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 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. This fatigue analysis is 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.

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 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.

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 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.

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. The aging management program will 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 Other Evaluations Based on CUF

The acceptance criteria in Subsection 4.6.2.1.1 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.

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.

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 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 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 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).