Proposed Corrective Action #1: Oconee will analyze surveillance data for Units 1 and 2 in a manner similar to that performed for Unit 3. Surveillance data for each unit will then be adjusted, as necessary, to account for excessive steel relaxation and/or creep of concrete caused by change(s) in a tendon seating force during surveillance activities.

Modified Lift-off Force Tables

Each tendon lift-off force obtained from preceding surveillances, modified as necessary for the difference between 'as-found' and 'as-left' forces, along with pertinent inspection data from all surveillances performed on Oconee Nuclear Station, Units 1 and 2, is documented in Appendices A (tables A-1 through A-4) and B (tables B-1 through B-3), respectively. Tabulation of data and required computations were performed using Microsoft Excel©, Version 5.0.

Time versus Lift-off Force Plots

Appendices A (figures A-1 through A-3) and B (figures B-1 through B-3) contain time versus lift-off force plots for all tendons inspected on Oconee Nuclear Station, Units 1 and 2, respectively. Plotted lift-off forces are the modified values described above. Minimum required value (MRV) for the respective tendon group - dome, horizontal, and vertical - is also shown on each plot. Plots were performed using Microsoft Excel©, Version 5.0.

Regression Analyses and Plots

Regression analyses were performed for each tendon group - dome, horizontal, and vertical - for Units 1 and 2 on the basis of the plotted data (i.e., time versus modified lift-off forces). Regression analysis summaries and best-fit line plots for Units 1 and 2 are also contained in Appendices A (figures A-4 through A-6) and B (figures B-4 through B-6), respectively.

Regression analyses were performed on a Hewlett-Packard HP 48GX calculator using the pre-programmed statistical function, *FIT DATA* [Reference 1]. The HP 48 can use any of four general regression models in the attempt to quantify the relationship between data in two columns from the current statistical matrix:

Linear Fit	$y = b + mx$
Logarithmic Fit	$y = b + m \ln x$
Exponential Fit	$y = be^{mx}$ or $\ln y = \ln b + mx$
Power Fit	$y = bx^{m}$ or $\ln y = \ln b + m \ln x$

For each general model, *FIT DATA* will determine an intercept (b) and a slope (m) that correspond to the least-squares fit for that model. It also computes and returns the covariance and the correlation coefficient for the regression. Regression analysis revealed that a logarithmic function provided the best-fit line for the plotted data. Plots were performed using Microsoft Excel©, Version 5.0.

Adjustment of Surveillance Data for Change in Steel Relaxation and/or Creep of Concrete

In order to maintain conservatism in analyses documented in Appendices A and B, tendon lift-off forces are *not* adjusted for a change in prestress loss due to steel relaxation and/or creep of concrete associated with a difference between 'as-found' and 'as-left' tendon seating forces. Appendix C contains a representative calculation and discussion of this topic.

Proposed Corrective Action #2: Based upon the outcome of the analyses conducted in corrective action #1, Oconee will perform, as necessary, calculations demonstrating acceptability of *average* prestress force of tendon groups - dome, horizontal, or vertical - which fall below the respective MRV. Because accuracy of computed average prestress force for each tendon group will be increased by maximizing the number of sample data points used in each calculation, average prestress forces for each unit will be computed as follows:

1. **Unit 1: average prestress force for each tendon group - dome, horizontal, and vertical - will be calculated from recorded surveillance data for both Units 1 and 2.**

2. **Unit 3: average prestress force for each tendon group will be calculated from surveillance data for both Units 2 and 3.**

3. **Unit 2: average prestress force for each tendon group will be calculated from surveillance data for all three (3) units.**

Review of regression analyses documented in Appendices A and B (Units 1 and 2, respectively) and those transmitted to NRC by letter dated March 14, 1996 (Unit 3) indicate adverse loss of prestress trends in Units 1 and 2 vertical tendon groups and Unit 3 dome tendon group. However, calculations shown in Appendix C demonstrate that computation of modified tendon lift-off forces (statistical data used for regression analyses) in accordance with NRC item *1a* of letter dated January 19, 1996 is conservative. Despite this fact, average Unit 3 dome tendon surveillance group lift-off force remains within 95.7 percent of its MRV (as of sixth surveillance dated June 1995); average Unit 2 vertical tendon surveillance group lift-off force remains within 99.2 percent of its MRV (as of sixth surveillance dated November 1994); and, average Unit 1 vertical tendon surveillance group lift-off force remains within 99.4 percent of its MRV (as of sixth surveillance dated January 1993).

Regression analyses performed for each unit are based solely upon statistical data (modified tendon lift-off forces) obtained for that unit. Results of regression analyses performed for Units 1, 2 and 3 indicate that combinations of surveillance data, as proposed above, would not appreciably alter loss of prestress trend indicated for vertical tendon group of each unit. Furthermore, such combination of data would disguise the anomalous behavior of Unit 3 dome tendon group.

No preliminary analyses or further justifications of adequacy of existing prestress levels will be performed. [See response to proposed corrective action #5.]

Proposed Corrective Action #3: Oconee will identify and evaluate potential causes of loss of prestress force in excess of those values computed during original plant design.

As stated in Duke's March 14, 1996 submittal to the NRC, Oconee recognizes that original estimates for loss of prestress may have been non-conservative. Computation of prestress loss due to steel relaxation was based upon an assumed average tendon seating stress of 70 percent of nominal Ultimate Tensile Strength (UTS) and following ambient temperature conditions [Reference 2]:

Vertical Tendon Group	79°F
Horizontal Tendon Group	71°F
Dome Tendon Group	74°F

Actual average seating stress for each tendon group was [Reference 3]:

Vertical Tendon Group	0.728 (% UTS)
Horizontal Tendon Group	0.726 (% UTS)
Dome Tendon Group	0.728 (% UTS)

Actual ambient temperature conditions for vertical, horizontal, and dome tendon groups are in the range of 80 to 100°F [Reference 3].

Both preceding conditions contribute to increased prestress loss as a result of steel relaxation *and* creep of concrete. A root cause analysis of accelerated tendon force losses and aberrant loss of prestress trend for Unit 3 dome tendon group will be performed following completion of the containment structure re-analysis discussed in response to proposed corrective action #5 with a planned completion date of March 1, 1997.

Proposed Corrective Action #4: Oconee will revise Technical Specification Section 4.4.2 in order to allow the implementation of a random tendon selection process in accordance with Reg. Guide 1.35 for the next scheduled tendon surveillance in April 1997 (Oconee Unit 1 Outage EOC17).

The proposed amendment to Oconee Nuclear Station Technical Specification Section 4.4.2 is under internal review and will be submitted to the NRC by September 30, 1996.

Proposed Corrective Action #5: If proposed corrective actions 1, 2 and 4 indicate that the Oconee containments' post-tensioning system provides an *average* level of prestress which is less than that necessary to satisfy its design basis requirements throughout the life of the plant, Oconee will re-analyze the containment structure using state-of-the-art analytical methods and tools in order to establish new MRV for each tendon group.

Containment structure analyses which support MRVs documented in Duke's response to NRC request *1c* of letter dated January 19, 1996 were performed using 1960s technology and methodologies. A re-analysis of the Oconee Nuclear Station Containment structures (one similar to that performed in 1994 for Florida Power & Light Company's Turkey Point Units 3 & 4 Containment structures), using state-of-the-art analytical methods and tools, would in all probability demonstrate ability of the containment structure to satisfy all design licensing basis requirements under prestressing forces lower than original design MRVs.

Oconee believes that sufficient evidence exists at this time to warrant a re-analysis of the containment structure in order to establish new MRVs for dome and vertical tendon groups. In addition to demonstrating that Oconee containments' post-tensioning systems provide a level of prestress sufficient to satisfy their design basis requirements throughout the life of the plant, these computations will support Oconee's application for a renewal license as permitted by 10 CFR Part 54.17(e). The re-analysis will consist of a non-linear finite element analysis methodology. The planned completion date is January 1, 1997.

References

1. *Hewlett-Packard HP 48G Series User's Guide*, ©Copyright Hewlett-Packard Company 1993.

2. Letter dated 6 October 1969 from L. Q. Mills (Prescon Corporation) to M. Malcom (Bechtel Corporation).

3. Duke Power Company Calculation OSC-2125, *Reactor Building Post-Tensioned Tendon Surveillance Program Review*.

APPENDIX A

Table A-1: Unit 1 Dome Tendons - Surveillance Data and Modified Lift-off Forces

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Method of Ram Pressure to Force Conversion	Shop End[15] Lift-off Pressure (psi)		Shop End[15] Lift-off Force (kips)		Field End[15] Lift-off Pressure (psi)		Field End[15] Lift-off Force (kips)		Average[15] Lift-off Force (kips)	
1D28	Date Stressed 6/26/70[1]			Ram Area[16]		6600		793.3		6600		793.3		793.3
	1st / Oct. - Dec. 1972[2]	30	21900	Ram Area[16]	5933	5920	713.1	711.6	6133	6150	737.2	739.2	725.2	725.4
	2nd / 11/15/74[4]	23	38690	Ram Area[16]	5917		711.2		6033		725.2		718.2	
	3rd / 12/21/77[5]	37	65700	Ram Area[16]	5950		715.2		5717		687.2		701.2	
	4th / 10/14/84[6, 7, 8]	82	125560	Calibration[17]	6200		734		5700		670		702.0	
	5th / 9/18/87[12, 13]	35	151110	Calibration[17]	5700	5500	680	660	6100	5950	735	720	707.5	690.0
	6th / 1/05/93[9, 10]	64	197830	Calibration[17]	5800	5800	697.2	697.2	5600	5600	669	669	683.1	683.1
2D28	Date Stressed 6/23/70[1]			Ram Area[16]		6500		781.3		6500		781.3		781.3
	1st / Oct. - Dec. 1972[2]	30	21900	Ram Area[16]	6225		748.2		6117		735.3		741.8	
	2nd 11/18/74[4]	23	38690	Ram Area[16]	6225	6400	748.2	769.3	6050	6350	727.2	763.3	737.7	766.3
	3rd / 12/19/77[5]	37	65700	Ram Area[16]	6230		748.8		5975		718.2		733.5	
	4th / 10/13/84[6, 7]	82	125560	Calibration[17]	6200		730		6000		713		721.5	
	5th / 9/22/87[12, 13]	35	151110	Calibration[17]	6150		745		6200		745		745.0	
	6th / 12/30/92[9, 10, 11]	63	197100	Calibration[17]	6050		723.4		6050		727.9		725.7	
3D28[8]	Date Stressed 7/8/70[1]			Ram Area[16]		6550		787.3		6550		787.3		787.3
	1st / Oct. - Dec. 1972[2]	29	21170	Ram Area[16]	6383		767.2		5767		693.2		730.2	
	2nd / 11/15/74[4]	23	37960	Ram Area[16]	5825		700.2		6350		763.3		731.7	
	3rd / 12/28/77[5]	37	64970	Ram Area[16]	6000	6400	721.2	769.3	6300	6250	757.3	751.3	739.2	760.3
	4th / 10/13/84[6, 7]	82	124830	Calibration[17]	6500	6300	765	740	6400	6200	759	734	762.0	737.0
	5th / 9/21/87[12, 13]	35	150380	Calibration[17]	6450		775		6150		750		762.5	
	6th / 1/04/93[9, 10, 11]	64	197100	Calibration[17]	6050		727.9		6050		723.4		725.7	

Table A-1: Unit 1 Dome Tendons - Surveillance Data and Modified Lift-off Forces (cont.)

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Cumulative[18] Number of Wires Missing/Removed	Initial[1] Number of Wires	Effective Number of Wires	Force[15] per Wire kips		Stress[15] f_p = force / ΠR^2 (R = 0.25" / 2) ksi	
1D28	Date Stressed 6/26/70[1]				92	92		8.62		175.7
	1st / Oct. - Dec. 1972[2]	30	21900	1		91	7.88	7.97	160.6	162.4
	2nd / 11/15/74[4]	23	38690	1		91	7.89		160.8	
	3rd / 12/21/77[5]	37	65700	1		91	7.71		157.0	
	4th / 10/14/84[6, 7, 8]	82	125560	3		89	7.71		157.2	
	5th / 9/18/87[12, 13]	35	151110	4		88	7.95	7.84	161.9	159.7
	6th / 1/05/93[9, 10]	64	197830	5		87	7.76	7.85	158.1	160.0
2D28	Date Stressed 6/23/70[1]				93	93		8.40		171.1
	1st / Oct. - Dec. 1972[2]	30	21900			93	7.98		162.5	
	2nd 11/18/74[4]	23	38690	1		92	7.93	8.33	161.6	169.7
	3rd / 12/19/77[5]	37	65700	1		92	7.97		162.4	
	4th / 10/13/84[6, 7]	82	125560	1		92	7.84		159.8	
	5th / 9/22/87[12, 13]	35	151110	1		92	8.10		165.0	
	6th / 12/30/92[9, 10, 11]	63	197100	1		92	7.89		160.7	
3D28[8]	Date Stressed 7/8/70[1]				93	93		8.47		172.5
	1st / Oct. - Dec. 1972[2]	29	21170			93	7.85		160.0	
	2nd / 11/15/74[4]	23	37960			93	7.87		160.3	
	3rd / 12/28/77[5]	37	64970	1		92	7.95	8.26	161.9	168.3
	4th / 10/13/84[6, 7]	82	124830	2		91	8.28	8.10	168.7	165.0
	5th / 9/21/87[12, 13]	35	150380	2		91	8.38		170.7	
	6th / 1/04/93[9, 10, 11]	64	197100	2		91	7.97		162.4	

Table A-1: Unit 1 Dome Tendons - Surveillance Data and Modified Lift-off Forces (cont.)

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Force[15] per Wire kips		$\Delta_{seating\ force\ per\ wire}$ = force/wire'as-left' - force/wire'as found' kips	$\Sigma\Delta_{seating\ force\ per\ wire}$[18] kips	Modified force/wire = force/wire'as found' - $\Sigma\Delta_{seating\ force\ per\ wire\ from\ previous\ su}$ kips	Time[19] from Installation years
1D28	Date Stressed 6/26/70[1]				8.62			8.62	0.01
	1st / Oct. - Dec. 1972[2]	30	21900	7.88	7.97	0.09	0.09	7.88	2.50
	2nd / 11/15/74[4]	23	38690	7.89			0.09	7.80	4.42
	3rd / 12/21/77[5]	37	65700	7.71			0.09	7.62	7.50
	4th / 10/14/84[6, 7, 8]	82	125560	7.71			0.09	7.63	14.33
	5th / 9/18/87[12, 13]	35	151110	7.95	7.84	-0.11	-0.02	7.86	17.25
	6th / 1/05/93[9, 10]	64	197830	7.76	7.85	0.09	0.07	7.78	22.58
2D28	Date Stressed 6/23/70[1]				8.40			8.40	0.01
	1st / Oct. - Dec. 1972[2]	30	21900	7.98				7.98	2.50
	2nd 11/18/74[4]	23	38690	7.93	8.33	0.40	0.40	7.93	4.42
	3rd / 12/19/77[5]	37	65700	7.97			0.40	7.58	7.50
	4th / 10/13/84[6, 7]	82	125560	7.84			0.40	7.45	14.33
	5th / 9/22/87[12, 13]	35	151110	8.10			0.40	7.70	17.25
	6th / 12/30/92[9, 10, 11]	63	197100	7.89			0.40	7.49	22.50
3D28[8]	Date Stressed 7/8/70[1]				8.47			8.47	0.01
	1st / Oct. - Dec. 1972[2]	29	21170	7.85				7.85	2.42
	2nd / 11/15/74[4]	23	37960	7.87				7.87	4.33
	3rd / 12/28/77[5]	37	64970	7.95	8.26	0.32	0.32	7.95	7.42
	4th / 10/13/84[6, 7]	82	124830	8.28	8.10	-0.18	0.13	7.97	14.25
	5th / 9/21/87[12, 13]	35	150380	8.38			0.13	8.25	17.17
	6th / 1/04/93[9, 10, 11]	64	197100	7.97			0.13	7.84	22.50

Table A-2: Unit 1 Horizontal Tendons - Surveillance Data and Modified Lift-off Forces

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Method of Ram Pressure to Force Conversion	Shop End[15] Lift-off Pressure (psi)		Shop End[15] Lift-off Force (kips)		Field End[15] Lift-off Pressure (psi)		Field End[15] Lift-off Force (kips)		Average[15] Lift-off Force (kips)	
13H9[8]	Date Stressed 7/22/70[1]			Ram Area[16]		6475		778.3		6475		778.3		778.3
	1st / Oct. - Dec. 1972[2]	29	21170	Ram Area[16]	5600	5917	673.1	711.2	5700	5900	685.1	709.2	679.1	710.2
	2nd / 11/22/74[4]	23	37960	Ram Area[16]	6008		722.2		5900		709.2		715.7	
	3rd / 7/5/77[5]	32	61320	Ram Area[16]	6037		725.6		5925		712.2		718.9	
	4th / 12/14/84[6, 7]	89	126290	Calibration[17]	5850	6400	690	755	5750	6200	684	734	687.0	744.5
	5th / 11/7/87[12, 13]	35	151840	Calibration[17]	5900		710		6100		735		722.5	
	6th / 7/09/91[9, 10]	44	183960	Calibration[17]	6000	5800	721.7	697.1	6000	5800	716.1	691.5	718.9	694.3
51H9	Date Stressed 7/22/70[1]			Ram Area[16]		6450		775.3		6450		775.3		775.3
	1st / Oct. - Dec. 1972[2]	29	21170	Ram Area[16]	5950		715.2		5667		681.2		698.2	
	2nd / 11/29/74[4]	23	37960	Ram Area[16]	5725	6300	688.1	757.3	5750	6400	691.2	769.3	689.6	763.3
	3rd / 7/3/77[5]	32	61320	Ram Area[16]	6017		723.2		6150		739.2		731.2	
	4th / 12/11/84[6, 7]	89	126290	Calibration[17]	6400		755		6150		731		743.0	
	5th / 11/02/87[12, 13]	35	151840	Calibration[17]	6000	5900	720	710	5900	5900	710	710	715.0	710.0
	6th / 7/30/91[9, 10]	44	183960	Calibration[17]	5800	5800	690.5	690.5	5900	5900	709.6	709.6	700.1	700.1
53H10	Date Stressed 7/22/70[1]			Ram Area[16]		6575		790.3		6575		790.3		790.3
	1st / Oct. - Dec. 1972[2]	29	21170	Ram Area[16]	5983		719.2		5600		673.1		696.1	
	2nd / 12/3/74[4]	24	38690	Ram Area[16]	5950		715.2		5900		709.2		712.2	
	3rd / 6/30/77[5]	30	60590	Ram Area[16]	5967	6400	717.2	769.3	5717	6350	687.2	763.3	702.2	766.3
	4th / 11/17/84[6, 7, 8]	89	125560	Calibration[17]	6100	6500	720	765	6250	6350	744	756	732.0	760.5
	5th / 11/16/87[12, 13]	36	151840	Calibration[17]	5900		710		5700		690		700.0	
	6th / 7/10/91[9, 10]	44	183960	Calibration[17]	6100	6250	733	751	5750	5750	691.2	691.2	712.1	721.1

Table A-2: Unit 1 Horizontal Tendons - Surveillance Data and Modified Lift-off Forces (cont.)

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Cumulative[18] Number of Wires Missing/Removed	Initial[1] Number of Wires	Effective Number of Wires	Force[15] per Wire kips		Stress[15] f_p = force / ΠR^2 (R = 0.25" / 2) ksi	
13H9[8]	Date Stressed 7/22/70[1]				90	90		8.65		176.2
	1st / Oct. - Dec. 1972[2]	29	21170	2		88	7.55	8.07	153.7	164.4
	2nd / 11/22/74[4]	23	37960	2		88	8.13		165.7	
	3rd / 7/5/77[5]	32	61320	2		88	8.17		166.4	
	4th / 12/14/84[6, 7]	89	126290	2		88	7.81	8.46	159.0	172.4
	5th / 11/7/87[12, 13]	35	151840	2		88	8.21		167.3	
	6th / 7/09/91[9, 10]	44	183960	2		88	8.17	7.89	166.4	160.7
51H9	Date Stressed 7/22/70[1]				90	90		8.61		175.5
	1st / Oct. - Dec. 1972[2]	29	21170			90	7.76		158.0	
	2nd / 11/29/74[4]	23	37960	1		89	7.66	8.58	156.1	174.7
	3rd / 7/3/77[5]	32	61320	1		89	8.22		167.4	
	4th / 12/11/84[6, 7]	89	126290	1		89	8.35		170.1	
	5th / 11/02/87[12, 13]	35	151840	2		88	8.03	8.07	163.7	164.4
	6th / 7/30/91[9, 10]	44	183960	3		87	7.96	8.05	162.1	163.9
53H10	Date Stressed 7/22/70[1]				90	90		8.78		178.9
	1st / Oct. - Dec. 1972[2]	29	21170			90	7.73		157.6	
	2nd / 12/3/74[4]	24	38690			90	7.91		161.2	
	3rd / 6/30/77[5]	30	60590	1		89	7.80	8.61	158.9	175.4
	4th / 11/17/84[6, 7, 8]	89	125560	3		87	8.22	8.74	167.6	178.1
	5th / 11/16/87[12, 13]	36	151840	4		86	8.05		163.9	
	6th / 7/10/91[9, 10]	44	183960	4		86	8.28	8.38	168.7	170.8

Table A-2: Unit 1 Horizontal Tendons - Surveillance Data and Modified Lift-off Forces (cont.)

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Force[15] per Wire kips		$\Delta_{seating\ force\ per\ wire}$ = force/wire$_{'as\text{-}left'}$ - force/wire$_{'as\ found'}$ [18] kips	$\Sigma\Delta_{seating\ force\ per\ wire}$[18] kips	Modified force/wire = force/wire$_{'as\ found'}$ - $\Sigma\Delta_{seating\ force\ per\ wire\ from\ previous\ sur}$ kips	Time[19] from Installation years
13H9[8]	Date Stressed 7/22/70[1]				8.65			8.65	0.01
	1st / Oct. - Dec. 1972[2]	29	21170	7.55	8.07	0.52	0.52	7.55	2.42
	2nd / 11/22/74[4]	23	37960	8.13			0.52	7.61	4.33
	3rd / 7/5/77[5]	32	61320	8.17			0.52	7.64	7.00
	4th / 12/14/84[6, 7]	89	126290	7.81	8.46	0.65	1.18	7.28	14.42
	5th / 11/7/87[12, 13]	35	151840	8.21			1.18	7.03	17.33
	6th / 7/09/91[9, 10]	44	183960	8.17	7.89	-0.28	0.90	6.99	21.00
51H9	Date Stressed 7/22/70[1]				8.61			8.61	0.01
	1st / Oct. - Dec. 1972[2]	29	21170	7.76				7.76	2.42
	2nd / 11/29/74[4]	23	37960	7.66	8.58	0.91	0.91	7.66	4.33
	3rd / 7/3/77[5]	32	61320	8.22			0.91	7.30	7.00
	4th / 12/11/84[6, 7]	89	126290	8.35			0.91	7.43	14.42
	5th / 11/02/87[12, 13]	35	151840	8.03	8.07	0.03	0.95	7.12	17.33
	6th / 7/30/91[9, 10]	44	183960	7.96	8.05	0.09	1.04	7.01	21.00
53H10	Date Stressed 7/22/70[1]				8.78			8.78	0.01
	1st / Oct. - Dec. 1972[2]	29	21170	7.73				7.73	2.42
	2nd / 12/3/74[4]	24	38690	7.91				7.91	4.42
	3rd / 6/30/77[5]	30	60590	7.80	8.61	0.81	0.81	7.80	6.92
	4th / 11/17/84[6, 7, 8]	89	125560	8.22	8.74	0.52	1.32	7.42	14.33
	5th / 11/16/87[12, 13]	36	151840	8.05			1.32	6.72	17.33
	6th / 7/10/91[9, 10]	44	183960	8.28	8.38	0.10	1.43	6.96	21.00

Table A-3: Unit 1 Vertical Tendons - Surveillance Data and Modified Lift-off Forces

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Method of Ram Pressure to Force Conversion	Shop End[15] Lift-off Pressure (psi)		Shop End[15] Lift-off Force (kips)		Field End[15] Lift-off Pressure (psi)		Field End[15] Lift-off Force (kips)		Average[15] Lift-off Force (kips)	
23V14	Date Stressed 8/11/70[1]			Ram Area[16]		6500		781.3		6500		781.3		781.3
	1st / Oct. - Dec. 1972[2]	28	20440	Ram Area[16]	5717	5883	687.2	707.1	6000	5983	721.2	719.2	704.2	713.1
	2nd / 12/9/74[4]	24	37960	Ram Area[16]	5750		691.2		5867		705.2		698.2	
	3rd / 12/15/77[5]	36	64240	Ram Area[16]	5800		697.2		5983		719.2		708.2	
	4th / 10/17/84[6, 7]	82	124100	Calibration[17]	5700		670		5800		688		679.0	
	5th / 10/02/87[12, 13]	36	150380	Calibration[17]	5950	5950	715	715	5800	5850	700	705	707.5	710.0
	6th / 12/21/92[9, 10]	62	195640	Calibration[17]	5800	5800	693	693	5850	5850	703.4	703.4	698.2	698.2
45V16	Date Stressed 8/5/70[1]			Ram Area[16]		6400		769.3		6400		769.3		769.3
	1st / Oct. - Dec. 1972[2]	28	20440	Ram Area[16]	5683		683.1		Note 3				683.1	
	2nd / 12/5/74[4]	24	37960	Ram Area[16]	5700	6500	685.1	781.3	Note 3				685.1	781.3
	3rd / 12/15/77[5]	36	64240	Ram Area[16]	5930		712.8		Note 3				712.8	
	4th / 10/18/84[6, 7]	82	124100	Calibration[17]	6300		740		Note 3				740.0	
	5th / 11/03/87[12, 13]	37	151110	Calibration[17]	6350		765		Note 3				765.0	
	6th / 12/15/92[9, 10, 11]	61	195640	Calibration[17]	6050		723.4		Note 3				723.4	
61V16	Date Stressed 8/7/70[1, 4]			Ram Area[16]		6550		787.3		6550		787.3		787.3
	1st / Oct. - Dec. 1972[2]	28	20440	Ram Area[16]	5800		697.2		5967		717.2		707.2	
	2nd / 12/09/74[4]	24	37960	Ram Area[16]	5675		682.1		5667		681.2		681.7	
	3rd / 12/13/77[5]	36	64240	Ram Area[16]	5800	6250	697.2	751.3	5800	6450	697.2	775.3	697.2	763.3
	4th / 10/16/84[6, 7]	82	124100	Calibration[17]	6200	6300	730	740	6200	6350	734	756	732.0	748.0
	5th / 11/04/87[12, 13]	37	151110	Calibration[17]	6350		770		6300		755		762.5	
	6th / 12/18/92[9, 10, 11]	61	195640	Calibration[17]	6050		726.6		6050		727.9		727.3	

Table A-3: Unit 1 Vertical Tendons - Surveillance Data and Modified Lift-off Forces (cont.)

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Cumulative[18] Number of Wires Missing/Removed	Initial[1] Number of Wires	Effective Number of Wires	Force[15] per Wire kips		Stress[15] f_p = force / ΠR^2 (R = 0.25" / 2) ksi	
23V14	Date Stressed 8/11/70[1]				90	90		8.68		176.9
	1st / Oct. - Dec. 1972[2]	28	20440	1		89	7.82	8.01	159.4	163.2
	2nd / 12/9/74[4]	24	37960	1		89	7.84		159.8	
	3rd / 12/15/77[5]	36	64240	1		89	7.96		162.1	
	4th / 10/17/84[6, 7]	82	124100	1		89	7.63		155.4	
	5th / 10/02/87[12, 13]	36	150380	2		88	7.95	8.07	161.9	164.4
	6th / 12/21/92[9, 10]	62	195640	3		87	7.93	8.03	161.6	163.5
45V16	Date Stressed 8/5/70[1]				88	88		8.74		178.1
	1st / Oct. - Dec. 1972[2]	28	20440			88	7.76		158.1	
	2nd / 12/5/74[4]	24	37960	1		87	7.79	8.98	158.6	182.9
	3rd / 12/15/77[5]	36	64240	1		87	8.19		166.9	
	4th / 10/18/84[6, 7]	82	124100	1		87	8.51		173.3	
	5th / 11/03/87[12, 13]	37	151110	1		87	8.79		179.1	
	6th / 12/15/92[9, 10, 11]	61	195640	1		87	8.31		169.4	
61V16	Date Stressed 8/7/70[1, 4]				90	90		8.75		178.2
	1st / Oct. - Dec. 1972[2]	28	20440			90	7.86		160.1	
	2nd / 12/09/74[4]	24	37960			90	7.57		154.3	
	3rd / 12/13/77[5]	36	64240	1		89	7.75	8.58	157.8	174.7
	4th / 10/16/84[6, 7]	82	124100	2		88	8.22	8.50	167.6	173.2
	5th / 11/04/87[12, 13]	37	151110	2		88	8.66		176.5	
	6th / 12/18/92[9, 10, 11]	61	195640	2		88	8.26		168.4	

Table A-3: Unit 1 Vertical Tendons - Surveillance Data and Modified Lift-off Forces (cont.)

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Force[15] per Wire kips		$\Delta_{seating\ force\ per\ wire}$ = force/wire$_{'as\text{-}left'}$ - force/wire$_{'as\ found'}$ kips[18]	$\Sigma\Delta_{seating\ force\ per\ wire}$ kips[18]	Modified force/wire = force/wire$_{'as\ found'}$ - $\Sigma\Delta_{seating\ force\ per\ wire\ from\ previous\ su}$ kips	Time[19] from Installation years
23V14	Date Stressed 8/11/70[1]				8.68			8.68	0.01
	1st / Oct. - Dec. 1972[2]	28	20440	7.82	8.01	0.19	0.19	7.82	2.33
	2nd / 12/9/74[4]	24	37960	7.84			0.19	7.66	4.33
	3rd / 12/15/77[5]	36	64240	7.96			0.19	7.77	7.33
	4th / 10/17/84[6, 7]	82	124100	7.63			0.19	7.44	14.17
	5th / 10/02/87[12, 13]	36	150380	7.95	8.07	0.12	0.31	7.76	17.17
	6th / 12/21/92[9, 10]	62	195640	7.93	8.03	0.09	0.40	7.63	22.33
45V16	Date Stressed 8/5/70[1]				8.74			8.74	0.01
	1st / Oct. - Dec. 1972[2]	28	20440	7.76				7.76	2.33
	2nd / 12/5/74[4]	24	37960	7.79	8.98	1.19	1.19	7.79	4.33
	3rd / 12/15/77[5]	36	64240	8.19			1.19	7.00	7.33
	4th / 10/18/84[6, 7]	82	124100	8.51			1.19	7.31	14.17
	5th / 11/03/87[12, 13]	37	151110	8.79			1.19	7.60	17.25
	6th / 12/15/92[9, 10, 11]	61	195640	8.31			1.19	7.12	22.33
61V16	Date Stressed 8/7/70[1, 4]				8.75			8.75	0.01
	1st / Oct. - Dec. 1972[2]	28	20440	7.86				7.86	2.33
	2nd / 12/09/74[4]	24	37960	7.57				7.57	4.33
	3rd / 12/13/77[5]	36	64240	7.75	8.58	0.83	0.83	7.75	7.33
	4th / 10/16/84[6, 7]	82	124100	8.22	8.50	0.28	1.11	7.39	14.17
	5th / 11/04/87[12, 13]	37	151110	8.66			1.11	7.56	17.25
	6th / 12/18/92[9, 10, 11]	61	195640	8.26			1.11	7.16	22.33

Table A-4: Unit 1 Non-surveillance Tendons - Surveillance Data and Modified Lift-off Forces

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Method of Ram Pressure to Force Conversion	Shop End[15] Lift-off Pressure (psi)	Shop End[15] Lift-off Force (kips)	Field End[15] Lift-off Pressure (psi)	Field End[15] Lift-off Force (kips)	Average[15] Lift-off Force (kips)
1D11[14]	Date Stressed 6/04/70[1]			Ram Area[16]	6400	769.3	6400	769.3	769.3
	6th / 12/06/92[9, 10]	270	197100	Calibration[17]	5200	622.1	4800	574	598.1
26H62[14]	Date Stressed 10/24/70[1]			Ram Area[16]	6500	781.3	6500	781.3	781.3
	6th / 12/05/92[9, 10]	266	194180	Calibration[17]	5200	622.1	5250	629.4	625.8
45V11[14]	Date Stressed 8/03/70[1]			Ram Area[16]	6400	769.3	6400	769.3	769.3
	6th / 12/08/92[9, 10]	268	195640	Calibration[17]	5550	665.2	5050	604.8	635.0
53H28[14]	Date Stressed 7/17/70[1]			Ram Area[16]	6450	775.3	6450	775.3	775.3
	3rd / 8/19/77[5]	85	62050	Ram Area[16]	5800	697.2	5800	697.2	697.2

Table A-4: Unit 1 Non-surveillance Tendons - Surveillance Data and Modified Lift-off Forces (cont.)

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Cumulative[18] Number of Wires Missing/Removed	Initial[1] Number of Wires	Effective Number of Wires	Force[15] per Wire kips	Stress[15] f_p = force / ΠR^2 (R = 0.25" / 2) ksi
1D11[14]	Date Stressed 6/04/70[1]				90	90	8.55	174.1
	6th / 12/06/92[9, 10]	270	197100			90	6.65	135.4
26H62[14]	Date Stressed 10/24/70[1]				90	90	8.68	176.9
	6th / 12/05/92[9, 10]	266	194180			90	6.95	141.6
45V11[14]	Date Stressed 8/03/70[1]				90	90	8.55	174.1
	6th / 12/08/92[9, 10]	268	195640			90	7.06	143.7
53H28[14]	Date Stressed 7/17/70[1]				90	90	8.61	175.5
	3rd / 8/19/77[5]	85	62050			90	7.75	157.8

Table A-4: Unit 1 Non-surveillance Tendons - Surveillance Data and Modified Lift-off Forces (cont.)

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Force[15] per Wire kips	$\Delta_{\text{seating force per wire}}$ = force/wire$_{\text{'as-left'}}$ - force/wire$_{\text{'as found'}}$ kips[18]	$\Sigma\Delta_{\text{seating force per wire}}$ kips[18]	Modified force/wire = force/wire$_{\text{'as found'}}$ - $\Sigma\Delta_{\text{seating force per wire from previous su}}$ kips
1D11[14]	Date Stressed 6/04/70[1]			8.55			8.55
	6th / 12/06/92[9, 10]	270	197100	6.65			6.65
26H62[14]	Date Stressed 10/24/70[1]			8.68			8.68
	6th / 12/05/92[9, 10]	266	194180	6.95			6.95
45V11[14]	Date Stressed 8/03/70[1]			8.55			8.55
	6th / 12/08/92[9, 10]	268	195640	7.06			7.06
53H28[14]	Date Stressed 7/17/70[1]			8.61			8.61
	3rd / 8/19/77[5]	85	62050	7.75			7.75

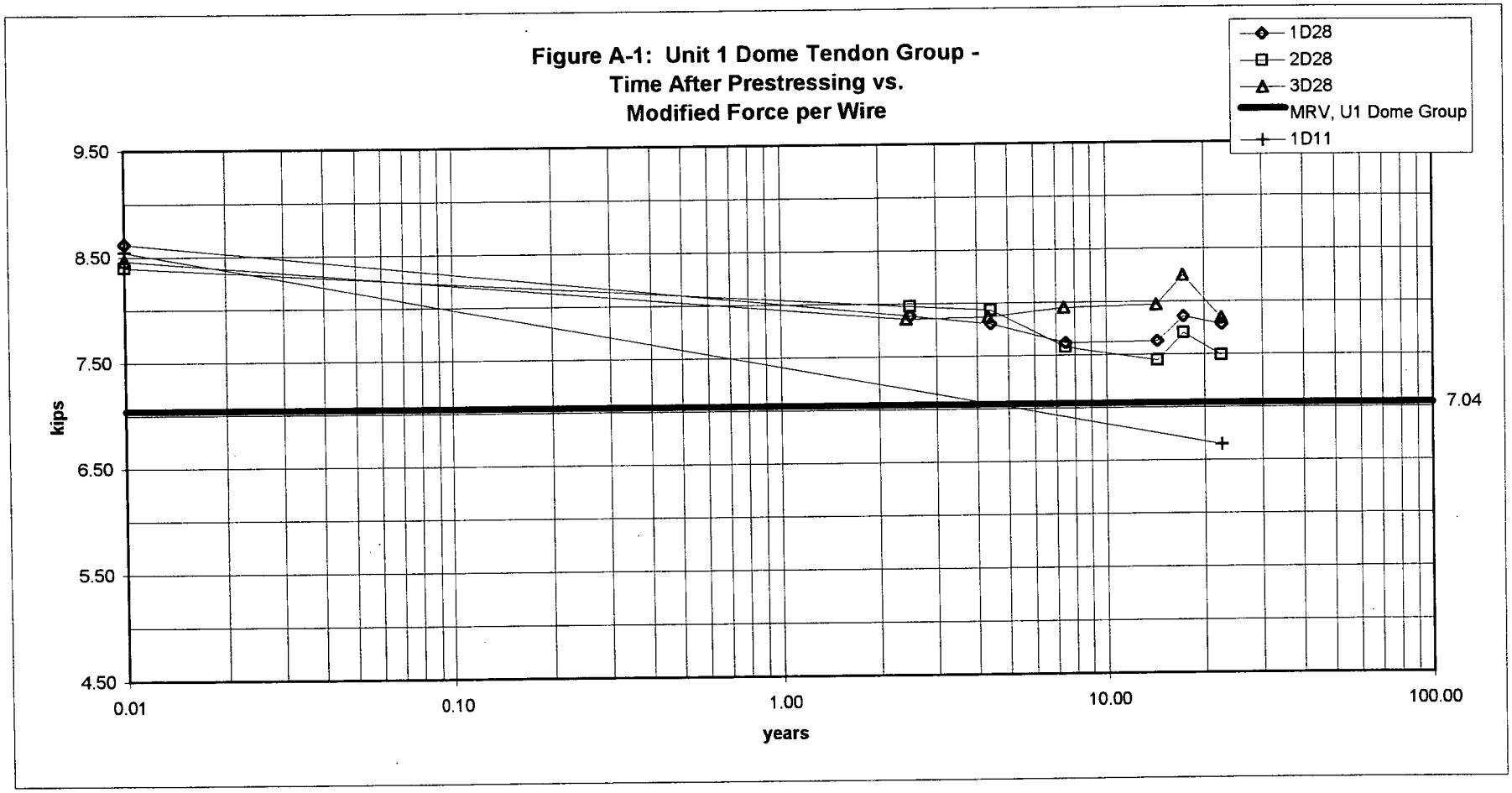
Figure A-1: Unit 1 Dome Tendon Group -
Time After Prestressing vs.
Modified Force per Wire
1D28
2D28
3D28
MRV, U1 Dome Group
1D11
9.50
8.50
7.50
6.50
5.50
4.50
kips
7.04
0.01
0.10
1.00
10.00
100.00
years

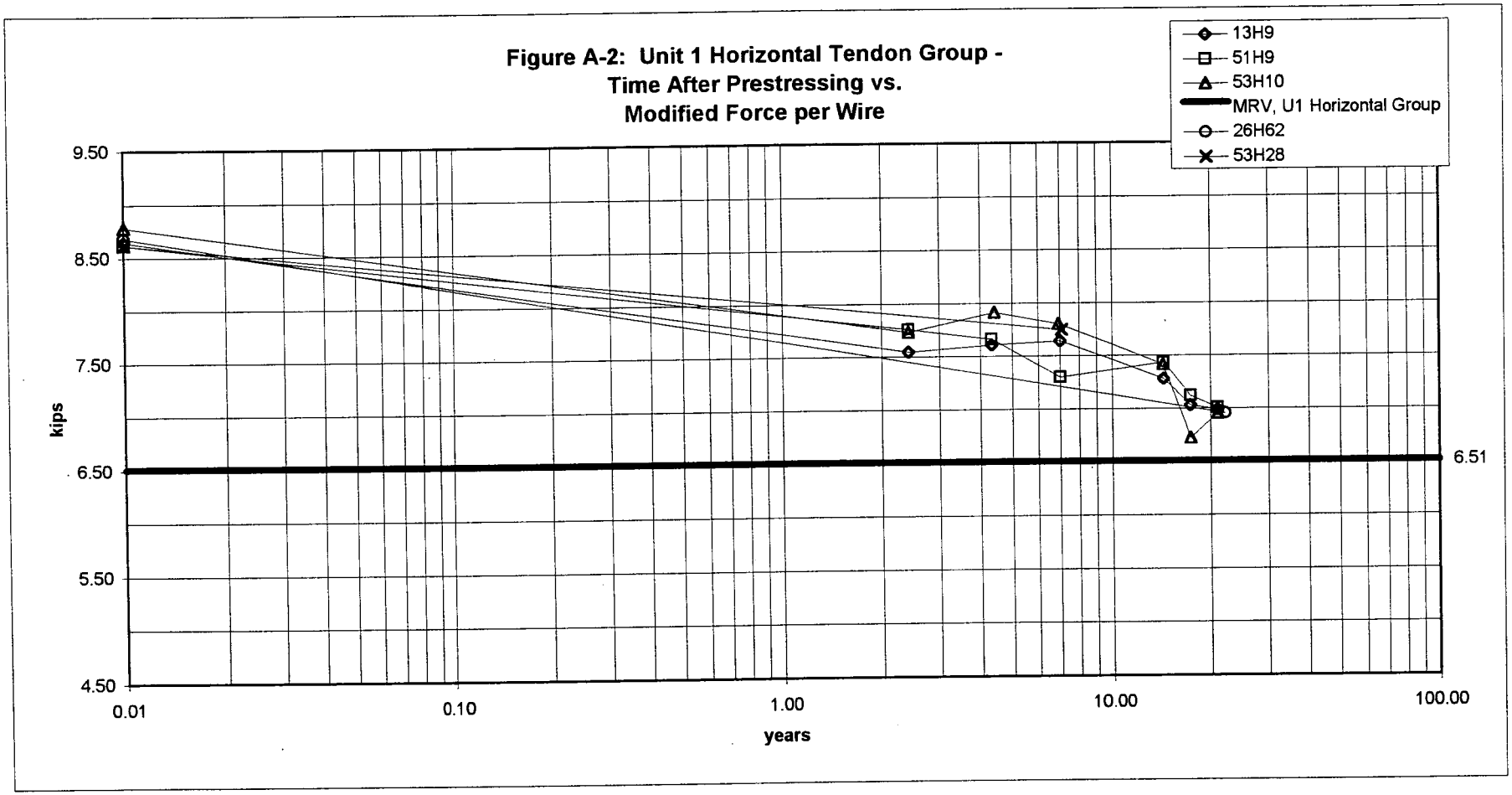
Figure A-2: Unit 1 Horizontal Tendon Group -
Time After Prestressing vs.
Modified Force per Wire
13H9
51H9
53H10
MRV, U1 Horizontal Group
26H62
53H28
9.50
8.50
7.50
6.50
5.50
4.50
kips
6.51
0.01
0.10
1.00
10.00
100.00
years

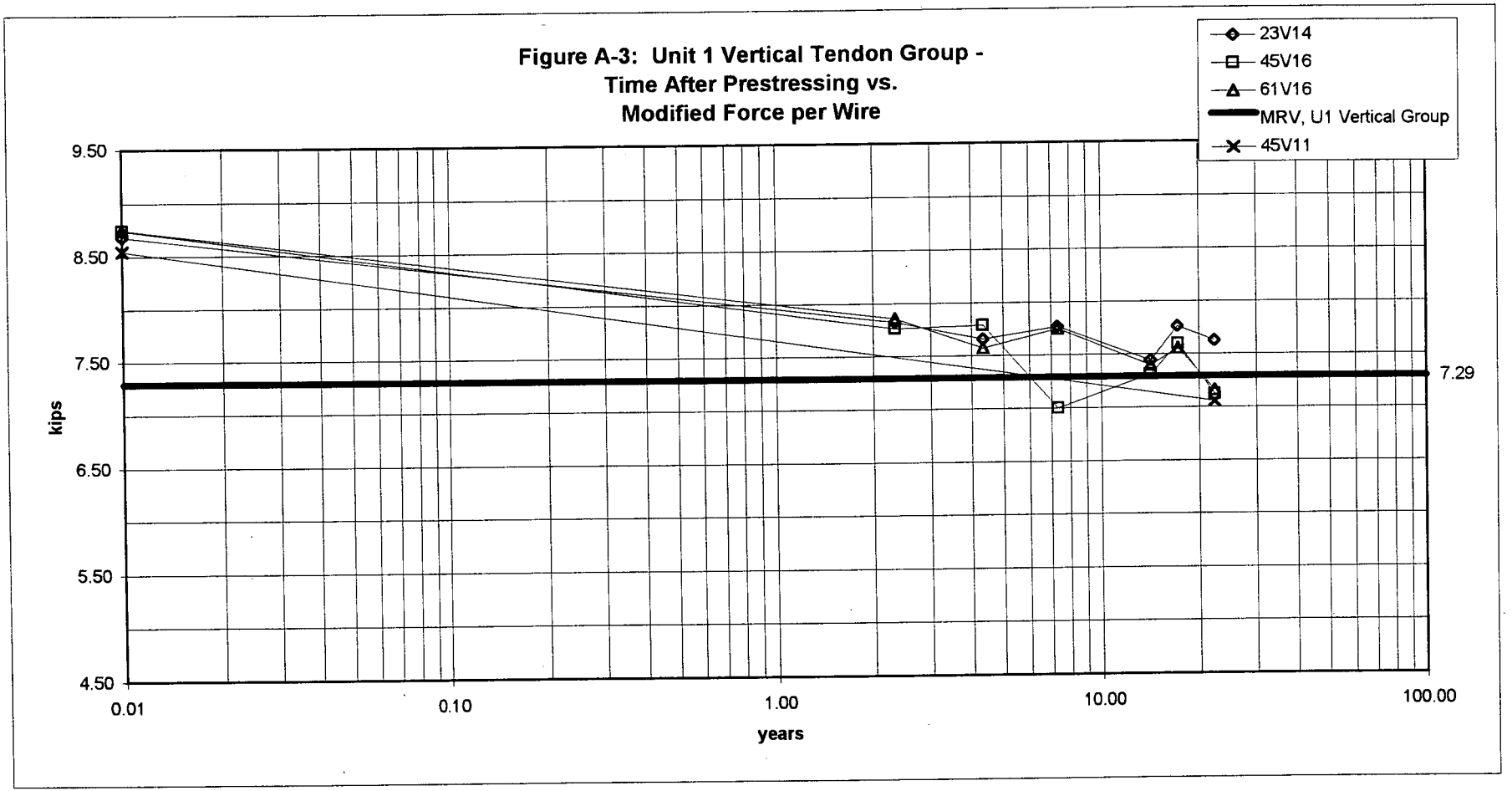
Figure A-3: Unit 1 Vertical Tendon Group -
Time After Prestressing vs.
Modified Force per Wire
23V14
45V16
61V16
MRV, U1 Vertical Group
45V11
9.50
8.50
7.50
6.50
5.50
4.50
kips
7.29
0.01
0.10
1.00
10.00
100.00
years

UNIT 1 DOME TENDON GROUP - REGRESSION ANALYSIS SUMMARY

STATISTICAL DATA	
Time from Installation years	Modified force per wire kips
0.01	8.62
2.50	7.88
4.42	7.80
7.50	7.62
14.33	7.63
17.25	7.86
22.58	7.78
0.01	8.40
2.50	7.98
4.42	7.93
7.50	7.58
14.33	7.45
17.25	7.70
22.50	7.49
0.01	8.47
2.42	7.85
4.33	7.87
7.42	7.95
14.25	7.97
17.17	8.25
22.50	7.84
0.01	8.55
22.5	6.65

REGRESSION STATISTICS
Covariance = -0.8651
Correlation = -0.7486

EQUATION OF BEST FIT LINE
f(x) = 7.993 + (-0.1148) * LN(x)

years	MRV
0.01	7.04
100	7.04

OUTPUT DATA	
Observation years	Predicted force per wire, f(x) kips
0.01	8.52
0.10	8.26
1	7.99
2	7.91
3	7.87
4	7.83
5	7.81
6	7.79
7	7.77
8	7.75
9	7.74
10	7.73
11	7.72
12	7.71
13	7.70
14	7.69
15	7.68
16	7.67
17	7.67
18	7.66
19	7.65
20	7.65
21	7.64
22	7.64
23	7.63
24	7.63
25	7.62
26	7.62
27	7.61
28	7.61
29	7.61
30	7.60
31	7.60
32	7.60
33	7.59
34	7.59
35	7.58
36	7.58
37	7.58
38	7.58
39	7.57
40	7.57

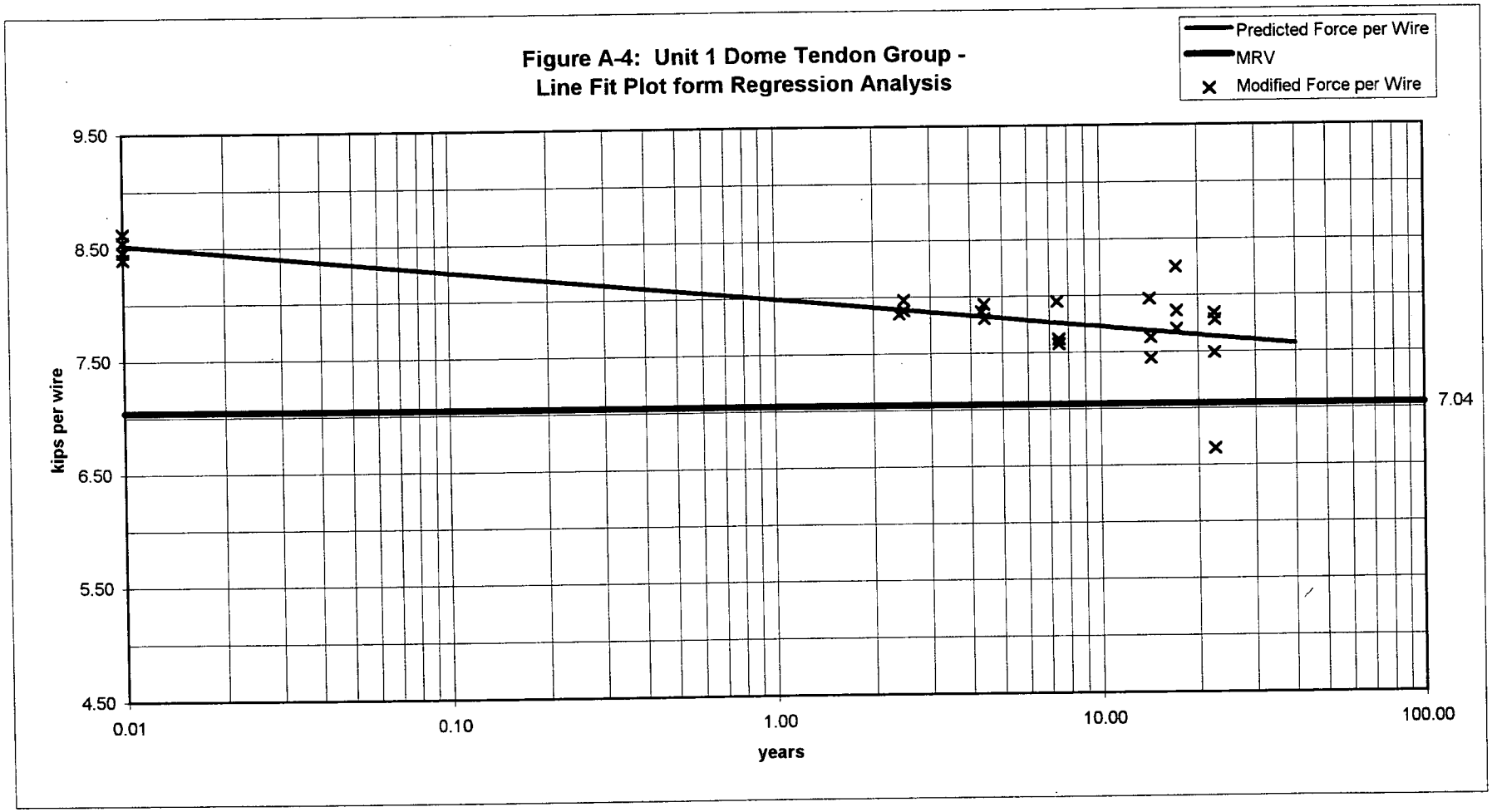
Figure A-4: Unit 1 Dome Tendon Group -
Line Fit Plot form Regression Analysis
Predicted Force per Wire
MRV
Modified Force per Wire
9.50
8.50
7.50
6.50
5.50
4.50
kips per wire
7.04
0.01
0.10
1.00
10.00
100.00
years

UNIT 1 HORIZONTAL TENDON GROUP - REGRESSION ANALYSIS SUMMARY

STATISTICAL DATA	
Time from Installation years	Modified force per wire kips
0.01	8.65
2.42	7.55
4.33	7.61
7.00	7.64
14.42	7.28
17.33	7.03
21.00	6.99
0.01	8.61
2.42	7.76
4.33	7.66
7.00	7.30
14.42	7.43
17.33	7.12
21.00	7.01
0.01	8.78
2.42	7.73
4.42	7.91
6.92	7.80
14.33	7.42
17.33	6.72
21.00	6.96
0.01	8.68
22.17	6.95
0.01	8.61
7.08	7.75

REGRESSION STATISTICS
Covariance = -1.637
Correlation = -0.9345

EQUATION OF BEST FIT LINE
f(x) = 7.803 + (-0.2003) * LN(x)

years	MRV
0.01	6.51
100	6.51

OUTPUT DATA	
Observation years	Predicted force per wire, f(x) kips
0.01	8.73
0.10	8.26
1	7.80
2	7.66
3	7.58
4	7.53
5	7.48
6	7.44
7	7.41
8	7.39
9	7.36
10	7.34
11	7.32
12	7.31
13	7.29
14	7.27
15	7.26
16	7.25
17	7.24
18	7.22
19	7.21
20	7.20
21	7.19
22	7.18
23	7.17
24	7.17
25	7.16
26	7.15
27	7.14
28	7.14
29	7.13
30	7.12
31	7.12
32	7.11
33	7.10
34	7.10
35	7.09
36	7.09
37	7.08
38	7.07
39	7.07
40	7.06

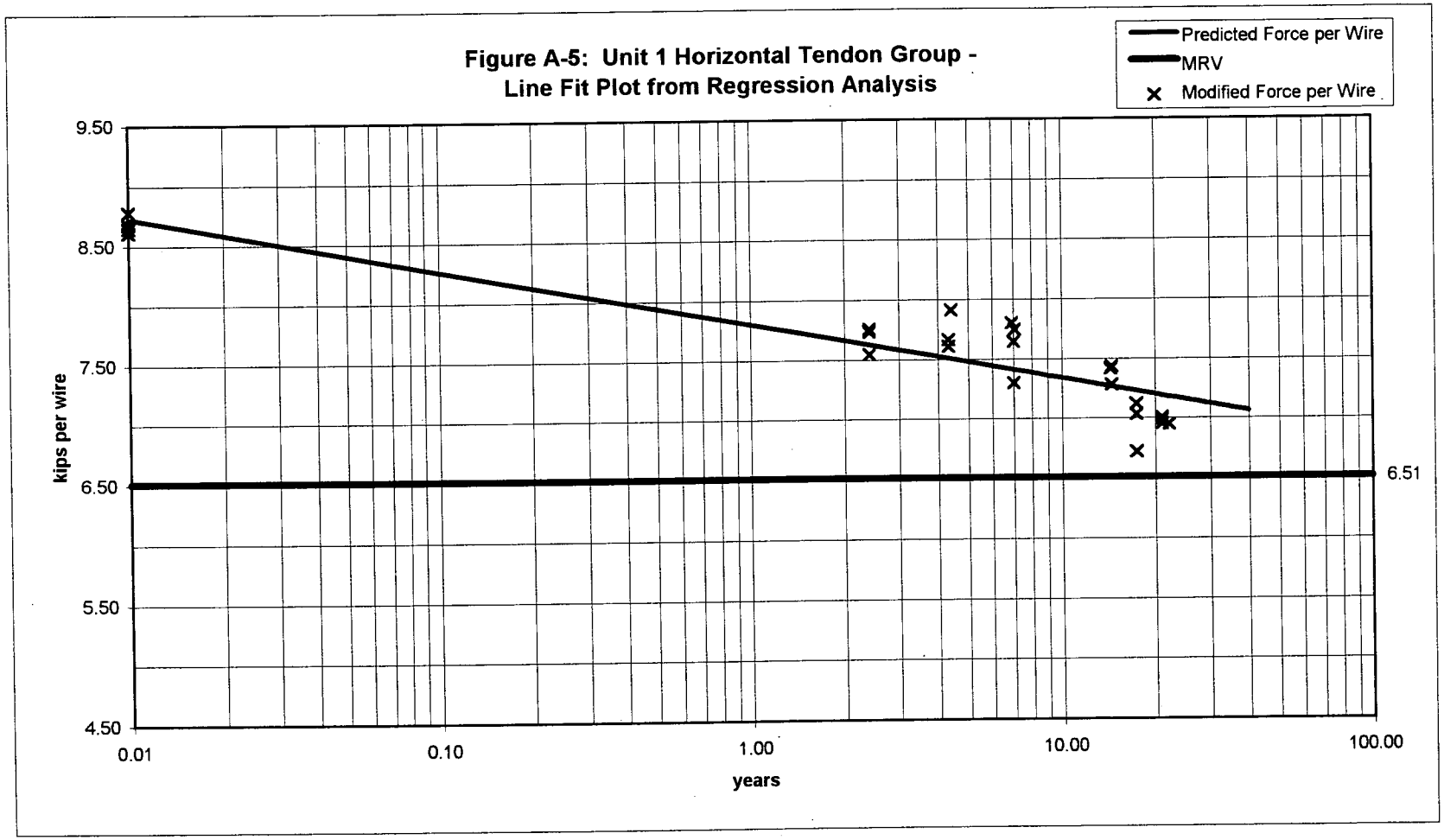
Figure A-5: Unit 1 Horizontal Tendon Group -
Line Fit Plot from Regression Analysis
Predicted Force per Wire
MRV
Modified Force per Wire
9.50
8.50
7.50
6.50
5.50
4.50
kips per wire
6.51
0.01
0.10
1.00
10.00
100.00
years

UNIT 1 VERTICAL TENDON GROUP - REGRESSION ANALYSIS SUMMARY

STATISTICAL DATA	
Time from Installation years	Modified force per wire kips
0.01	8.68
2.33	7.82
4.33	7.66
7.33	7.77
14.17	7.44
17.17	7.76
22.33	7.63
0.01	8.74
2.33	7.76
4.33	7.79
7.33	7.00
14.17	7.31
17.25	7.60
22.33	7.12
0.01	8.75
2.33	7.86
4.33	7.57
7.33	7.75
14.17	7.39
17.25	7.56
22.33	7.16
0.01	8.55
22.33	7.06

REGRESSION STATISTICS
Covariance = -1.292
Correlation = -0.9167

EQUATION OF BEST FIT LINE
f(x) = 7.902 + (-0.1717) * LN(x)

years	MRV
0.01	7.29
100	7.29

OUTPUT DATA	
Observation years	Predicted force per wire, f(x) kips
0.01	8.69
0.10	8.30
1	7.90
2	7.78
3	7.71
4	7.66
5	7.63
6	7.59
7	7.57
8	7.54
9	7.52
10	7.51
11	7.49
12	7.48
13	7.46
14	7.45
15	7.44
16	7.43
17	7.42
18	7.41
19	7.40
20	7.39
21	7.38
22	7.37
23	7.36
24	7.36
25	7.35
26	7.34
27	7.34
28	7.33
29	7.32
30	7.32
31	7.31
32	7.31
33	7.30
34	7.30
35	7.29
36	7.29
37	7.28
38	7.28
39	7.27
40	7.27

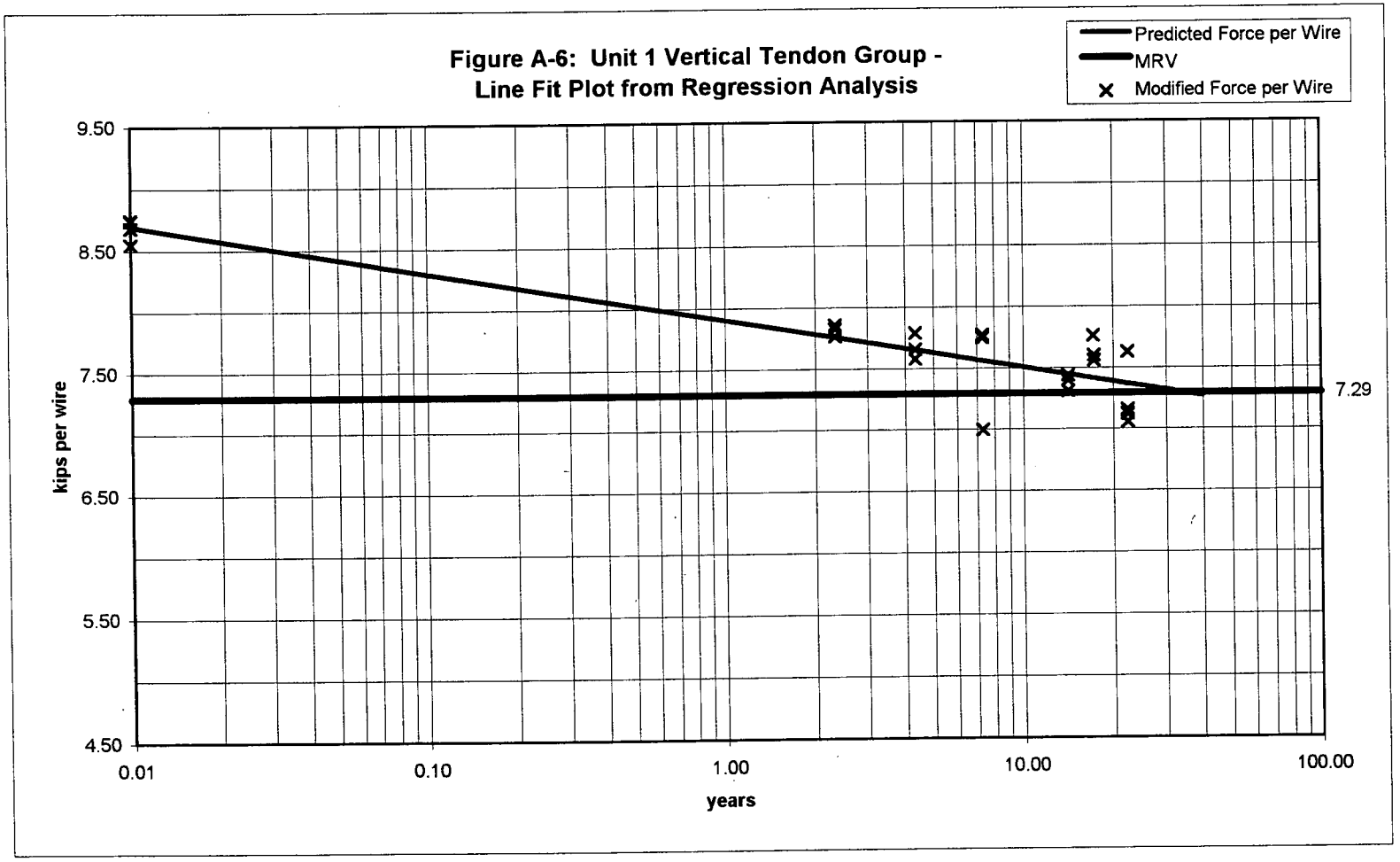
Figure A-6: Unit 1 Vertical Tendon Group -
Line Fit Plot from Regression Analysis
Predicted Force per Wire
MRV
Modified Force per Wire
9.50
8.50
7.50
6.50
5.50
4.50
kips per wire
7.29
0.01
0.10
1.00
10.00
100.00
years

Appendix A Notes and References

1. Reference: *Prestressing Report, Reactor Building, Duke Power Company, Oconee Nuclear Station, Unit 1*, by Bechtel Corporation dated April 1971.

2. Reference: *Duke Power Company, Oconee Nuclear Station, Unit 1, Reactor Building, Post-Tensioning System Initial Surveillance* dated 15 January 1973 and transmitted by letter dated 15 January 1973 from A. C. Thies (DPC) to A. Giambusso (NRC).

3. Field end of tendon 45V16 is a dead-end plate and is unsuitable for taking lift-off readings.

4. For lift-off values, reference: Field data for *Duke Power Company, Oconee Nuclear Station, Unit 1, Reactor Building, Post-Tensioning System Surveillance Program* dated 12 March 1975 transmitted by letter dated 12 March 1975 from A. C. Thies (DPC) to A. Giambusso (NRC).

5. For lift-off values, reference: Field data for third surveillance of Oconee Nuclear Station Unit 1 post-tensioning system.

6. For ram pressures, reference: Field data for fourth surveillance of Oconee Nuclear Station Unit 1 post-tensioning system.

7. Lift-off force obtained from ram calibration records dated June 1983.

8. One buttonhead @ each end anchorage observed missing - assume two broken wires.

9. For ram pressures, reference: Field data for sixth surveillance of Oconee Nuclear Station Unit 1 post-tensioning system.

10. Lift-off force obtained from ram calibration records dated June 1991.

11. Testing suspended at documented force, 'Shop End' and 'Field End'. Safety concerns prohibited increased ram pressures necessary to achieve lift-off. [Reference Proposed Resolution to OEP IN 91-80]

12. For ram pressures, reference: Field data for fifth surveillance of Oconee Nuclear Station Unit 1 post-tensioning system.

13. Lift-off force obtained from ram calibration records dated September 1987.

14. Non-surveillance tendon.

15. Double entries appear for detensioned/retensioned tendons only and represent as-found and as-left conditions, respectively.

Appendix A Notes and References (cont.)

16. Until 1982 surveillance on Oconee Nuclear Station Unit 3 post-tensioning system, pressure gauge was calibrated; however, hydraulic ram was not. Tendon Force = Ram Pressure (psi) * 120.2 in^2 / 1000 lbs/kip. [Reference: Duke Power Company Calculation OSC-2125]

17. After 1982 surveillance on Oconee Nuclear Station Unit 3 post-tensioning system, all ram/gauge combinations were calibrated simultaneously, and tendon forces were obtained directly from this calibration data. [Reference: Duke Power Company Calculation OSC-2125]

18. A blank represents a value of zero.

19. Time of initial seating force is identified as 0.01 years in order to accommodate logarithmic scale for time.

APPENDIX B

Table B-1: Unit 2 Dome Tendons - Surveillance Data and Modified Lift-off Forces

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Method of Ram Pressure to Force Conversion	Shop End[8] Lift-off Pressure (psi)		Shop End[8] Lift-off Force (kips)		Field End[8] Lift-off Pressure (psi)		Field End[8] Lift-off Force (kips)		Average[8] Lift-off Force (kips)	
1D28	Date Stressed 7/20/71[1,2]			Ram Area[9]		6700		805.3		6700		805.3		805.3
	1st 12/74[3]	41	29930	Ram Area[9]	5683	6392	683.1	768.3	5767	6367	693.2	765.3	688.1	766.8
	2nd 5/78[4]	41	59860	Ram Area[9]	5966		717.1		5950		715.2		716.2	
	3rd 6/84[6]	73	113150	Calibration[10]									738.0	
	4th 9/86 - 12/86[6]	30	135050	Calibration[10]									760.0	744.0
	5th 9/90 - 11/90[6]	47	169360	Calibration[10]			715.0				673.5		694.3	
	6th 10/94 - 11/94[6]	48	204400	Calibration[10]			749.2	712.5			706.5	718.6	727.9	715.6
2D28	Date Stressed 7/20/71[1,6]			Ram Area[9]		6650		799.3		6700		805.3		802.3
	1st 12/74[3]	41	29930	Ram Area[9]	5767		693.2		5633		677.1		685.1	
	2nd 5/78[4]	41	59860	Ram Area[9]	5833	5675	701.1	682.1	5700	5650	685.1	679.1	693.1	680.6
2D29	Date Stressed 7/21/71[1,2]			Ram Area[9]		6500		781.3		6450		775.3		778.3
	3rd 6/84[6]	155	113150	Calibration[10]									672.0	705.0
	4th 9/86 - 12/86[6]	30	135050	Calibration[10]									730.0	
	5th 9/90 - 11/90[6]	47	169360	Calibration[10]			691.0				673.8		682.4	
	6th 10/94 - 11/94[6, 12]	48	204400	Calibration[10]			724.6				700.2		712.4	
3D28	Date Stressed 7/20/71[1,2]			Ram Area[9]		6700		805.3		6700		805.3		805.3
	1st 12/74[3]	41	29930	Ram Area[9]	5850		703.2		5783		695.1		699.1	
	2nd 5/78[4]	41	59860	Ram Area[9]	5825		700.2		5938		713.7		707.0	
	3rd 6/84[6]	73	113150	Calibration[10]									708.0	726.0
	4th 9/86 - 12/86[6]	30	135050	Calibration[10]									715.0	
	5th 9/90 - 11/90[6]	47	169360	Calibration[10]			708.6	679.3			673.8	662.0	691.2	670.7
	6th 10/94 - 11/94[6]	48	204400	Calibration[10]			688.0				706.5		697.3	

Table B-1: Unit 2 Dome Tendons - Surveillance Data and Modified Lift-off Forces (cont.)

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Cumulative[11] Number of Wires Missing/Removed	Initial[1] Number of Wires	Effective Number of Wires	Force[8] per Wire kips		Stress[8] f_p = force / ΠR^2 (R = 0.25" / 2) ksi	
1D28	Date Stressed 7/20/71[1,2]				93	93		8.66		176.4
	1st 12/74[3]	41	29930	1		92	7.40	8.33	150.7	169.8
	2nd 5/78[4]	41	59860	1		92	7.78		158.6	
	3rd 6/84[6]	73	113150	1		92	8.02		163.4	
	4th 9/86 - 12/86[6]	30	135050	2		91	8.26	8.18	168.3	166.6
	5th 9/90 - 11/90[6]	47	169360	2		91	7.63		155.4	
	6th 10/94 - 11/94[6]	48	204400	3		90	8.00	7.95	162.9	162.0
2D28	Date Stressed 7/20/71[1,6]				93	93		8.63		175.8
	1st 12/74[3]	41	29930			93	7.37		150.1	
	2nd 5/78[4]	41	59860	1		92	7.45	7.40	151.8	150.7
2D29	Date Stressed 7/21/71[1,2]				90	90		8.65		176.2
	3rd 6/84[6]	155	113150	1		89	7.47	7.92	152.1	161.4
	4th 9/86 - 12/86[6]	30	135050	1		89	8.20		167.1	
	5th 9/90 - 11/90[6]	47	169360	1		89	7.67		156.2	
	6th 10/94 - 11/94[6, 12]	48	204400	1		89	8.00		163.1	
3D28	Date Stressed 7/20/71[1,2]				93	93		8.66		176.4
	1st 12/74[3]	41	29930			93	7.52		153.1	
	2nd 5/78[4]	41	59860			93	7.60		154.9	
	3rd 6/84[6]	73	113150	1		92	7.61	7.89	155.1	160.8
	4th 9/86 - 12/86[6]	30	135050	1		92	7.77		158.3	
	5th 9/90 - 11/90[6]	47	169360	2		91	7.51	7.37	153.1	150.1
	6th 10/94 - 11/94[6]	48	204400	2		91	7.66		156.1	

Table B-1: Unit 2 Dome Tendons - Surveillance Data and Modified Lift-off Forces (cont.)

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Force[8] per Wire kips		$\Delta_{seating\ force\ per\ wire}$ = force/wire'as-left' - force/wire'as found' kips[11]	$\Sigma\Delta_{seating\ force\ per\ wire}$ kips[11]	Modified force/wire = force/wire'as found' - $\Sigma\Delta_{seating\ force\ per\ wire\ from\ previous\ su}$ kips	Time[14] from Installation years
1D28	Date Stressed 7/20/71[1,2]				8.66			8.66	0.01
	1st 12/74[3]	41	29930	7.40	8.33	0.94	0.94	7.40	3.42
	2nd 5/78[4]	41	59860	7.78			0.94	6.85	6.83
	3rd 6/84[6]	73	113150	8.02			0.94	7.09	12.92
	4th 9/86 - 12/86[6]	30	135050	8.26	8.18	-0.09	0.85	7.33	15.42
	5th 9/90 - 11/90[6]	47	169360	7.63			0.85	6.78	19.33
	6th 10/94 - 11/94[6]	48	204400	8.00	7.95	-0.05	0.80	7.15	23.33
2D28	Date Stressed 7/20/71[1,6]				8.63			8.63	0.01
	1st 12/74[3]	41	29930	7.37				7.37	3.42
	2nd 5/78[4]	41	59860	7.45	7.40	-0.05	-0.05	7.45	6.83
2D29	Date Stressed 7/21/71[1,2]				8.65			8.65	0.01
	3rd 6/84[6]	155	113150	7.47	7.92	0.45	0.45	7.47	12.92
	4th 9/86 - 12/86[6]	30	135050	8.20			0.45	7.75	15.42
	5th 9/90 - 11/90[6]	47	169360	7.67			0.45	7.21	19.33
	6th 10/94 - 11/94[6, 12]	48	204400	8.00			0.45	7.55	23.33
3D28	Date Stressed 7/20/71[1,2]				8.66			8.66	0.01
	1st 12/74[3]	41	29930	7.52				7.52	3.42
	2nd 5/78[4]	41	59860	7.60				7.60	6.83
	3rd 6/84[6]	73	113150	7.61	7.89	0.28	0.28	7.61	12.92
	4th 9/86 - 12/86[6]	30	135050	7.77			0.28	7.49	15.42
	5th 9/90 - 11/90[6]	47	169360	7.51	7.37	-0.14	0.14	7.23	19.33
	6th 10/94 - 11/94[6]	48	204400	7.66			0.14	7.53	23.33

Table B-2: Unit 2 Horizontal Tendons - Surveillance Data and Modified Lift-off Forces

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Method of Ram Pressure to Force Conversion	Shop End[8] Lift-off Pressure (psi)		Shop End[8] Lift-off Force (kips)		Field End[8] Lift-off Pressure (psi)		Field End[8] Lift-off Force (kips)		Average[8] Lift-off Force (kips)	
13H9	Date Stressed 8/29/71[1,2]			Ram Area[9]		6600		793.3		6600		793.3		793.3
	1st 12/74[3]	40	29200	Ram Area[9]	5650	6367	679.1	765.3	5350	6450	643.1	775.3	661.1	770.3
	2nd 7/77[4]	31	51830	Ram Area[9]	6367		765.3		5950		715.2		740.3	
	3rd 6/84[6]	83	112420	Calibration[10]									720.0	
	4th 9/86 - 12/86[6]	30	134320	Calibration[10]									730.0	711.0
	5th 9/90 - 11/90[6]	47	168630	Calibration[10]			585.6				738.6		662.1	
	6th 10/94 - 11/94[6]	48	203670	Calibration[10]			639.0				729.4		684.2	
51H9	Date Stressed 8/29/71[1,2]			Ram Area[9]		6700		805.3		6400		769.3		787.3
	1st 12/74[3]	40	29200	Ram Area[9]	5800		697.2		5600		673.1		685.1	
	2nd 7/77[4]	31	51830	Ram Area[9]	5800	6350	697.2	763.3	5500	6475	661.1	778.3	679.1	770.8
	3rd 6/84[6]	83	112420	Calibration[10]									750.0	
	4th 9/86 - 12/86[6]	30	134320	Calibration[10]									754.0	
	5th 9/90 - 11/90[6]	47	168630	Calibration[10]			727.5	751.1			691.0	573.9	709.3	662.5
	6th 10/94 - 11/94[6, 12]	48	203670	Calibration[10]			717.3				651.2		684.3	
53H10	Date Stressed 8/29/71[1,2]			Ram Area[9]		6600		793.3		6650		799.3		796.3
	1st 12/74[3]	40	29200	Ram Area[9]	5750		691.2		Note 5		Note 5		691.2	
	2nd 7/77[4]	31	51830	Ram Area[9]	6216		747.2		5800		697.2		722.2	
	3rd 6/84[6]	83	112420	Calibration[10]									654.0	708.0
	4th 9/86 - 12/86[6, 13]	30	134320	Calibration[10]									699.0	
	5th 9/90 - 11/90[6]	47	168630	Calibration[10]			667.9				597.3		632.6	
	6th 10/94 - 11/94[6]	48	203670	Calibration[10]			705.2	717.3			675.7	688.0	690.5	702.7

Table B-2: Unit 2 Horizontal Tendons - Surveillance Data and Modified Lift-off Forces (cont.)

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Cumulative[11] Number of Wires Missing/Removed	Initial[1] Number of Wires	Effective Number of Wires	Force[8] per Wire kips		Stress[8] f_p = force / πR^2 (R = 0.25" / 2) ksi	
13H9	Date Stressed 8/29/71[1,2]				93	93		8.53		173.8
	1st 12/74[3]	40	29200	1		92	7.11	8.37	144.8	170.6
	2nd 7/77[4]	31	51830	1		92	8.05		163.9	
	3rd 6/84[6]	83	112420	1		92	7.83		159.4	
	4th 9/86 - 12/86[6]	30	134320	2		91	7.93	7.81	161.6	159.2
	5th 9/90 - 11/90[6]	47	168630	2		91	7.28		148.2	
	6th 10/94 - 11/94[6]	48	203670	2		91	7.52		153.2	
51H9	Date Stressed 8/29/71[1,2]				93	93		8.47		172.5
	1st 12/74[3]	40	29200			93	7.37		150.1	
	2nd 7/77[4]	31	51830	1		92	7.30	8.38	148.8	170.7
	3rd 6/84[6]	83	112420	1		92	8.15		166.1	
	4th 9/86 - 12/86[6]	30	134320	1		92	8.20		167.0	
	5th 9/90 - 11/90[6]	47	168630	2		91	7.71	7.28	157.1	148.3
	6th 10/94 - 11/94[6, 12]	48	203670	2		91	7.52		153.2	
53H10	Date Stressed 8/29/71[1,2]				93	93		8.56		174.4
	1st 12/74[3]	40	29200			93	7.43		151.4	
	2nd 7/77[4]	31	51830			93	7.77		158.2	
	3rd 6/84[6]	83	112420	1		92	7.03	7.70	143.3	156.8
	4th 9/86 - 12/86[6, 13]	30	134320	3		90	7.77		158.2	
	5th 9/90 - 11/90[6]	47	168630	3		90	7.03		143.2	
	6th 10/94 - 11/94[6]	48	203670	4		89	7.67	7.89	156.3	160.8

Table B-2: Unit 2 Horizontal Tendons - Surveillance Data and Modified Lift-off Forces (cont.)

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Force[8] per Wire kips		$\Delta_{seating\ force\ per\ wire}$ = force/wire'as-left' - force/wire'as found' kips [11]	$\Sigma\Delta_{seating\ force\ per\ wire}$ kips [11]	Modified force/wire = force/wire'as found' - $\Sigma\Delta_{seating\ force\ per\ wire\ from\ previous\ su}$ kips	Time[14] from Installation years
13H9	Date Stressed 8/29/71[1,2]				8.53			8.53	0.01
	1st 12/74[3]	40	29200	7.11	8.37	1.26	1.26	7.11	3.33
	2nd 7/77[4]	31	51830	8.05			1.26	6.78	5.92
	3rd 6/84[6]	83	112420	7.83			1.26	6.56	12.83
	4th 9/86 - 12/86[6]	30	134320	7.93	7.81	-0.12	1.14	6.67	15.33
	5th 9/90 - 11/90[6]	47	168630	7.28			1.14	6.13	19.25
	6th 10/94 - 11/94[6]	48	203670	7.52			1.14	6.38	23.25
51H9	Date Stressed 8/29/71[1,2]				8.47			8.47	0.01
	1st 12/74[3]	40	29200	7.37				7.37	3.33
	2nd 7/77[4]	31	51830	7.30	8.38	1.08	1.08	7.30	5.92
	3rd 6/84[6]	83	112420	8.15			1.08	7.08	12.83
	4th 9/86 - 12/86[6]	30	134320	8.20			1.08	7.12	15.33
	5th 9/90 - 11/90[6]	47	168630	7.71	7.28	-0.43	0.65	6.63	19.25
	6th 10/94 - 11/94[6, 12]	48	203670	7.52			0.65	6.87	23.25
53H10	Date Stressed 8/29/71[1,2]				8.56			8.56	0.01
	1st 12/74[3]	40	29200	7.43				7.43	3.33
	2nd 7/77[4]	31	51830	7.77				7.77	5.92
	3rd 6/84[6]	83	112420	7.03	7.70	0.66	0.66	7.03	12.83
	4th 9/86 - 12/86[6, 13]	30	134320	7.77			0.66	7.10	15.33
	5th 9/90 - 11/90[6]	47	168630	7.03			0.66	6.37	19.25
	6th 10/94 - 11/94[6]	48	203670	7.67	7.89	0.22	0.89	7.01	23.25

Table B-3: Unit 2 Vertical Tendons - Surveillance Data and Modified Lift-off Forces

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Method of Ram Pressure to Force Conversion	Shop End[8] Lift-off Pressure (psi)		Shop End[8] Lift-off Force (kips)		Field End[8] Lift-off Pressure (psi)		Field End[8] Lift-off Force (kips)		Average[8] Lift-off Force (kips)	
23V14	Date Stressed 9/16/71[1,2]			Ram Area[9]		6500		781.3		6450		775.3		778.3
	1st 12/74[3]	39	28470	Ram Area[9]	5717	6350	687.2	763.3	5750	6300	691.2	757.3	689.2	760.3
	2nd 5/78[4]	41	58400	Ram Area[9]	6200		745.2		6250		751.3		748.2	
	3rd 6/84[6]	73	111690	Calibration[10]									732.0	
	4th 9/86 - 12/86[6]	30	133590	Calibration[10]									748.0	742.0
	5th 9/90 - 11/90[6]	47	167900	Calibration[10]			691.5				691.0		691.3	
	6th 10/94 - 11/94[6]	48	202940	Calibration[10]			712.5				717.3		714.9	
45V16	Date Stressed 9/16/71[1,2]			Ram Area[9]		6500		781.3		6600		793.3		787.3
	1st 12/74[3]	39	28470	Ram Area[9]	5850		703.2		5750		691.2		697.2	
	2nd 5/78[4]	41	58400	Ram Area[9]	5300	5650	637.1	679.1	5670	5500	681.5	661.1	659.3	670.1
	3rd 6/84[6]	73	111690	Calibration[10]									665.0	702.0
	4th 9/86 - 12/86[6]	30	133590	Calibration[10]									711.0	
	5th 9/90 - 11/90[6]	47	167900	Calibration[10]			667.9				655.9		661.9	
	6th 10/94 - 11/94[6]	48	202940	Calibration[10]			694.4	621.8			668.8	674.9	681.6	648.4
61V14[7]	Date Stressed 9/16/71[1]			Ram Area[9]		6400		769.3		6400		769.3		769.3
	6th 10/94 - 11/94[6]	278	202940	Calibration[10]			670.2				656.6		663.4	
61V16	Date Stressed 9/16/71[1,2]			Ram Area[9]		6650		799.3		6700		805.3		802.3
	1st 12/74[3]	39	28470	Ram Area[9]	5833		701.1		5800		697.2		699.1	
	2nd 5/78[4]	41	58400	Ram Area[9]	5765		693.0		5775		694.2		693.6	
	3rd 6/84[6]	73	111690	Calibration[10]									714.0	705.0
	4th 9/86 - 12/86[6]	30	133590	Calibration[10]									717.0	
	5th 9/90 - 11/90[6]	47	167900	Calibration[10]			650.2	679.7			667.6	644.2	658.9	662.0
	6th 10/94 - 11/94[6]	48	202940	Calibration[10]			670.2				656.6		663.4	
61V22[7]	Date Stressed 9/15/71[1]			Ram Area[9]		6500		781.3		6500		781.3		781.3
	6th 10/94 - 11/94[6]	278	202940	Calibration[10]			694.4				656.6		675.5	
61V28[7]	Date Stressed 9/14/71[1]			Ram Area[9]		6450		775.3		6450		775.3		775.3
	6th 10/94 - 11/94[6]	278	202940	Calibration[10]			664.1				644.5		654.3	

Table B-3: Unit 2 Vertical Tendons - Surveillance Data and Modified Lift-off Forces (cont.)

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Cumulative[11] Number of Wires Missing/Removed	Initial[1] Number of Wires	Effective Number of Wires	Force[8] per Wire kips		Stress[8] f_p = force / ΠR^2 (R = 0.25" / 2) ksi	
23V14	Date Stressed 9/16/71[1,2]				93	93		8.37		170.5
	1st 12/74[3]	39	28470	1		92	7.41	8.26	151.0	168.3
	2nd 5/78[4]	41	58400	1		92	8.13		165.7	
	3rd 6/84[6]	73	111690	1		92	7.96		162.1	
	4th 9/86 - 12/86[6]	30	133590	2		91	8.13	8.15	165.6	166.1
	5th 9/90 - 11/90[6]	47	167900	2		91	7.60		154.7	
	6th 10/94 - 11/94[6]	48	202940	2		91	7.86		160.0	
45V16	Date Stressed 9/16/71[1,2]				93	93		8.47		172.5
	1st 12/74[3]	39	28470			93	7.50		152.7	
	2nd 5/78[4]	41	58400	1		92	7.09	7.28	144.4	148.4
	3rd 6/84[6]	73	111690	1		92	7.23	7.63	147.3	155.4
	4th 9/86 - 12/86[6]	30	133590	1		92	7.73		157.4	
	5th 9/90 - 11/90[6]	47	167900	1		92	7.19		146.6	
	6th 10/94 - 11/94[6]	48	202940	2		91	7.41	7.12	150.9	145.1
61V14[7]	Date Stressed 9/16/71[1]				90	90		8.55		174.1
	6th 10/94 - 11/94[6]	278	202940			90	7.37		150.2	
61V16	Date Stressed 9/16/71[1,2]				93	93		8.63		175.8
	1st 12/74[3]	39	28470			93	7.52		153.1	
	2nd 5/78[4]	41	58400			93	7.46		151.9	
	3rd 6/84[6]	73	111690	1		92	7.68	7.66	156.4	156.1
	4th 9/86 - 12/86[6]	30	133590	1		92	7.79		158.8	
	5th 9/90 - 11/90[6]	47	167900	2		91	7.16	7.27	145.9	148.2
	6th 10/94 - 11/94[6]	48	202940	2		91	7.29		148.5	
61V22[7]	Date Stressed 9/15/71[1]				90	90		8.68		176.9
	6th 10/94 - 11/94[6]	278	202940			90	7.51		152.9	
61V28[7]	Date Stressed 9/14/71[1]				90	90		8.61		175.5
	6th 10/94 - 11/94[6]	278	202940			90	7.27		148.1	

Table B-3: Unit 2 Vertical Tendons - Surveillance Data and Modified Lift-off Forces (cont.)

Surv. Tendon Id.	Inspection / Date	Surv. Interval mnths.	Time from Installation hrs.	Force[8] per Wire kips		$\Delta_{seating\ force\ per\ wire}$ = force/wire$_{'as\text{-}left'}$ - force/wire$_{'as\ found'}$ kips[11]	$\Sigma\Delta_{seating\ force\ per\ wire}$ kips[11]	Modified force/wire = force/wire$_{'as\ found'}$ - $\Sigma\Delta_{seating\ force\ per\ wire\ from\ previous\ sur}$ kips	Time[14] from Installation years
23V14	Date Stressed 9/16/71[1,2]				8.37			8.37	0.01
	1st 12/74[3]	39	28470	7.41	8.26	0.85	0.85	7.41	3.25
	2nd 5/78[4]	41	58400	8.13			0.85	7.28	6.67
	3rd 6/84[6]	73	111690	7.96			0.85	7.10	12.75
	4th 9/86 - 12/86[6]	30	133590	8.13	8.15	0.02	0.88	7.28	15.25
	5th 9/90 - 11/90[6]	47	167900	7.60			0.88	6.72	19.17
	6th 10/94 - 11/94[6]	48	202940	7.86			0.88	6.98	23.17
45V16	Date Stressed 9/16/71[1,2]				8.47			8.47	0.01
	1st 12/74[3]	39	28470	7.50				7.50	3.25
	2nd 5/78[4]	41	58400	7.09	7.28	0.19	0.19	7.09	6.67
	3rd 6/84[6]	73	111690	7.23	7.63	0.40	0.60	7.03	12.75
	4th 9/86 - 12/86[6]	30	133590	7.73			0.60	7.13	15.25
	5th 9/90 - 11/90[6]	47	167900	7.19			0.60	6.60	19.17
	6th 10/94 - 11/94[6]	48	202940	7.41	7.12	-0.28	0.31	6.81	23.17
61V14[7]	Date Stressed 9/16/71[1]				8.55			8.55	0.01
	6th 10/94 - 11/94[6]	278	202940	7.37				7.37	23.17
61V16	Date Stressed 9/16/71[1,2]				8.63			8.63	0.01
	1st 12/74[3]	39	28470	7.52				7.52	3.25
	2nd 5/78[4]	41	58400	7.46				7.46	6.67
	3rd 6/84[6]	73	111690	7.68	7.66	-0.01	-0.01	7.68	12.75
	4th 9/86 - 12/86[6]	30	133590	7.79			-0.01	7.81	15.25
	5th 9/90 - 11/90[6]	47	167900	7.16	7.27	0.11	0.10	7.18	19.17
	6th 10/94 - 11/94[6]	48	202940	7.29			0.10	7.19	23.17
61V22[7]	Date Stressed 9/15/71[1]				8.68			8.68	0.01
	6th 10/94 - 11/94[6]	278	202940	7.51				7.51	23.17
61V28[7]	Date Stressed 9/14/71[1]				8.61			8.61	0.01
	6th 10/94 - 11/94[6]	278	202940	7.27				7.27	23.17

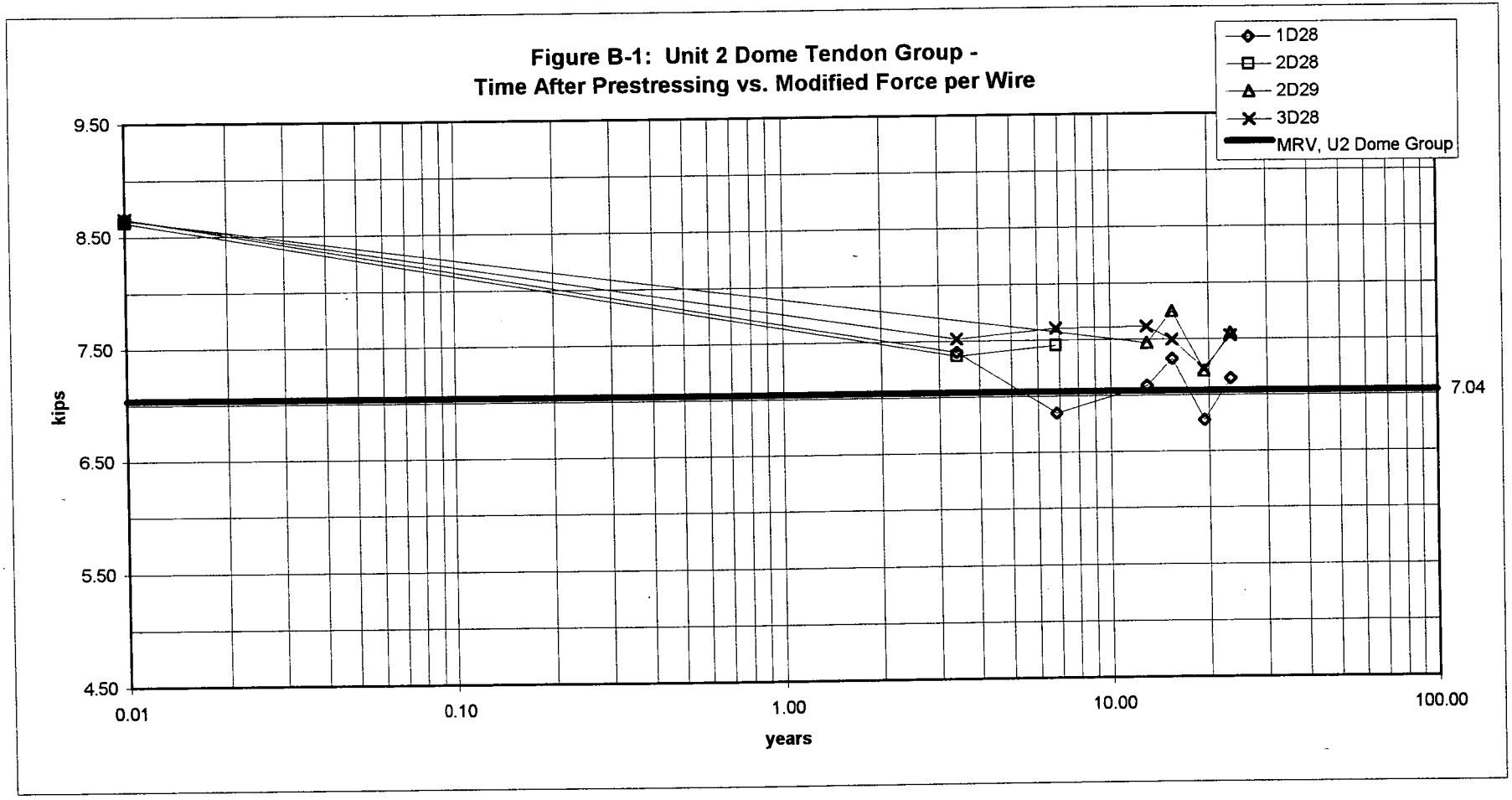
Figure B-1: Unit 2 Dome Tendon Group -
Time After Prestressing vs. Modified Force per Wire
1D28
2D28
2D29
3D28
MRV, U2 Dome Group
9.50
8.50
7.50
6.50
5.50
4.50
kips
7.04
0.01
0.10
1.00
10.00
100.00
years

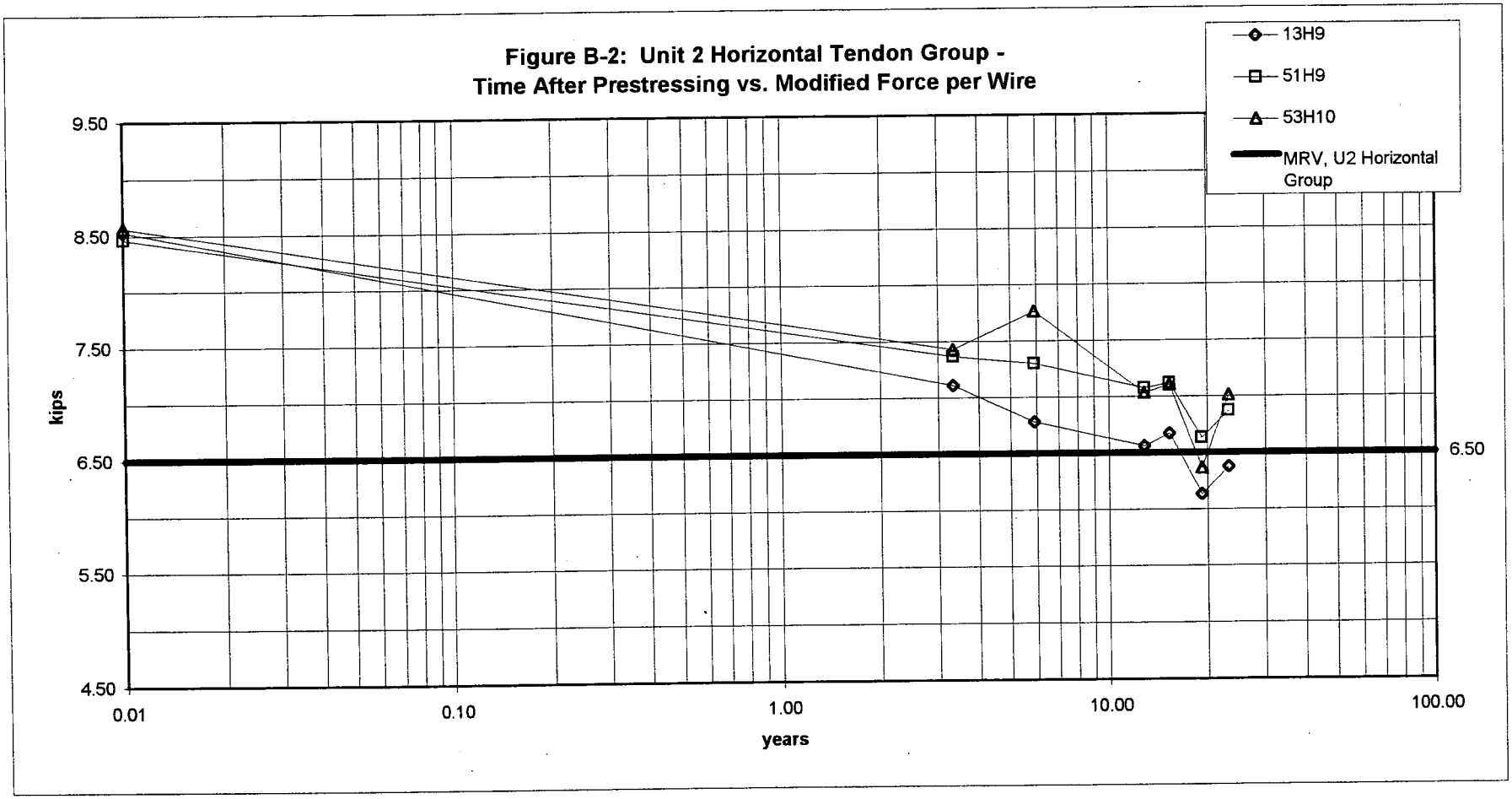
Figure B-2: Unit 2 Horizontal Tendon Group -
Time After Prestressing vs. Modified Force per Wire
13H9
51H9
53H10
MRV, U2 Horizontal Group
9.50
8.50
7.50
6.50
5.50
4.50
kips
6.50
0.01
0.10
1.00
10.00
100.00
years

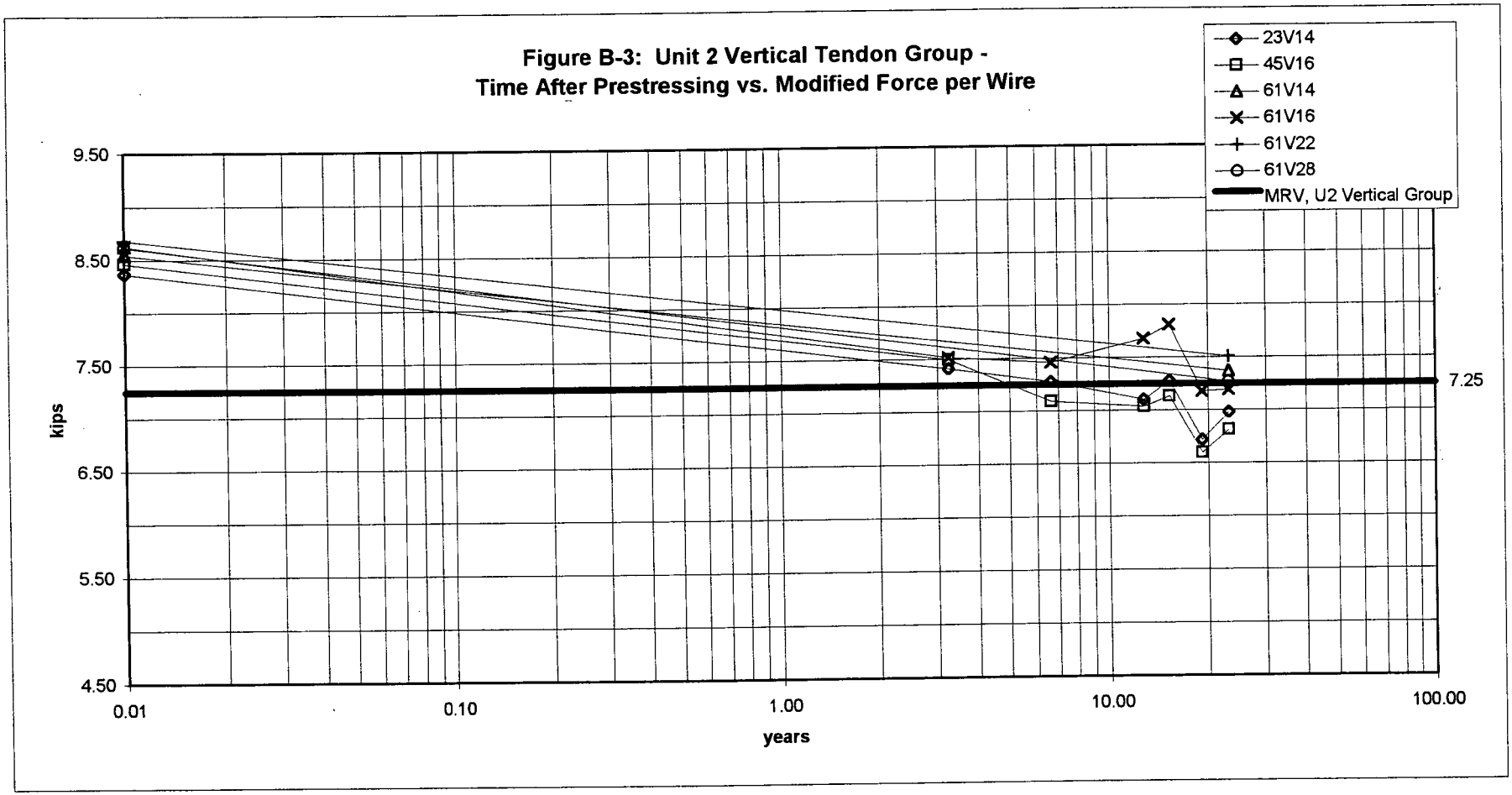
Figure B-3: Unit 2 Vertical Tendon Group -
Time After Prestressing vs. Modified Force per Wire
23V14
45V16
61V14
61V16
61V22
61V28
MRV, U2 Vertical Group
9.50
8.50
7.50
6.50
5.50
4.50
kips
7.25
0.01
0.10
1.00
10.00
100.00
years

UNIT 2 DOME TENDON GROUP - REGRESSION ANALYSIS SUMMARY

STATISTICAL DATA	
Time from Installation years	Modified force per wire kips
0.01	8.66
3.42	7.40
6.83	6.85
12.92	7.09
15.42	7.33
19.33	6.78
23.33	7.15
0.01	8.63
3.42	7.37
6.83	7.45
0.01	8.65
12.92	7.47
15.42	7.75
19.33	7.21
23.33	7.55
0.01	8.66
3.42	7.52
6.83	7.60
12.92	7.61
15.42	7.49
19.33	7.23
23.33	7.53

REGRESSION STATISTICS
Covariance = -1.436
Correlation = -0.8981

EQUATION OF BEST FIT LINE
f(x) = 7.794 + (-0.1778) * LN(x)

years	MRV
0.01	7.04
100	7.04

OUTPUT DATA	
Observation years	Predicted force per wire, f(x) kips
0.01	8.61
0.10	8.20
1	7.79
2	7.67
3	7.60
4	7.55
5	7.51
6	7.48
7	7.45
8	7.42
9	7.40
10	7.38
11	7.37
12	7.35
13	7.34
14	7.32
15	7.31
16	7.30
17	7.29
18	7.28
19	7.27
20	7.26
21	7.25
22	7.24
23	7.24
24	7.23
25	7.22
26	7.21
27	7.21
28	7.20
29	7.20
30	7.19
31	7.18
32	7.18
33	7.17
34	7.17
35	7.16
36	7.16
37	7.15
38	7.15
39	7.14
40	7.14

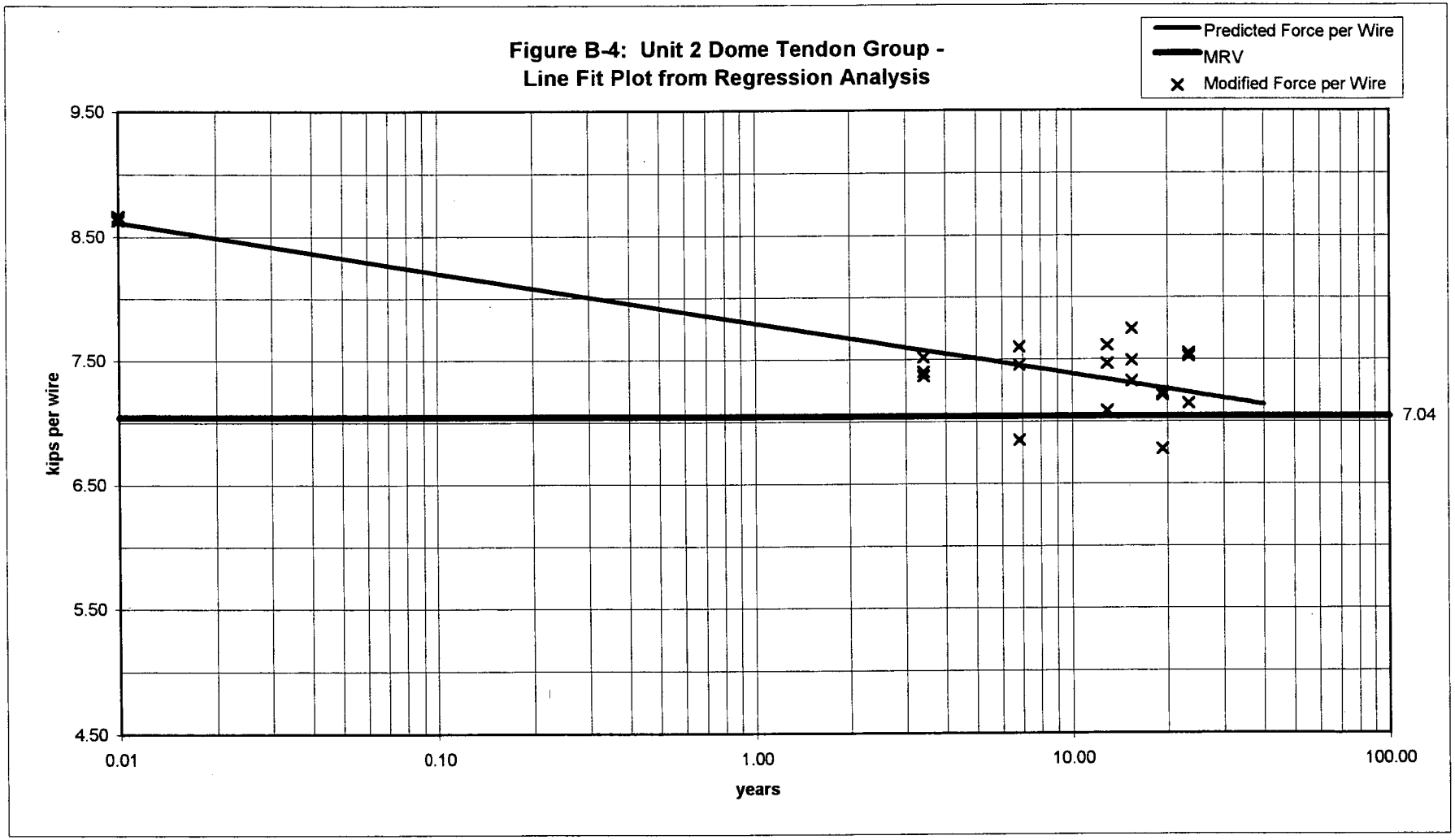
Figure B-4: Unit 2 Dome Tendon Group -
Line Fit Plot from Regression Analysis
Predicted Force per Wire
MRV
Modified Force per Wire
9.50
8.50
7.50
6.50
5.50
4.50
kips per wire
7.04
0.01
0.10
1.00
10.00
100.00
years

UNIT 2 HORIZONTAL TENDON GROUP - REGRESSION ANALYSIS SUMMARY

STATISTICAL DATA	
Time from Installation years	Modified force per wire kips
0.01	8.53
3.33	7.11
5.92	6.78
12.83	6.56
15.33	6.67
19.25	6.13
23.25	6.38
0.01	8.47
3.33	7.37
5.92	7.30
12.83	7.08
15.33	7.12
19.25	6.63
23.25	6.87
0.01	8.56
3.33	7.43
5.92	7.77
12.83	7.03
15.33	7.10
19.25	6.37
23.25	7.01

REGRESSION STATISTICS
Covariance = -1.598
Correlation = -0.8933

EQUATION OF BEST FIT LINE
f(x) = 7.487 + (-0.2377) * LN(x)

years	MRV
0.01	6.50
100	6.50

OUTPUT DATA	
Observation years	Predicted force per wire, f(x) kips
0.01	8.58
0.10	8.03
1	7.49
2	7.32
3	7.23
4	7.16
5	7.10
6	7.06
7	7.02
8	6.99
9	6.96
10	6.94
11	6.92
12	6.90
13	6.88
14	6.86
15	6.84
16	6.83
17	6.81
18	6.80
19	6.79
20	6.77
21	6.76
22	6.75
23	6.74
24	6.73
25	6.72
26	6.71
27	6.70
28	6.69
29	6.69
30	6.68
31	6.67
32	6.66
33	6.66
34	6.65
35	6.64
36	6.64
37	6.63
38	6.62
39	6.62
40	6.61

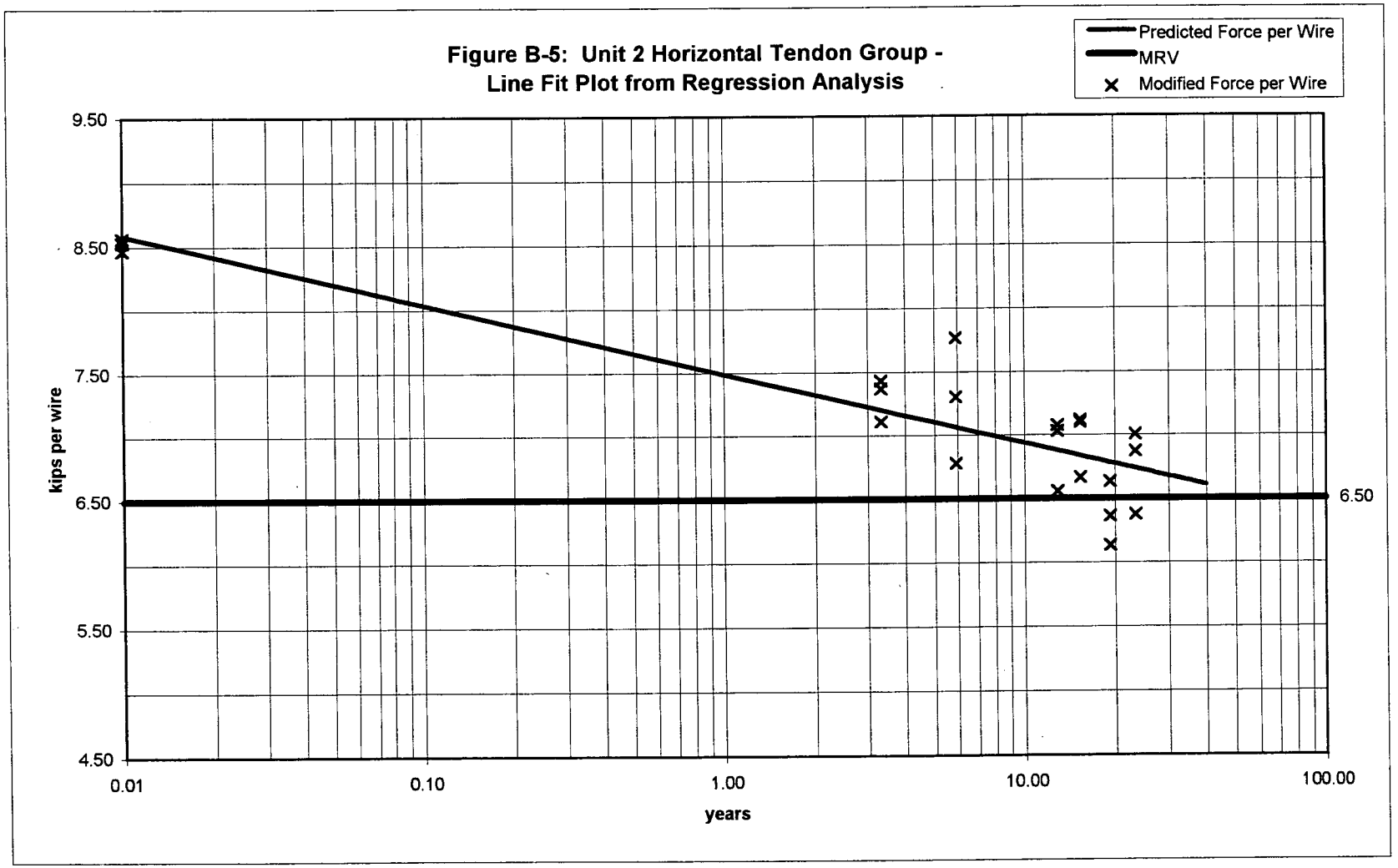
Figure B-5: Unit 2 Horizontal Tendon Group -
Line Fit Plot from Regression Analysis
Predicted Force per Wire
MRV
Modified Force per Wire
9.50
8.50
7.50
6.50
5.50
4.50
kips per wire
6.50
0.01
0.10
1.00
10.00
100.00
years

UNIT 2 VERTICAL TENDON GROUP - REGRESSION ANALYSIS SUMMARY

STATISTICAL DATA	
Time from Installation years	Modified force per wire kips
0.01	8.37
3.25	7.41
6.67	7.28
12.75	7.10
15.25	7.28
19.17	6.72
23.17	6.98
0.01	8.47
3.25	7.50
6.67	7.09
12.75	7.03
15.25	7.13
19.17	6.60
23.17	6.81
0.01	8.55
23.17	7.37
0.01	8.63
3.25	7.52
6.67	7.46
12.75	7.68
15.25	7.81
19.17	7.18
23.17	7.19
0.01	8.68
23.17	7.51
0.01	8.61
23.17	7.27

REGRESSION STATISTICS
Covariance = -1.746
Correlation = -0.9136

EQUATION OF BEST FIT LINE
f(x) = 7.699 + (-0.1846) * LN(x)

years	MRV
0.01	7.25
100	7.25

OUTPUT DATA	
Observation years	Predicted force per wire, f(x) kips
0.01	8.55
0.10	8.12
1	7.70
2	7.57
3	7.50
4	7.44
5	7.40
6	7.37
7	7.34
8	7.32
9	7.29
10	7.27
11	7.26
12	7.24
13	7.23
14	7.21
15	7.20
16	7.19
17	7.18
18	7.17
19	7.16
20	7.15
21	7.14
22	7.13
23	7.12
24	7.11
25	7.10
26	7.10
27	7.09
28	7.08
29	7.08
30	7.07
31	7.07
32	7.06
33	7.05
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35	7.04
36	7.04
37	7.03
38	7.03
39	7.02
40	7.02

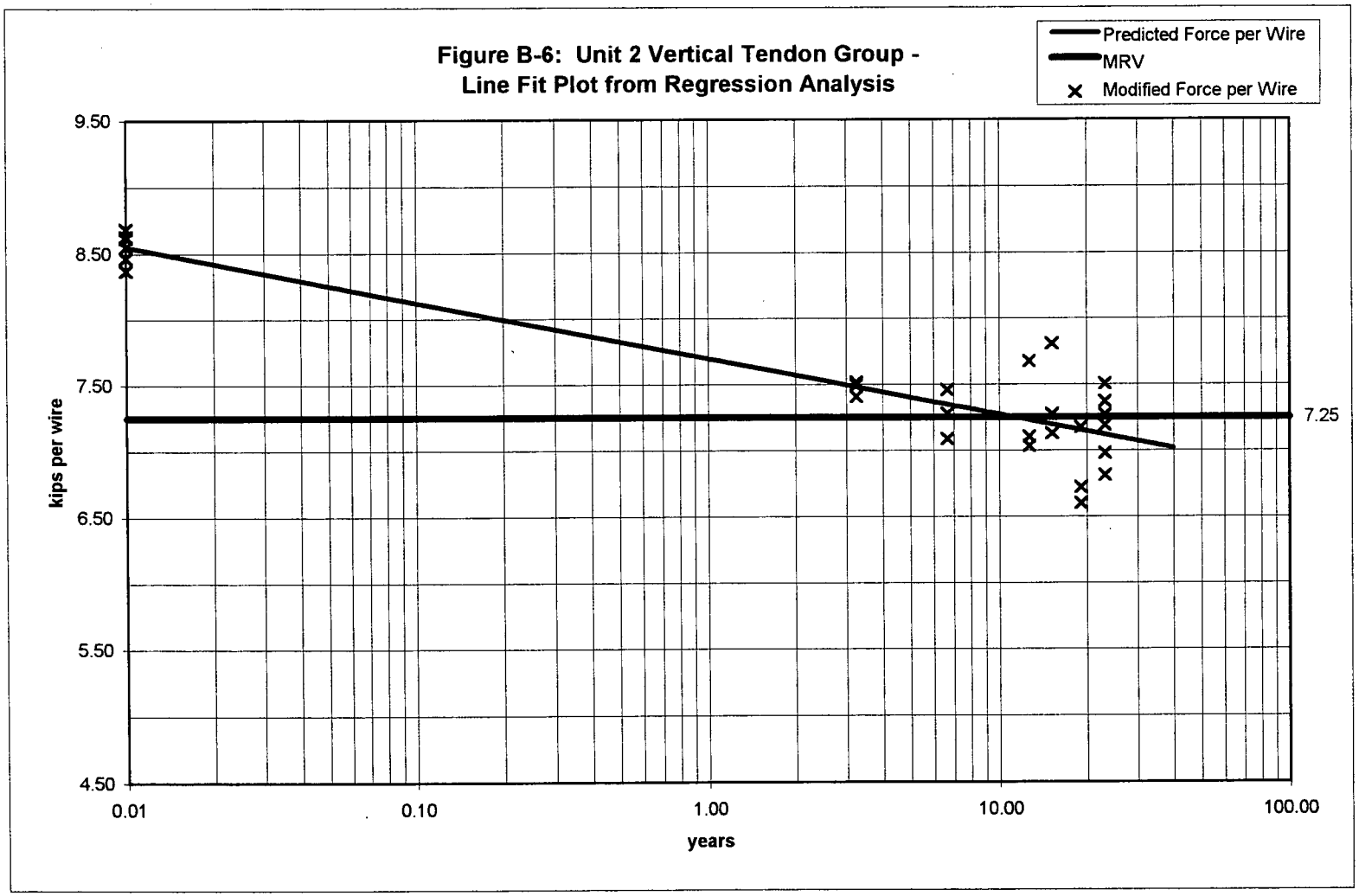
Figure B-6: Unit 2 Vertical Tendon Group -
Line Fit Plot from Regression Analysis
Predicted Force per Wire
MRV
Modified Force per Wire
9.50
8.50
7.50
6.50
5.50
4.50
kips per wire
7.25
0.01
0.10
1.00
10.00
100.00
years

Appendix B Notes and References

1. Reference: *Prestressing Report, Reactor Building, Duke Power Company, Oconee Nuclear Station, Unit 2*, by Bechtel Corporation dated March 1972.

2. For lift-off values, reference: Tendon Stressing Cards (i.e., field data recorded during plant construction).

3. For lift-off values, reference: Field data for *Duke Power Company, Oconee Nuclear Station, Unit 2, Reactor Building, Post-Tensioning System Initial Surveillance* dated 20 March 1975.

4. For lift-off values, reference: Field data for *Duke Power Company, Oconee Nuclear Station, Unit 2, Reactor Building, Tendon Surveillance Program* transmitted by letter dated 21 November 1978 from W. O. Parker, Jr. (DPC) to J. P .O'Reilly (NRC).

5. Lift-off value not obtained because of interference caused by Emergency Feedwater Line.

6. Reference: Duke Power Company Calculation OSC-2125, *Reactor Building Post-Tensioned Tendon Surveillance Program Review*.

7. Non-surveillance tendon.

8. Double entries appear for detensioned/retensioned tendons only and represent as-found and as-left conditions, respectively.

9. Until 1982 surveillance on Oconee Nuclear Station Unit 3 post-tensioning system, pressure gauge was calibrated; however, hydraulic ram was not. Tendon Force = Ram Pressure (psi) * 120.2 in^2 / 1000 lbs/kip. [Reference: Duke Power Company Calculation OSC-2125]

10. After 1982 surveillance on Oconee Nuclear Station Unit 3 post-tensioning system, all ram/gauge combinations were calibrated simultaneously, and tendon forces were obtained directly from this calibration data. [Reference: Duke Power Company Calculation OSC-2125]

11. A blank represents a value of zero.

12. Testing suspended at documented force, 'Shop End' only. Safety concerns prohibited increased ram pressures necessary to achieve lift-off. [Reference: Proposed Resolution to OEP IN 91-80]

13. One buttonhead @ each end anchorage observed missing - assume two broken wires.

14. Time of initial seating force is identified as 0.01 years in order to accommodate logarithmic scale for time.

APPENDIX C

Adjustment of Surveillance Data for Change in Steel Relaxation and/or Creep of Concrete

Duke Power Company's response to NRC request *1a* of letter dated 19 January 1996 stated that computation of the modified tendon lift-off forces in accordance with NRC item *1a* is conservative. The requested computation adjusts all subsequent lift-off force observations for detensioned tendons that experienced a change between 'as-found' and 'as-left' seating forces. Moreover, the modified values computed for these tendons do not account for the associated change in prestress loss due to steel relaxation and creep of concrete. Each of these time-dependent sources of prestress loss is also directly proportional to prestressing force; therefore, any change in a tendon's seating force will cause a commensurate change in the rate and magnitude of prestress loss due to steel relaxation and creep of concrete. In most instances, these surveillance tendons have sustained an increased loss of prestress relative to the general tendon population.

On average, steel relaxation produces almost 50% of loss of prestress in post-tensioned concrete construction and is affected by level of initial prestress and temperature [See data tabulated below]. Creep of concrete contributes approximately 25% of loss of prestress and is affected by volume-to-surface ratio, age of concrete at time of prestress, relative humidity, and type of concrete (lightweight or normal). Given the nature of relaxation of steel and creep of concrete and the relative magnitudes of loss of prestress that each causes, and because tendon stress loss in general is not a precise calculation, only increased steel relaxation caused by a change between 'as-found' and 'as-left' seating forces is investigated.

The most significant change between the 'as-found' and as 'as-left' lift-off conditions documented for a tendon during any one surveillance occurred for tendon 13H9 of Unit 2 [See values of '$\Delta_{\text{seating force per wire}}$' for Unit 1 and 2 surveillance data tabulated in Appendices A and B, respectively, and Unit 3 surveillance data transmitted by letter dated 14 March 1996].

Page 101 of [Reference 1] states that loss of prestress due to steel relaxation (RE) may be represented by the equation (1):

$$f_p / f_{pi} = 1 - ((\log t) / 10) * (f_{pi} / f_{py} - 0.55),$$

and, with a time interval between the moment of stressing t_1 and a later time t when the remaining force is to be estimated, by the following equation (2):

$$f_p / f_{pi} = 1 - ((\log t - \log t_1) / 10) * (f_{pi} / f_{py} - 0.55)$$

Computation of RE at t = 29200 hr. for tendon 13H9:

f_{py} = 240 ksi for uncoated stress-relieved wire for prestressed concrete conforming to type BA of ASTM A421-65.

f_{pi} = 173.8 ksi

$f_p / f_{pi} = 1 - ((\log 29200) / 10) * (173.8 / 240 - 0.55)$

$f_p / f_{pi} = 0.922$, or %RE = 7.78%

RE = 7.78% * 173.8 = 13.5 ksi = 13.5 * $\pi(0.25/2)^2$ = 0.664 kips/wire

Validation of RE at t = 29200 hr. for tendon 13H9:
In post-tensioned concrete structures, the following are representative of the amounts of average loss of prestress, expressed as a percentage of initial prestress, for average steel and concrete properties, cured under average air conditions: [Reference 1, page 116]:

Elastic shortening (ES) and bending of concrete:	1
Creep of concrete (CR)	5
Shrinkage of concrete (SH)	6
Steel relaxation (RE)	8
	20

For tendon 13H9, total loss of prestress at time, t = 29200 hr., is:

173.8 - 144.8 = 29 ksi, or 29 / 173.8 = 16.7%

Dividing this loss among ES, CR, SH, and RE based on the above tabulated percentages:

ES = (1 / 20) * 16.7 = 0.834%
CR = (5 / 20) * 16.7 = 4.17 %
SH = (6 / 20) * 16.7 = 5.01 %
RE = (8 / 20) * 16.7 = 6.67 %

Given the fact that the majority of loss of prestress occurs during the very beginning (first two years) of a structure's life and the approximate nature of the above equations and distributions of loss of prestress to ES, CR, SH, and RE, it can be seen that Equation 1 provides a reasonable estimate of the loss of prestress due to RE.

Computation of RE t_1 = 29200 to t = 203670 for tendon 13H9:
Assumption: Change in level of prestress between 'as-found' and as 'as-left' lift-off conditions during fourth surveillance ($\Delta_{\text{seating force}}$ = -0.12 kips per wire) does not significantly affect this computation.

f_{py} = 240 ksi
f_{pi} = 173.8 ksi

$f_p / f_{pi} = 1 - ((\log 203670 - \log 29200) / 10) * (173.8 / 240 - 0.55)$
$f_p / f_{pi} = 0.985$, or %RE = 1.47%
RE = 1.47% * 173.8 = 2.55 ksi = $2.55 * \pi(0.25/2)^2 = 0.125$ kips/wire

However, at time t = 29200, tendon 13H9 was effectively restressed to its original seating stress ($f_{p\ @\ t=29200}$ = 170.6 compared to f_{pi} = 173.8); therefore, loss of prestress due to RE for tendon 13H9 from t_1 = 29200 to t = 203670 is:

$$f_p / f_{pi} = 1 - ((\log t) / 10) * (f_{pi} / f_{py} - 0.55)$$

where:
t = 203670 - 29200 = 174470 hr.
f_{py} = 240 ksi
f_{pi} = 170.6 ksi

$f_p / f_{pi} = 1 - ((\log 174470) / 10) * (170.6 / 240 - 0.55)$,
$f_p / f_{pi} = 0.916$, or %RE = 8.43%
RE = 8.43% * 170.6 = 14.4 ksi = 14.4 * $\pi(0.25/2)^2$ = 0.706 kips/wire

Additional loss of prestress due to RE resulting from restressing of tendon 13H9 at time, t = 29200:

ΔRE = 0.706 - 0.125 = 0.581 kips/wire

Conclusion:
Estimated loss of prestress and associated equations for computing amounts of such losses are approximate in nature. Combination of this fact with the various circumstances affecting accuracy of lift-off readings over time [See below] precludes the use of the above results in any quantitative manner. However, the above calculations do demonstrate qualitatively that computation of modified tendon lift-off forces in accordance with NRC item *1a* is conservative and that, in instances such as that evaluated above, surveillance tendons have sustained an increased loss of prestress relative to the general tendon population.

Factors affecting accuracy of lift-off readings over time:

1. Surveillance tendon force fluctuation (either increase or decrease) produced by tendon detensioning/retensioning activities.

2. Change in method of ram pressure - lift-off force conversion:
   a) Tendon lift-off force initially computed by multiplying ram area by hydraulic pressure.
   b) Tendon lift-off force later based on ram and pressure gauge calibration (circa 1984).

3. Ram/gauge calibration and lift-off pressure reading accuracy as discussed in Duke Power Company submittal transmitted to NRC by letter dated 14 March 1996.

4. Ambient temperature effects (both internal containment and external atmosphere) on prestress level at time of measurement.

5. Conservative assumption in number of broken wires based on missing buttonheads - unless wires are known to have been removed during previous tendon surveillance(s), total number of broken wires equals sum of missing buttonheads at each end anchorage.

Appendix C Notes and References

1. *Design of Prestressed Concrete Structures*, Third Edition by T. Y. Lin and Ned H. Burns.