ENCLOSURE

Florida Power and Light Company

Turkey Point Units 3 and 4

FIFTEENTH YEAR TENDON SURVEILLANCE
SUPPLEMENTAL REPORT

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1.0 Background/Purpose

Background

The Units 3 and 4 Turkey Point fifteenth year tendon surveillances were performed in 1988 and the results of the inspections are documented in the surveillance reports (References 4.11 and 4.12).

The fifteenth year tendon surveillance program utilized guidelines described in the proposed draft NRC Regulatory Guide 1.35.1 (Reference 4.7) for determining the predicted upper and lower limit lift-off forces for each individual tendon. This method was a departure from the approach used in the previous surveillances in which the acceptable lower limit was established based on the assumption that 70 percent of the time-dependent losses occur during the first year.

The predicted lower and upper limit lift-off forces for the fifteenth year tendon surveillance were calculated considering the initial losses (elastic shortening loss including the effects of sequence of stressing, friction losses, and anchorage seating losses) and time-dependent losses (shrinkage, creep, and wire relaxation) as outlined in Reference 4.7.

The fifteenth year tendon surveillances for the Turkey Point Units 3 and 4 were performed in accordance with the Plant Technical Specifications (References 4.2 and 4.10).

The Technical Specifications (Reference 4.2) in effect for the fifteenth year tendon surveillance program specified previously inspected tendons as surveillance tendons. These tendons had undergone stressing and restressing operations in the previous surveillances. To take this into account, the measured lift-off must be adjusted to maintain an accurate correlation between the sample tendons and the total tendon population. This adjustment is accomplished by applying an appropriate normalizing factor (correction factor) to the measured lift-off forces. The application of normalizing factors to the measured lift-off forces was omitted in the fifteenth year surveillance program because the guidelines described in the proposed Regulatory Guide 1.35.1 (Reference 4.7) were followed to determine the predicted lower and upper bound limits. These guidelines did not address the application of normalizing factors.

In addition, because the time-dependent losses are subject to variation, a method was presented in Reference 4.7 to account for these variations. This method of varying the time-dependent losses (i.e., shrinkage strain by $\pm$ 20%, creep strain by +25% and -15%, and the stress relaxation value by $\pm$ 15%) to develop the predicted lower and upper limit lift-off forces is more appropriate for a containment in the design stage. The method of varying the time-dependent losses was not used in the original design of containment post-tensioning systems for Turkey Point Units 3 and 4. These containments were designed based on specific values for the time-dependent losses. Increasing these losses at some later time to develop a lower limit could cause

the lower limit to fall below the minimum required design prestress force. This method was inappropriate for use in the fifteenth year surveillance.

Purpose

The purpose of this engineering evaluation is to re-evaluate the results of lift-off measurements obtained during the fifteenth year tendon surveillance of Turkey Point Units 3 and 4 containment post-tensioning system and establish their acceptability.

This evaluation supplements the original final reports issued for the fifteenth year tendon surveillance for Units 3 and 4 (References 4.11 and 4.12). As such, the original conclusions and recommendations included in these reports remain valid unless specifically noted herein.

2.0 Engineering Evaluation

2.1 Background:

The following delineates the fifteenth year surveillance tendons for both units:

Unit 3:

A total of nine tendons were specified by Technical Specification (Reference 4.2) for inspection during the fifteenth year surveillance; a total of twelve tendons were actually inspected.

Dome Tendons: 1D53, 2D28, 3D28

Hoop Tendons: 42H70, 62H18, 64H50, 13H47*

Vertical Tendons: 12V3*, 23V1, 45V7, 61V1, 61V2*

* Undisturbed Tendons - These tendons were not inspected during the surveillances prior to the fifteenth year.

Notes:

1. Tendon 13H47 was inspected to meet the intent of the Technical Specification Implementation Procedure 0-ADM-021 (Reference 4.10). Tendons 12V3 and 61V2 were inspected to satisfy commitments made during the special vertical tendon surveillance performed in 1983.

2. The other nine tendons were listed in the Technical Specifications (Reference 4.2) to be inspected during the tendon surveillance.

Unit 4:

A total of nine tendons were specified by Technical Specification (Reference 4.2) for inspection during the fifteenth year surveillance; a total of 14 tendons were actually inspected.

Dome Tendons: 1D28, 2D3, 3D28

Hoop Tendons: 42H80, 62H38, 64H70, 13H51*, 13H48*, 13H49*, 13H50*, 13H52*

Vertical Tendons: 12V29, 34V29, 56V29

* Undisturbed Tendons - These tendons were not inspected during the surveillances prior to the fifteenth year.

Note: Tendon 13H51 was inspected to meet the intent of the Technical Specification Implementation Procedure 0-ADM-021 (Reference 4.10). In accordance with the procedural requirements, tendons 13H48, 13H49, 13H50, and 13H52 were inspected for lift-off measurement due to low lift-off reading for surveillance tendon 13H51. A special report was submitted to the NRC by FPL Letter L-88-336 (Reference 4.13), which evaluated this condition.

2.2 Method Of Evaluation

The following summarizes the methodology used in this evaluation to demonstrate the acceptability of the fifteenth year measured lift-off forces:

2.2.1 The revised predicted lower and upper limit lift-off forces were established (Reference 4.3). Time-dependent losses specified in the Turkey Point UFSAR (Reference 4.1) were considered to vary linearly with the logarithm of time. Consistent with the previous surveillance methodology and industry observations and assumptions used in the design of the post-tensioning systems based on known material behavior, 70 percent of the time-dependent losses were considered to occur during the first year.

2.2.2 The Turkey Point UFSAR, Section 5.1.4.4 states that the initial seating force was determined (775 kips $\approx$ 0.73 F_u, where F_u = minimum specified ultimate tensile strength of tendon wires) such that the requirements of American Concrete Institute (ACI) 318-63 code were satisfied (i.e., maximum anchor force after elastic losses immediately after anchoring does not exceed 0.7 F_u). Therefore, the average initial tendon seating force (F_i) was considered to be 0.7 F_u in calculating the lower and upper predicted limits.

2.2.3 The normalizing factors used in this evaluation were calculated based on the formulas included in Appendix A. These factors account for variances in the tendon initial seating forces, the sequence of tensioning tendons in different directions, and the subsequent restressing operations which have occurred since the original installation.

The Units 3 and 4 fifteenth year normalized lift-off forces for each individual surveillance tendon and the calculated percentage of the lift-off force with respect to the predicted lower limit (PLL) are listed in Tables 1 and 2. The normalized lift-off values are presented as force per wire.

2.2.4 The predicted upper limit lift-off force is represented (Figure 1) by a line parallel to that of the PLL and starting at a force corresponding to value $0.93F_i$ at one year (F_i = initial seating force). This method is consistent with recommendations made in Reference 4.7. See Figure 1 for the revised predicted lower and upper limits.

2.2.5 The normalized lift-off forces per wire and the PLL were compared. The following decisions/logic were considered:

a) If all individual normalized tendon wire forces in a tendon group (vertical, hoop, dome) were above the respective PLL, the subject tendon group was considered acceptable and no additional evaluation was performed.

b) If any one normalized tendon wire force in a tendon group was below the PLL, then this condition was evaluated in accordance with Section 2.2.6 below.

2.2.6 The average normalized lift-off force per wire for the subject tendon group was calculated. If this value was above the PLL, the subject tendon group was considered acceptable. If this value was below the PLL, additional evaluation as noted in Section 2.2.7 was performed.

2.2.7 The average normalized lift-off force per wire was compared with the minimum expected prestress force per wire (6.55 kips/wire - see Tables 1 and 2) at 40-year design life (calculated based on the UFSAR time-dependent losses). Tendon groups with average normalized lift-off force per wire above this minimum expected force were considered acceptable at the fifteenth year. In addition, the following analysis was performed to demonstrate the acceptability of the tendon group for the 40-year design life:

A statistical regression analysis was performed using the data from previous surveillances (first year through fifteenth year) to predict the 40-year lift-off force per wire. If the 40-year predicted lift-off force per wire for the subject tendon group was greater than the 40-year minimum expected prestress force (6.55 kips/wire), the subject tendon group was considered acceptable for the 40-year design life.

2.2.8 If the average normalized lift-off force per wire was below the 40-year minimum expected prestress force (6.55 kips/wire), the following steps were taken:

The minimum required design prestress force per wire at the anchorage for the subject tendon group was calculated (6.288 kips/wire for hoop tendon group, Reference 4.3). If the average normalized lift-off force per wire and the 40-year predicted lift-off force per wire (calculated in Section 2.2.7) were above the minimum required design prestress force per wire, it was concluded that the subject tendon group provides adequate prestressing force to satisfy the design requirements at fifteenth year and for 40-year plant design life.

The basic philosophy used in the comparisons specified in Sections 2.2.7 and 2.2.8 for the fifteenth year surveillance results is that if some individual normalized tendon forces are below their respective predicted lower limit, further evaluation is required. However, as long as the average prestress force level in the containment is greater than the minimum required design prestress force, sufficient prestress force is provided to satisfy post-tensioning system design basis. This is consistent with the guidelines included in Section 7.1.5 of Reference 4.8 and Section IWL-3220 of Reference 4.9.

2.3 Results of Evaluation

Considering the methodology described in Section 2.2, the following summarizes the results of this evaluation (Refer to Tables 1 and 2, and Figures 1, 2, and 3 for further details. This evaluation is documented in Reference 4.3).

Unit 3:

All individual fifteenth year normalized lift-off forces per wire for the dome tendon group were above the PLL. Therefore, the Unit 3 fifteenth year measured lift-off forces for the dome tendon group are acceptable.

The average fifteenth year normalized lift-off forces per wire for both the vertical and hoop tendon groups were above the PLL. Therefore, the Unit 3 fifteenth year measured lift-off forces for the vertical and hoop tendon groups are acceptable.

Unit 4:

All individual fifteenth year normalized lift-off forces per wire for the vertical tendons were above the PLL. Therefore, the Unit 4 fifteenth year measured lift-off forces for the vertical tendon group are acceptable.

The average fifteenth year normalized lift-off force for the dome tendon group was equal to the PLL. In addition, a further evaluation was performed consisting of a regression analysis which resulted in a 40-year predicted lift-off force above the minimum expected prestress force (6.55 kips/wire). Therefore, the Unit 4 fifteenth year measured lift-off forces for the dome tendon group are acceptable.

The average fifteenth year normalized lift-off force for the hoop tendons was below the PLL and the 40-year minimum expected prestress force but was above the minimum required design prestress force. In addition, the predicted 40-year force was calculated to be 6.283 kips/wire by regression analysis. This predicted force was then compared with the minimum required design prestress force (6.288 kips/wire). Considering the surveillance equipment (jacking ram and pressure gage) calibration tolerance, the difference between the predicted force and the minimum required design prestress force (i.e., 6.283 kips/wire versus 6.288 kips/wire, 0.08% difference) is insignificant and found acceptable. Therefore, the Unit 4 fifteenth year measured lift-off forces for the hoop tendon group are acceptable.

2.4 Design Margins Available in the Post-Tensioning System

Turkey Point UFSAR, Section 5.1.2 states that any three adjacent tendons in any tendon group can be lost without significantly affecting the strength of the containment structure. This design feature considers the load redistribution capabilities of the containment shell.

According to Reference 4.1, Section 5.1.1, the containment is structurally designed to withstand a pressure of 59 psig. This section also states that the transient analysis peak accident pressure is 49.9 psig. This provides additional margin of safety.

3.0 Conclusion

Based on the results of this engineering evaluation and the available margins existing in the design of the Turkey Point Units 3 and 4 post-tensioning systems, it is concluded that:

a) the level of prestress force available in the vertical, hoop, and dome tendons at the end of the fifteenth year tendon surveillance is acceptable.

b) the Turkey Point Units 3 and 4 post-tensioning systems will maintain their structural integrity under all postulated loading conditions and will function within their design basis parameters.

4.0 References

4.1 Turkey Point Units 3 and 4 Updated Final Safety Analysis Report (UFSAR), Revision 9, dated July 1991, Section 5.0.

4.2 Turkey Point Units 3 and 4 Technical Specifications Sections 4.4.5 Amendments 91/85 (effective through Amendments 136/131).

4.3 Bechtel Calculation No. C-SJ539-05, Revision 0.

4.4 Unit 3 Tendon Surveillance Procedure for Containment Structure Post-Tensioning System (Fifteenth Year Surveillance) - Bechtel Procedure 18712-106-CP-1, Revision 4.

4.5 Unit 4 Tendon Surveillance Procedure for Containment Structure Post-Tensioning System (Fifteenth Year Surveillance) - Bechtel Procedure 18712-106-CP-2, Revision 4.

4.6 Proposed Draft Revision 3 to Regulatory Guide 1.35, "In-service Inspection of Ungrouted Tendons in Prestressed Concrete Containment", dated April 1979.

4.7 Proposed Draft Regulatory Guide 1.35.1, "Determining Prestressing Forces For Inspection of Prestressed Concrete Containments", dated April 1979.

4.8 Regulatory Guide 1.35, "In-service Inspection of Ungrouted Tendons in Prestressed Concrete Containment", Revision 3, dated July 1990.

4.9 ASME Code 1989, Section XI - Division 1, Article IWL-3000, "Acceptance Standards".

4.10 Procedure 0-ADM-021, Technical Specification Implementation Procedure, dated March 10, 1988.

4.11 Unit 3 Containment Structure Post-Tensioning System Fifteenth Year Surveillance Report, dated November 11, 1988.

4.12 Unit 4 Containment Structure Post-Tensioning System Fifteenth Year Surveillance Report, dated November 11, 1988.

4.13 Letter, W. F. Conway (FPL) to USNRC Document Control Desk, "Turkey Point Unit 4 Special Report - Low Lift-Off Values of Hoop Tendons, L-88-336, dated August 4, 1988.

TABLE 1 - UNIT 3 FIFTEENTH YEAR NORMALIZED LIFT-OFF FORCES

Fifteenth Year Predicted Lower Limit (PLL) = 6.67 kips/wire

Fifteenth Year Predicted Upper Limit (PUL) = 7.28 kips/wire

Minimum Expected Prestress Force at 40 years = 6.55 kips/wire

Tendon	Measured Normalized Lift-Off Force (kips/wire)		Percentage of PLL
62H18	6.70		100.5%
64H50	6.68		100.2%
42H70	7.10		106.5%
13H47	6.48		97.2%
Avg. Hoop Tendon Force	6.74	kips/wire	101.1%
1D53	7.07		106%
2D28	7.15		107.2%
3D28	7.38		110.6%
Avg. Dome Tendon Force	7.20	kips/wire	107.9%
12V3	6.77		101.5%
23V1	6.99		104.8%
45V7	6.62		99.3%
61V1	6.59		98.8%
61V2	7.04		105.6%
Avg. Vertical Tendon Force	6.80	kips/wire	102%

TABLE 2 - UNIT 4 FIFTEENTH YEAR NORMALIZED LIFT-OFF FORCES

Fifteenth Year Predicted Lower Limit (PLL) = 6.67 kips/wire

Fifteenth Year Predicted Upper Limit (PUL) = 7.28 kips/wire

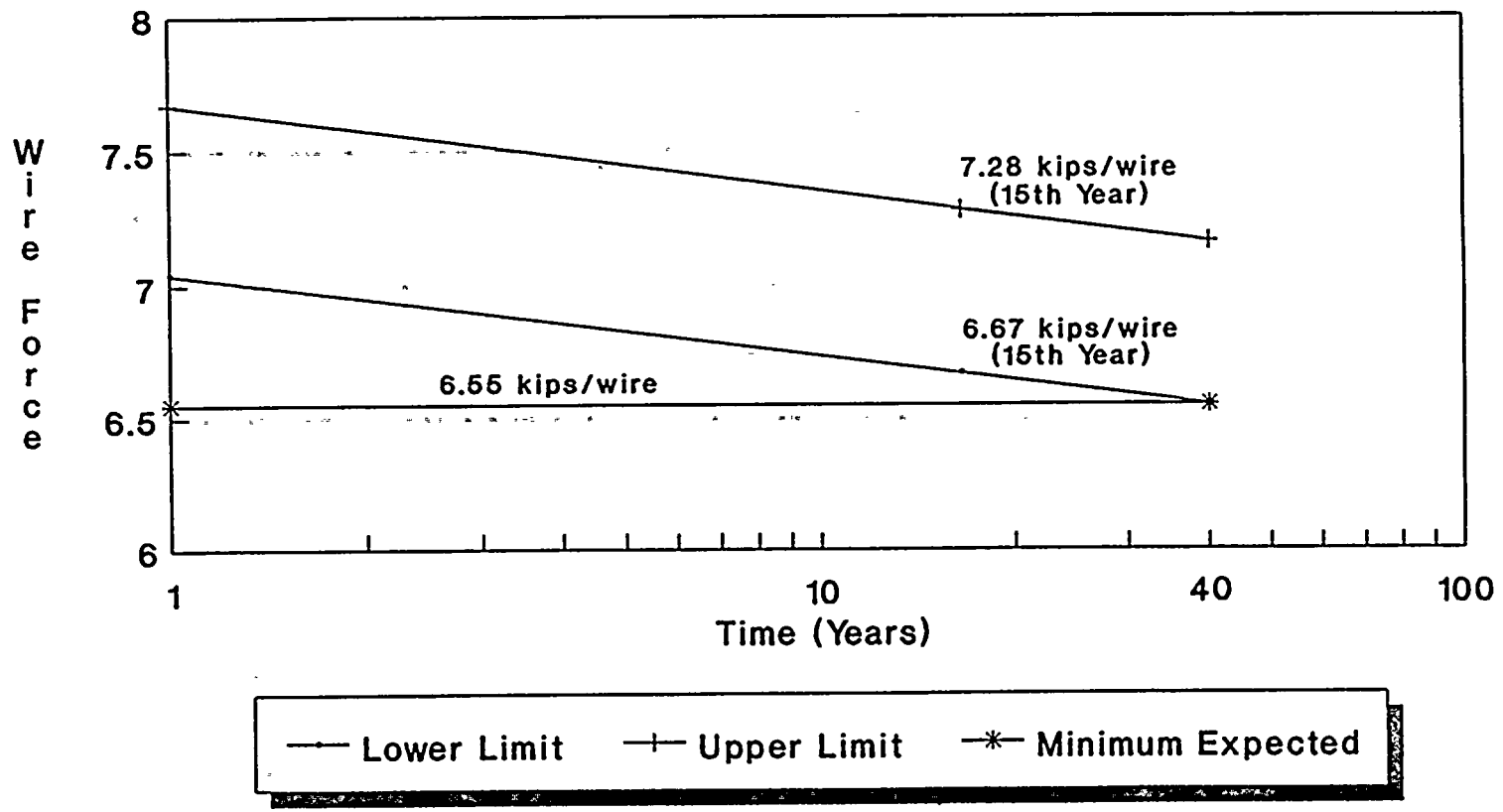
Minimum Expected Prestress Force at 40 years = 6.55 kips/wire

Minimum Required Prestress Force = 6.288 kips/wire
At Anchorage For Hoop Tendons

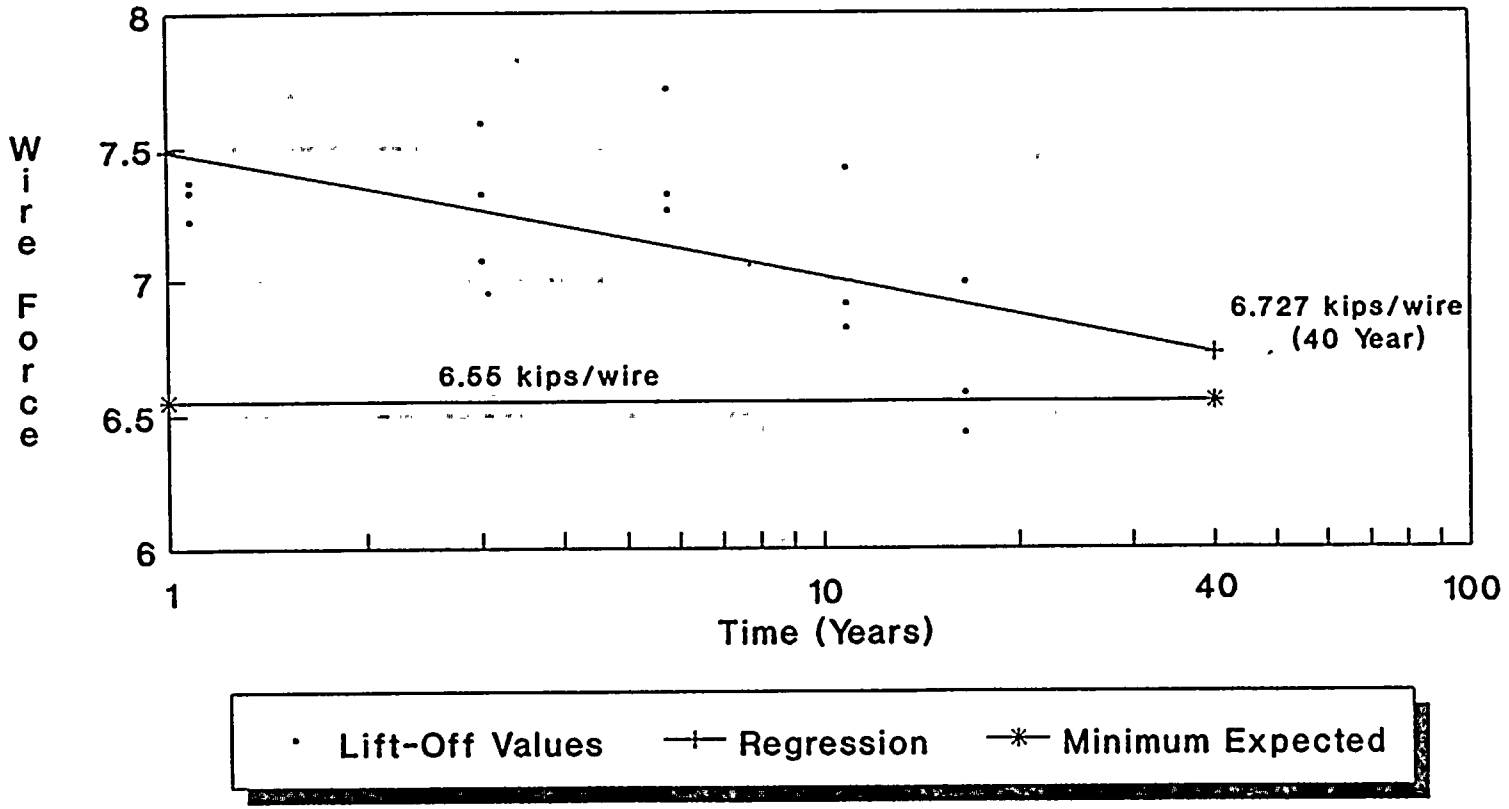
Tendon	Measured Normalized Lift-Off Force (kips/wire)	Percentage of PLL
62H38	6.18	92.7%
64H70	6.14	92.0%
42H80	6.61	99.1%
13H48	6.42	96.3%
13H49	6.38	95.7%
13H50	6.36	95.4%
13H51	6.35	95.2%
13H52	6.62	99.3%
Avg. Hoop Tendon Force	6.38* kips/wire	95.7%
1D28	6.99	104.8%
2D3	6.58	98.7%
3D28	6.43	96.4%
Avg. Dome Tendon Force	6.67* kips/wire	100%
12V29	7.07	106.0%
34V29	7.15	107.2%
56V29	7.01	105.1%
Avg. Vertical Tendon Force	7.08 kips/wire	106.1%

* Note: See Figures 2 and 3 for Regression Analysis Results

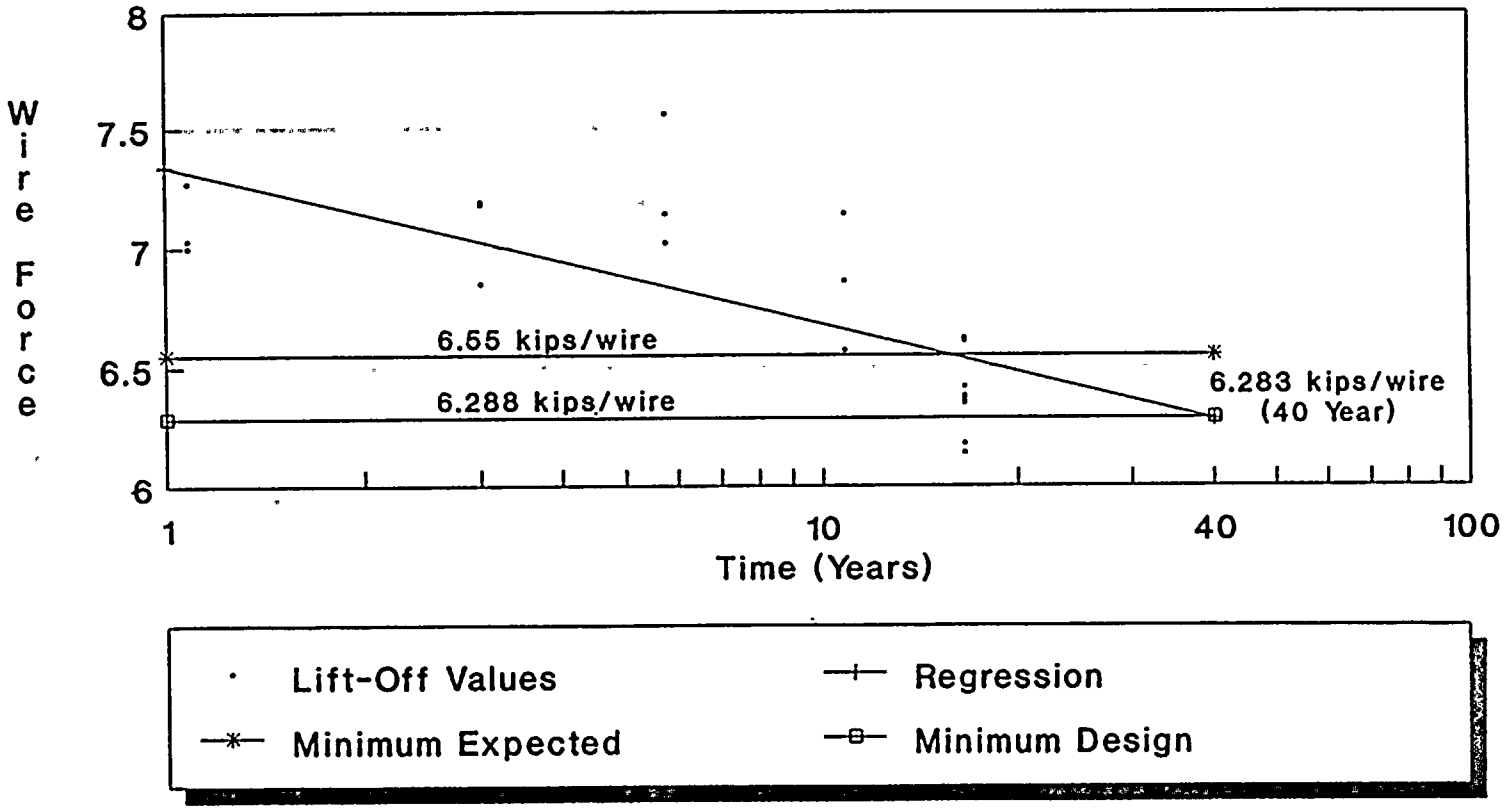
Predicted Lower and Upper Limit Lift-Off
Fifteenth Year Tendon Surveillance
Figure 1



Unit 4 Dome Tendons Regression Analysis
Fifteenth Year Tendon Surveillance
Figure 2



Unit 4 Hoop Tendons Regression Analysis
Fifteenth Year Tendon Surveillance
Figure 3



APPENDIX A

FORMULAS FOR NORMALIZING FACTORS

Normalizing factors for Undisturbed Tendons:

Hoop Tendons

$$N_{f1} = \frac{0.7\ F_u}{\frac{L_c}{N_{wc}\ A_w} - \frac{N_h - n_h}{N_h} \times S_{oh} + \mu \times \frac{N_v - n_v}{N_v} \times S_{ov}}$$

Vertical Tendons

$$N_{f1} = \frac{0.7\ F_u}{\frac{L_c}{N_{wc}\ A_w} - \frac{N_v - n_v}{N_v} \times S_{ov} + \mu \times \frac{N_h - n_h}{N_h} \times S_{oh}}$$

Note: All dome tendons were disturbed. Therefore, no formula for N_{f1} is applicable.

Normalizing Factors For Tendons Restressed In Previous Surveillances:

$$Nf(i) = Nf(i\text{-}1) \times \frac{L(i\text{-}1)}{Lr(i\text{-}1)} \times \frac{Nwr(i\text{-}1)}{Nw(i\text{-}1)}$$

APPENDIX A (CONT.)

NOMENCLATURE

A_w	=	Cross sectional area of one tendon wire (in^2)
F_u	=	Minimum specified ultimate tensile strength of tendon wire (ksi)
L_c	=	Initial seating force of surveillance tendon (kips)
L(i-1)	=	Lift-off force obtained at the (i-1) surveillance (kips)
Lr(i-1)	=	Lift-off force during retensioning at the (i-1) surveillance (kips)
n_h	=	Number of hoop tendons tensioned prior to tensioning (a vertical or hoop) surveillance tendon
N_{f1}	=	Normalizing factor for undisturbed tendon
N_h	=	Total number of hoop tendons
n_v	=	Number of vertical tendons tensioned prior to tensioning (a vertical or hoop) surveillance tendon
N_v	=	Total number of vertical tendons
N_{wc}	=	Number of effective wires in tendon when initially installed
Nw(i-1)	=	Number of effective wires in tendon at (i-1) surveillance
Nwr(i-1)	=	Number of effective wires in tendon during retensioning at (i-1) surveillance
S_{eh}	=	Total elastic loss in hoop tendons (ksi)
S_{ev}	=	Total elastic loss in vertical tendons (ksi)
Nf(i)	=	Normalizing factor for the i^{th} surveillance
Nf(i-1)	=	Normalizing factor for the $(i-1)^{th}$ surveillance
μ	=	Poisson's ratio for concrete