

5E.3 EVALUATION OF PLANT OPERATING LICENSE EXTENSION ON TENDON SYSTEM

5E.3.1 TENDON POPULATIONS

Following original construction of the Units 1 and 2 Containments, there were only three distinct tendon populations: vertical, hoop, and dome. Inservice inspection (ISI) surveillance criteria for tendons during the early years of plant operation were based on Reference 1. Since the two Containments were identical in design, Reference 1 only required that lift-off testing surveillance be performed on one Unit for each tendon population. Tendon prestress losses in each population were generically calculated based on a nominal plant operating life of 40-years. In 2000, Calvert Cliffs received an extension of 20-years to its original operating license. With license extension, the prestress losses in each tendon population would require extrapolation from a 40-year nominal period to a 60-year nominal period. However, with the introduction of different NRC-mandated ISI criteria in 1996, and the discovery of corrosion in the vertical tendon population in 1997, simple extrapolation to 60 years of the existing prestress losses was not possible. Prestress losses for each tendon population on each Containment would have to be developed.

Part of the long-term corrective action plan was the replacement and restressing of vertical tendons on both Containments. The replacement vertical tendons have a different relaxation percentage than the original tendons, and a different effective prestress loss time period. The restressed original vertical tendons also have different relaxation characteristics from the original vertical tendons that were not restressed, and a different effective prestress loss time period.

These changes resulted in tendon prestress losses being developed for three vertical tendon sub-populations, the horizontal tendon population, and the dome tendon population for each Containment unit. Tables 5E-3 and 5E-4 show the tendon populations for each Unit and their effective life.

5E.3.2 ORIGINAL TENDON PRESTRESS LOSSES

The Unit 1 original vertical tendons, hoop tendons, and dome tendons already had 40-year average prestress losses calculated, which had been converted into average tendon force versus time curves to be used in evaluating ISI surveillance lift-off force data. For these three original tendon population curves, the expected tendon force curves only were required to be extended to cover the new nominal 60-year plant end-of-life time period due to license extension.

To develop prestress losses for the Unit 2 original vertical, hoop, and dome tendons, data from the original Unit 2 prestressing report was used. Since the prestress losses and conversion into a tendon force versus time curve represents the average tendon in a population, the average seating stress for the original three populations was taken from the original stressing report. The expected prestress losses at the end of 40 years were then determined based on the original loss values for elastic shortening of concrete, creep and shrinkage of concrete, and relaxation of tendon wire steel as provided in Section 5.1.4.2. Once a loss equation was developed to fit the 40-year values, the equation was used to extend the expected tendon force curves to cover the tendon initial stressing to plant end-of-life time period (60 nominal years).

Special consideration is required for the original Units 1 and 2 tendons that were restressed. These tendons were initially stressed in the early 1970s, held under sustained tension, and then retensioned in 2002. As described in Reference 2, tendons that are restressed will reinitiate relaxation losses as if being stressed for the first time, although not to the same extent. Reference 2 documents an acceptable restress factor of 0.65. To

apply the factor of 0.65 to restressed tendons, the tendon wire relaxation for a given time period is determined for virgin, unstressed wire, and then multiplied by the 0.65 factor.

The average date for restressing the Unit 1 vertical tendons was August 2002. The average date for initial stressing of the Unit 1 vertical tendons was March 1973. Therefore, the 2002 restress corresponds to year 29.5 of the tendon life. The end-of-plant operating life corresponds to year 61.5 of the tendon life. The new tendon force versus time curves based on prestress losses for restressed tendons have an initial stressing date of August 2002. The amount of concrete creep/shrinkage losses that are expected to occur between years 29.5 and 61.5 of the original tendon life were able to be determined since the creep/shrinkage loss is a function of time from the point that the Containmentment was originally stressed. No new concrete elastic shortening losses were considered. For tendons that are restressed or newly installed, there will not be an appreciable concrete elastic loss since only a few tendons were permitted to be detensioned at any given time. Since the vast majority of tendons remained in tension at all times, the concrete Containmentments remained under compressive stress and retained the associated elastic deformations from the original stressing in the early 1970s. Equations were developed to determine the amount of average prestress losses due to containment concrete creep and shrinkage between years 29.5 and 61.5, and the amount of prestress losses due to wire relaxation for 32 years after applying a 65% factor. Once the 32-year prestress losses were determined, another equation was fitted to the beginning average restressing force and final average calculated tendon force at the end-of-life. From this equation, tendon force versus time curves were developed to evaluate future tendon surveillance lift-off force test results.

The same approach was used for the Unit 2 restressed vertical tendons in developing final force versus time curves. The only differences were the average tendon remaining life and the average initial restressing force used in the approach.

5E.3.3 NEW TENDON PRESTRESS LOSSES

A total of 47 (Unit 1) and 46 (Unit 2) new vertical tendons were installed during 2001 and 2002. Each tendon consisted of 90-1/4" diameter wires with buttonheaded anchorages, just like the original tendon design. The only significant fabrication change for all the new tendons was that the upper stressing washers all utilized the Prescon 93 hole design. The three empty holes were to provide a vent path during the tendon greasing process to prevent formation of a grease void below the stressing washer. The new tendon wire is per American Society for Testing and Materials A421 Type BA. The relaxation of the prestressing wire steel was specified to be less than 4% for a design life of 40 years. Three 1000-hour relaxation tests were performed on sample wires. Test data was plotted and, using regression analysis, a best fit line was plotted. Each line was projected out to 40 years with the expected relaxation losses at 40 years ranging from 1.5% to 2.2%. An average relaxation value of 2.0% at 40 years was used in calculating the average tendon prestress loss and developing the tendon force versus time curves for the new tendons.

The new tendons will have a total life of 32 years. The tendon force versus time curves based on prestress losses for new tendons have an initial stressing date of August 2002. The amount of concrete creep/shrinkage losses that are expected to occur between years 29.5 and 61.5 of the original tendon life were determined since the creep/shrinkage loss is a function of time from the point that the Containmentment was originally stressed. Steel relaxation, however, is initiated at the time of stressing of the new tendons. No new concrete elastic shortening losses were considered. For tendons that are newly installed, there will not be an appreciable concrete elastic loss since only a few tendons were permitted to be detensioned at any given time. Since the vast majority of tendons remained in tension at any given time, the concrete Containmentments remained under compressive stress and retained the associated elastic deformations from stressing in the

early 1970s. Equations were developed to determine the amount of average prestress loss due to containment concrete creep and shrinkage between years 29.5 and 61.5, and the amount of prestress loss due to 2% (over 40 years) wire relaxation for 32 years only. Once the 32-year prestress losses were determined, another equation was fitted to the average new tendon initial stressing force and final average calculated tendon force at end-of-life. From this equation, tendon force versus time curves were developed to evaluate future tendon surveillance lift-off force test results. Since the tendon force versus time curves are used to evaluate tendon ISI surveillance lift-off data, the actual average wire relaxation test result of 2% was used in developing the curves instead of the maximum specified wire 40-year relaxation value of 4%.

The same approach was used for the Unit 2 new vertical tendons in developing final tendon force versus time curves. The only differences were the average tendon remaining life and the average initial new tendon stressing force.

5E.3.4 REFERENCES

1. NRC Regulatory Guide 1.35, Revision 2, "Inservice Inspection of UngROUTED Tendons in Prestressed Concrete Containment Structures"
2. Report From Ginna Nuclear Power Station, GAI Report No. 2499, Containment Vessel Tendons – Stress Relaxation Properties of Retensioned Wires, December 1, 1983

TABLE 5E-3

UNIT 1 TENDON POPULATIONS AND EFFECTIVE LIVES

		UNIT 1				
		<u>Vertical Original</u>	<u>Vertical Restressed</u>	<u>Vertical New</u>	<u>Hoop</u>	<u>Dome</u>
A	60-Year Plant License Expiration	7/31/2034	7/31/2034	7/31/2034	7/31/2034	7/31/2034
B	Average Stressing Date (Take as middle of month)	3/1973 ^a	8/18/2002	8/20/2002	11/1971 ^b	11/1971 ^b
C	Years from Stressing Until Plant End-of-Life: A-B (Rounded to 1/4 year)	61.5	32	32	62.75	62.75

^a Per the original Unit 1 prestressing report, nearly the entire population of Unit 1 vertical tendons was detensioned and repairs were made to the anchor bearing plates after initial stressing. The repairs and subsequent restressing of the tendons occurred between January and April 1973. Average date taken was March 1973.

^b Per the original Unit 1 prestressing report, the Unit 1 tendons were initially stressed over a period of nine months between June 1971 and March 1972. Average date taken was November 1971.

TABLE 5E-4

UNIT 2 TENDON POPULATIONS AND EFFECTIVE LIVES

		UNIT 2				
		<u>Vertical Original</u>	<u>Vertical Restressed</u>	<u>Vertical New</u>	<u>Hoop</u>	<u>Dome</u>
A	60-Year Plant License Expiration	8/13/2036	8/13/2036	8/13/2036	8/13/2036	8/13/2036
B	Average Stressing Date (Take as middle of month)	6/1973 ^a	5/2002	6/2002	10/1972 ^b	10/1972 ^b
C	Years from Stressing Until Plant End-of-Life: A-B (Rounded to 1/4 year)	63.25	34.25	34.25	63.75	63.75

^a Per the original Unit 2 prestressing report, nearly the entire population of Unit 2 vertical tendons was detensioned and repairs were made to the anchor bearing plates after initial stressing. The repairs and subsequent restressing of the tendons occurred between April and September 1973. Average date taken was June 1973.

^b Per the original Unit 2 prestressing report, the Unit 2 tendons were initially stressed over a period of eleven months between May 1972 and April 1973. Average date taken was October 1972.