4.6 CONTAINMENT LINER PLATE, METAL CONTAINMENTS, 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. Some plants may have metal containments instead of concrete containments with liner plates. Fatigue of the liner plates and metal containments may be 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 leak tight penetrations.

The containment liner plates, metal containments, penetration sleeves (including dissimilar metal welds), and penetration bellows may be designed in accordance with requirements of Section III of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code. If a plant's code of record requires a fatigue analysis, then this fatigue analysis 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.

The adequacy of the fatigue analyses of the containment liner plates (including welded joints), metal containments, 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 pressure boundary of process piping 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), metal containments, penetration sleeves, dissimilar metal welds, and penetration bellows may be designed and/or analyzed in accordance with ASME 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 of each plant.

4.6.1.1.1 ASME Section III, MC or Class 1

ASME Section III, Division 2, “Code for Concrete Reactor Vessel and Containments,” Subsection CC, “Concrete Containment,” and Division 1, Subsection NE, “Class MC Components,” (Ref. 1) require a fatigue analysis for liner plates, metal containments, and penetrations, considering all cyclic loads based on the anticipated number of cycles. Containment components may also be designed to ASME Section III, Class 1 requirements. A Section III MC or 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 plates, metal containments, and penetrations 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) or NE-3366.2(e)(3). For these cases, the discussion relating to ASME Section III, MC or 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, metal containments, liner plate weld joints, dissimilar metal welds, penetration sleeves, and penetration bellows are:

4.6.2.1.1 ASME Section III, MC or Class 1

For containment liner plates, metal containments, and penetrations designed or analyzed to ASME MC or 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, was 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 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 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 analyses regarding the basis for determining that the applicant has made the demonstration required by 10 CFR 54.21(c)(1).

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, MC or Class 1

For containment liner plates, metal containments, and penetrations designed or analyzed to ASME MC or 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 54.21(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 information to be included in the FSAR supplement including a summary description of the evaluation of containment liner plate, metal containments, 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. The staff expects to impose a license condition in the renewed license, if granted, to require the applicant to update its FSAR to include this FSAR supplement at the next update required pursuant to 10 CFR 50.71(e)(4). As part of the license condition, until the FSAR update is complete, the applicant may make changes to the programs described in its FSAR supplement without prior Commission approval, provided that the applicant evaluates each such change pursuant to the criteria set forth in 10 CFR 50.59.

As noted in Table 4.6-1, an applicant need not incorporate the implementation schedule into its FSAR. However, an applicant should identify and commit to any future aging management activities to be completed before the period of extended operation. The staff expects to impose a license condition in the renewed license, if granted, to ensure that the applicant will complete these activities no later than the committed date.

4.6.4 Evaluation Findings

The reviewer verifies that the applicant has provided sufficient information 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 [choose what is appropriate] the containment liner plate or metal containment, and penetrations fatigue TLAA [choose what is appropriate], (i) the analyses remain valid for the period of extended operation, (ii) the analyses have been projected to the end of the period of extended operation, or (iii) the effects of aging on the intended function(s) will be adequately managed for the period of extended operation. The staff also concludes that the FSAR supplement contains an appropriate summary description of the containment liner plate or metal containment, 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.

4.6.6 References

1. ASME Boiler and Pressure Vessel Code, Section III, Division 2, "Code for Concrete Reactor Vessels and Containments," Subsection CC, "Concrete Containment," and Division 1, Subsection NE, "MC Components," American Society of Mechanical Engineers, New York, New York, 1989 or other editions as approved in 10 CFR 50.55a.

Table 4.6-1. Examples of FSAR Supplement for Containment Liner Plates, Metal Containments, and Penetrations Fatigue TLAA Evaluation

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

TLAA	Description of Evaluation	Implementation Schedule*
Containment liner plates (or metal containment) and penetrations fatigue	The containment liner plates (or metal containment), liner weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows provide a leak tight barrier. A Section III MC or 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 plates (or metal containment) and penetrations fatigue	The containment liner plates (or metal containment), liner weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows provide a leak tight barrier. A Section III MC or 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 plates (or metal containment) and penetrations fatigue	The containment liner plates (or metal containment), liner weld joints, penetration sleeves, dissimilar metal welds, and penetration bellows provide a leak tight barrier. A Section III MC or 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 should be implemented before 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).

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