

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 in prestressed concrete containments lose their prestressing forces with time due to creep and shrinkage of concrete, and relaxation of 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.

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 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.

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)

An applicant may utilize this option as follows:

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 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)

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.

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 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), (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)

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.

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 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), (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, (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. 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. 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 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 will be implemented by...

	<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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