

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. The operating experiences with the trend of prestressing forces indicate that the prestressing tendons lose their prestressing forces at a rate higher than predicted due to sustained high temperature (Ref. 3). Thus, it is necessary to perform time limited aging analysis (TLAA) for the extended period of operation.

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 criteria for the area of review described in Subsection 4.5.1 of this review plan section define acceptable methods for meeting the requirements of the Commission's regulations in 10 CFR 54.21(c)(1).

4.5.2.1 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) 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 covers 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.

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

The predicted lower limits (PLLs) of prestressing forces for each group of tendons developed for 40 years period of operation should be extended to 60 years. The applicant should demonstrate that the trend lines of the measured prestressing forces will stay above the PLLs and the design Minimum Required 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)

In Chapter X of the Generic Aging Lessons Learned (GALL) report (Ref. 4), the staff has evaluated a program that assesses the concrete containment tendon prestressing forces. The staff has determined that it is an acceptable aging management program to address concrete containment tendon prestress according to 10 CFR 54.21(c)(1)(iii), except for operating experience. The GALL report recommends further evaluation of the applicant's operating experience related to the containment prestress force.

The GALL report may be referenced in a license renewal application and should be treated in the same manner as an approved topical report. In referencing the GALL report, an applicant should indicate that the material presented in the GALL report is applicable to the specific plant involved and provide the information necessary to adopt the finding of program acceptability as described and evaluated in the GALL report. An applicant should also verify that the approvals set forth in the GALL report for the generic program apply to the applicant's program.

4.5.2.2 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).

4.5.3 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), (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 the measured prestressing force when plotted on the predicted prestressing force curve shows that the existing analysis will cover 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.

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

An applicant may reference the GALL report in its license renewal application, as appropriate. The applicant should state that the GALL report is applicable to its plant with respect to its program that assesses the concrete containment tendon prestressing forces. The reviewer verifies that the applicant has identified the appropriate program as described and evaluated in the GALL report. The reviewer also ensures that the applicant has stated that its program contains the same program elements that the staff evaluated and relied upon in approving the corresponding generic program in the GALL report.

The GALL report recommends further evaluation of the applicant's operating experience related to the containment prestress force. The applicant's program should incorporate the relevant operating experience that occurred at the applicant's plant as well as at other plants. The applicant should consider applicable portions of the experience with prestressing systems described in Information Notice 99-10 (Ref. 3). Tendon operating experience could be different at plants with prestressed concrete containments. The difference could be due to the prestressing system design (for example, button-heads, wedge or swaged anchorages), environment, and type of reactor (that is, PWR and BWR). The reviewer reviews the applicant's program to verify that the applicant has adequately considered plant-specific operating experience.

4.5.3.2 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 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. 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 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 4.5-1, 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.

4.5.4 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 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 [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 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.

**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 prestressing force evaluation has been determined to remain valid to the end of 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 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

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	Program should be implemented before the period of extended operation.

	<p>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.</p>	
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*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.