later code edition pursuant to 10 CFR 50.55a. In the latter case, the reviewer verifies that the requirements in 10 CFR 50.55a are met.

#### 4.6.3.1.2.3 10 CFR 54.21(c)(1)(iii)

The applicant's proposed program to ensure that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation is reviewed. If the applicant proposed component replacement before it exceeds the assumed thermal cycles, the reviewer verifies that the allowable stresses for the replacement will remain sufficient as required by the code during the period of extended operation. Other applicant-proposed programs will be reviewed on a case-by-case basis.

#### 4.6.3.1.3 Other Evaluations Based on CUF

The review procedures in Subsection 4.6.3.1 of this review plan section apply.

### 4.6.3.2 FSAR Supplement

The reviewer verifies that the applicant has provided a FSAR supplement on the summary description of the evaluation of the containment liner plate and penetrations fatigue TLAA. Table 4.6-1 of this review plan section 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 4.6-1.

## 4.6.4 Evaluation Findings

The reviewer verifies that sufficient and adequate information has been provided to satisfy the provisions of this standard 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 evaluation concludes that the applicant has provided an acceptable demonstration, pursuant to 10 CFR 54.21(c)(1), that for the containment liner plate and penetrations fatigue TLAA, (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 containment liner plate and penetrations fatigue TLAA evaluation for the period of extended operation.

## 4.6.5 Implementation

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

## 4.5.6 4.6.6 References


1. ASME Boiler and Pressure Vessel Code, Section III, Division 2, "Code for Concrete Reactor Vessels and Containments, Subsection CC, Concrete Containment," American Society of Mechanical Engineers, New York, New York, 1989 Edition.

**Table 4.6-1. Examples of FSAR Supplement for Containment Liner Plate and Penetrations Fatigue TLAA Evaluation**

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

| TLAA | Description of Evaluation | |
|---|---|---|
| Containment liner plate and penetrations fatigue | The containment liner plates, liner weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows provide a leak tight barrier. A Section III Class 1 fatigue analysis limits the "Cumulative Usage Factor" (CUF) to a value of less than unity for acceptable fatigue design. The existing CUF evaluation has been determined to remain valid because the number of assumed cyclic loads would not be exceeded during the period of extended operation. | |

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

| TLAA | Description of Evaluation | |
|---|---|---|
| Containment liner plate and penetrations fatigue | The containment liner plates, liner weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows provide a leak tight barrier. A Section III Class 1 fatigue analysis limits the CUF to a value of less than unity for acceptable fatigue design. The CUF calculations have been re-evaluated based on an increased number of assumed cyclic loads to include the period of extended operation and the revised CUF will not exceed unity during the period of extended operation. | |

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

| TLAA | Description of Evaluation | |
|---|---|---|
| Containment liner plate and penetrations fatigue | The containment liner plates, liner weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows provide a leak tight barrier. A Section III Class 1 fatigue analysis limits the CUF to a value of less than unity for acceptable fatigue design. The component will be replaced and the CUF for the replacement will be shown to be less than unity during the period of extended operation. | |

Note: All containment components need not meet the same requirement. It is likely that the liner plate and the bellows may be evaluated per 10CFR54.21(c)(1)(i), while high energy penetrations may be evaluated per 10CFR54.21(c)(1)(ii).

## 4.7 OTHER PLANT-SPECIFIC TIME LIMITED AGING ANALESES

**Review Responsibilities**

**Primary** - Branch responsible for engineering
**Secondary** – Other branches responsible for systems, as appropriate

### 4.7.1 Areas of Review

There are certain safety analyses which may have been based on an explicitly assumed 40-year plant life (for example, aspects of the reactor vessel design). Pursuant to 10 CFR 54.21(c), a license renewal applicant is required to evaluate time-limited aging analyses (TLAAs). The definition of TLAAs is provided in 10 CFR 54.3 and Section 4.1of this standard review plan.

The adequacy of the plant's current licensing basis (CLB), which includes TLAAs, is not an area of review. Potential concerns or enhancements regarding the CLB are to be addressed under the backfit rule (10 CFR 50.109) and are separate from the license renewal process.

License renewal reviews focus on the period of extended operation. Pursuant to 10 CFR 54.30, if the reviews show that the TLAAs are not sufficient to provide reasonable assurance during the current license term that licensed activities will be conducted in accordance with the CLB, the licensee is required to take measures under its current license to ensure that the intended function of those structures or components will be maintained in accordance with the CLB throughout the term of the current license. The adequacy of the measures for the term of the current license is not an area of review for license renewal.

Pursuant to 10 CFR 54.21(c), an applicant must provide a listing of TLAAs and plant-specific exemptions that are based on TLAAs. The staff reviews the applicant's identification of TLAAs and exemptions that are based on TLAAs separately following the guidance in Section 4.1 of this standard review plan.

Based on lessons learned in the review of the initial license renewal applications, the staff has developed review procedures for the evaluation of certain TLAAs. If an applicant identifies these TLAAs as applicable to its plant, the staff reviews them separately following the guidance in Sections 4.2 through 4.6 of this standard review plan. The staff reviews other TLAAs that are identified by the applicant following the generic guidance in this review plan section. The staff from branches responsible for systems may be requested to assist in the review, as appropriate.

The following areas relating to a TLAA are reviewed:

#### 4.7.1.1 Time-Limited Aging Analysis

The evaluation of the TLAA for the period of extended operation is reviewed.

#### 4.7.1.2 FSAR Supplement

The FSAR supplement summarizing the evaluation of the TLAA for the period of extended operation in accordance with 10 CFR 54.21(d) is reviewed.

### 4.7.2 Acceptance Criteria

The acceptance criteria for the areas of review described in Subsection 4.8.1 of this review plan section define acceptable methods for meeting the requirements of the Commission's regulations in 10 CFR 54.21(c)(1).

#### 4.7.2.1 Time-Limited Aging Analysis

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

(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.

#### 4.7.2.2 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 provides appropriate description such that later changes can be controlled by 10 CFR 50.59. The description should contain information associated with the TLAAs regarding the basis for determining that the TLAAs have been dispositioned for the period of extended operation.

### 4.7.3 Review Procedures

The requirement of TLAAs captures, for renewal review, certain aging analyses that are explicitly based on the duration of the current operating license of the plant. The concern is that these aging analyses do not consider the period of extended operation. Unless these analyses are evaluated, there is no assurance that the systems, structures, and components addressed by these analyses can perform their intended function(s) during the period of extended operation.

For each area of review described in Subsection 4.8.1 of this review plan section, the following review procedures are followed:

#### 4.7.3.1 Time-Limited Aging Analysis

For the TLAA identified, the review procedures depending on the applicant's choice, that is, 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

##### 4.7.3.1.1 10 CFR 54.21(c)(1)(i)

Justification provided by the applicant is reviewed to verify that the existing analyses are valid for the period of extended operation. The existing analyses should be shown to be bounding even during the period of extended operation.

An applicant should describe the TLAA with respect to the objectives of the analysis, conditions, and assumptions used in the analysis, acceptance criteria, relevant aging effects, and intended

function(s). The applicant should show that (1) the conditions and assumptions used in the analysis already address the relevant aging effects for the period of extended operation, and (2) acceptance criteria are maintained to provide reasonable assurance that the intended function(s) is maintained for renewal. Thus, no reanalysis is necessary for renewal.

In some instances the applicant may identify activities to be performed to verify the assumption basis of the calculation such as cycle counting. An evaluation of that activity should be provided by the applicant. The reviewer should assure that the applicant's activity is sufficient to confirm the calculation assumptions for the 60 year period.

If the TLAA has to be modified or recalculated to extend the period of evaluation to consider the period of extended operation, the re-evaluation should be addressed under 10 CFR 54.21(c)(1)(ii).

#### 4.7.3.1.2 10 CFR 54.21(c)(1)(ii)

The documented results of the revised analyses are reviewed to verify that the period of evaluation of the analyses is extended such that they are valid for the period of extended operation, for example, 60 yearsAn applicant may recalculate the TLA. The applicable analysis technique can be the one that is in effect in the plant's CLB at the time of renewal application.

A using a 60 year period to show that the TLAA acceptance criteria continue to be satisfied for the period of extended operation. The applicant may also revise the TLAA by recognizing and re-evaluating any overly conservative conditions and assumptions. Examples include relaxing overly conservative assumptions in the original analysis, using new or refined analytical techniques, and performing the analysis using a 60 year period. The applicant shall document the results of the reanalysis to show that it is satisfactory for the 60 year period. The analysis itself does not need to be reviewed.

As applicable, the plant's code of record should be used for the re-evaluation or the applicant may update to a later code edition pursuant to 10 CFR 50.55a. In the latter case, the reviewer verifies that the requirements in 10 CFR 50.55a are met.

In some cases the applicant may identify activities to be performed to verify the assumption basis of the calculation such as cycle counting. An evaluation of that activity should be provided by the applicant. The reviewer should assure that the applicant's activity is sufficient to confirm the calculation assumptions for the 60 year period.

#### 4.7.3.1.3 10 CFR 54.21(c)(1)(iii)

Under this option, an applicant would propose to manage the aging effects associated with the TLAA by an aging management program, in the same manner as the integrated plant assessment (IPA) in 10 CFR 54.21(a)(3). The reviewer reviews the applicant's aging management program to verify that the effects of aging on the intended function(s) will be adequately managed consistent with the CLB for the period of extended operation.

An applicant should identify the structures and components associated with the TLAA. The TLAA should be described with respect to the objectives of the analysis, conditions, and assumptions used in the analysis, acceptance criteria, relevant aging effects and intended function(s). In cases where a mitigation or inspection program is proposed, the reviewer may use the guidance provided in Branch Technical Position RLSB-1 of this standard review plan to

ensure that the effects of aging on the structure and component intended function(s) are adequately managed for the period of extended operation.

#### 4.7.3.2 FSAR Supplement

The reviewer verifies that the applicant has provided a FSAR supplement on the description of the evaluation of the TLAA. The summary description of the evaluation of TLAA for the period of extended operation in the FSAR supplement is reviewed to verify that it provides an appropriate description such that later changes can be controlled by 10 CFR 50.59. The description should contain information that the TLAAs have been dispositioned for the period of extended operation. Sections 4.2 through 4.6 of this standard review plan contain examples of acceptable FSAR supplement information for TLAA evaluation.

### 4.7.4 Evaluation Findings

The reviewer verifies that sufficient and adequate information has been provided 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 evaluation concludes that the applicant has provided an acceptable demonstration, pursuant to 10 CFR 54.21(c)(1), that, for the (name of specific) TLAA, (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 this TLAA evaluation for the period of extended operation.

### 4.7.5 Implementation

Except in those cases in which the applicant proposes an acceptable alternative method, the method described herein will be used by the staff in its evaluation of conformance with Commission regulation.

### 4.7.6 References

None.