GAI REPORT NO. 2521
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ROBERT E. GINNA NUCLEAR POWER STATION
CONTAINMENT VESSEL TENDONS
LOAD CELL EVALUATION

PREPARED FOR:

ROCHESTER GAS AND ELECTRIC COMPANY

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1.0 INTRODUCTION

The NRC requested RG&E to establish a short term tendon force monitoring program following the 1980 tendon retensioning program to ensure tendon prestress levels prior to the scheduled July 1981 surveillance. The program actually started in March, 1981 using four 800,000 pound capacity split load cells which had been installed in April, 1969. Their original function had been to monitor tendon force levels during the initial Structural Integrity Test. These load cells were installed beneath the anchorages of tendons 13, 53, 93 and 133.

In addition to the force monitoring, RG&E also instituted a temperature monitoring program. This was to determine the effect of seasonal variations on tendon forces. Thermocouples were installed in each of five tendon conduits (the four tendons previously mentioned plus tendon 126) about two feet down from the top anchorage. Thermocouples were also installed on the exterior surface of the containment building wall adjacent to each of the above five tendons. Tendon 126, although not having a load cell, was included in the temperature monitoring because it passes around a steam line penetration, as does tendon 53.

The long term monitoring program began in August 1981, following calibration of the load cells during the July, 1981 surveillance, and was concluded in July, 1982.

2.0 EVALUATION PROCEDURE

Five variables were presented in the field data supplied for the evaluation (Reference 1):

a. tendon conduit internal temperature
b. concrete surface temperature

c. containment building internal temperature

d. average outdoor ambient temperature

e. tendon force

In an effort to determine the relationships between the data, the following curves were developed for each tendon:

a. temperature vs time

b. measured tendon force vs tendon conduit internal temperature

c. corrected tendon force vs tendon conduit internal temperature

d. monthly average tendon force vs time

3.0 RESULTS OF EVALUATION

a. Temperature vs Time (Figures 1 through 5) - These figures indicate that, for tendons 13, 93 and 133, the tendon conduit internal temperature closely follows the concrete surface temperature and the outside ambient temperature. The conduit internal temperature, being measured at an elevation where the containment is exposed to outside ambient temperature, is not significantly affected by the containment temperature. For tendons 53 and 126, which are both adjacent to steam penetrations, the conduit internal temperature still basically follows the variations in concrete surface and outdoor temperatures but is somewhat higher in temperature, as would be expected.

   It is expected that temperatures further down in each conduit, below the adjacent building roofs, would show less variation with the outside ambient temperature. The temperatures at these locations would be higher, being close to the average of the temperatures inside the containment and the adjacent building.

b. Measured Tendon Force vs Conduit Internal Temperature (Figures 6b through 9b) - Since tendon 126 had no load cell,

it is not included in these figures. For the remaining four tendons (with load cells), the plotted data are scattered, but the data does display the trend of a reduction in tendon force with increasing temperature. It is noted that, since the data covers a twelve month period, the tendon forces are being affected not only by temperature, but by stress relaxation as well. To see the effect of temperature only on the tendon force, the stress relaxation losses over the period of interest must be added to the load cell values.

In order to establish the approximate amount of stress relaxation experienced by each of these tendons over the one-year period, two data sets of equal temperature, as many months apart as possible, were selected for each tendon. From the differences in the force readings, monthly rates of stress relaxation loss were derived and applied to the load cell force readings. Tables 1, 2, 3 and 4 are included to show the tabulation of these values.

c. Corrected Tendon Force vs Tendon Conduit Internal Temp. (Figures 6a through 9a) - Once the tendon forces have been corrected for stress relaxation and are then plotted against temperature, a more linear relationship between tendon force and conduit internal temperature becomes apparent. For the four tendons for which force and temperature was available, the tendon force reduces by about 2 kips for each 10°F increase in the internal temperature of the tendon conduit within the temperature range of available data.

It should be noted that only a small vertical portion (17 ft. average) of the exterior wall is exposed to outside ambient air temperatures, with the balance (94 ft. average) being adjacent to the interior areas of other buildings. Calculations show that if the full length of the tendons were subjected to the temperature change recorded by the conduit

internal thermocouples, the force change would be about an 8 kips reduction for each 10°F increase in tendon conduit internal temperature.

d. Monthly Average Tendon Force vs Time (Figures 10 through 13) - The tendon load cells were read on the 10th, 20th and 30th of each month (Reference 1). The average of the three values of tendon forces measured each month are plotted as solid dots against time. The result is a curve showing basically a constant or even a slightly increasing tendon force as the testing program progressed from warm weather (Aug. '81) through the winter months up to about April 1982. This trend occurs because the stress relaxation of the tendon is offset by the general trend of decreasing ambient temperatures. Beyond April 1982 the tendon forces fall off as warm weather is encountered. The average tendon force reduced by 15 kips from April 1982 to July 1982, and most of this decline can be attributed to temperature, as discussed below.

The monthly average of the tendon forces has been corrected for stress relaxation in Tables 1, 2, 3 and 4 and entered on Figures 10, 11, 12 and 13 as "X"s. The corrected curves show an average increase in tendon force of 5 kips, which is associated with the decreasing temperature trend as the testing progressed from August 1981 to April 1982. There is an average loss of force of 12 kips as warmer months were again encountered from April 1982 to July 1982. Therefore, of the 15 kips average force loss over this latter period, 12 kips on the average is due to the general increase in ambient temperature which occurred.

4.0 CONCLUSIONS

The load cell results indicate that the tendon forces were reasonably stable over the period from August 1981 to July 1982, and no abnormal force losses occurred. Most of the fluctuation in

measured force during this period can be attributed to seasonal variations in outside air temperature.

The results indicate that a tendon could exhibit a force loss as large as 16 kips between two measurements taken first in Winter and then in Summer, and most of this loss would relate to temperature. An approximation of the temperature effect is that tendon force is inversely proportional to temperature, and the tendon force declines about 2 kips for each 10°F increase in outside monthly average ambient temperature.

5.0 REFERENCES

1. Ginna Containment Vessel, TENDON LOAD CELL MONITORING REPORT, Jan., 1984. Letter from C.A. Forbes (RG&E) to D.R. Campbell, dated February 2, 1984 (13NI-RG-L0627).

TABLE 1

Force and Temperature Data

Tendon 13

Months from start	Meas. Force F (K)	Temp. Deg. F	Stress Relax. SR (K)	F+SR (K)	F+SR Ave. (K)
0	714	--	0	714	
0	710	--	0	710	710
0	706	--	0	706	
1	708	--	1	709	
1	708	69	1	709	709
1	708	60	1	709	
2	708	55	2	710	
2	710	51	2	712	711
2	710	50	2	712	
3	710	51	3	713	
3	710	51	3	713	714
3	712	41	3	715	
4	710	42	4	714	
4	710	37	4	714	714
4	710	41	4	714	
5	710	37	5	715	
5	710	32	5	715	715
5	710	32	5	715	
6	708	--	5	713	
6	706	--	5	711	712
6	706	--	5	711	
7	708	--	6	714	
7	706	--	6	712	713
7	706	--	6	712	
8	708	32	7	715	
8	706	55	7	713	714
8	706	50	7	713	
9	702	64	8	710	
9	702	69	8	710	710
9	702	73	8	710	
10	700	73	8	708	
10	700	73	8	708	707
10	698	77	8	706	
11	694	91	9	703	
11	690	95	9	699	702
11	694	86	9	703	

TABLE 2

Force and Temperature Data

Tendon 53

Months from start	Meas. Force F (K)	Temp. Deg. F	Stress Relax. SR (K)	F+SR (K)	F+SR Ave. (K)
0	730	76	0	730	
0	726	82	0	726	727
0	724	86	0	724	
1	720	64	1	721	
1	726	73	1	727	725
1	726	76	1	727	
2	728	55	1	729	
2	728	55	1	729	729
2	728	64	1	729	
3	730	46	2	732	
3	728	55	2	730	731
3	728	55	2	730	
4	728	41	2	730	
4	728	46	2	730	731
4	730	46	2	732	
5	728	32	3	731	
5	728	32	3	731	731
5	728	37	3	731	
6	730	32	4	734	
6	730	32	4	734	734
6	730	37	4	734	
7	730	32	4	734	
7	730	41	4	734	733
7	728	41	4	732	
8	728	42	5	733	
8	728	50	5	733	733
8	730	55	5	735	
8	728	55	5	733	
9	724	69	5	729	
9	724	69	5	729	728
9	722	73	5	727	
10	720	73	6	726	
10	720	78	6	726	726
10	720	82	6	726	
11	714	91	7	721	
11	716	95	7	723	722
11	716	95	7	723	

TABLE 3

Force and Temperature Data

Tendon 93

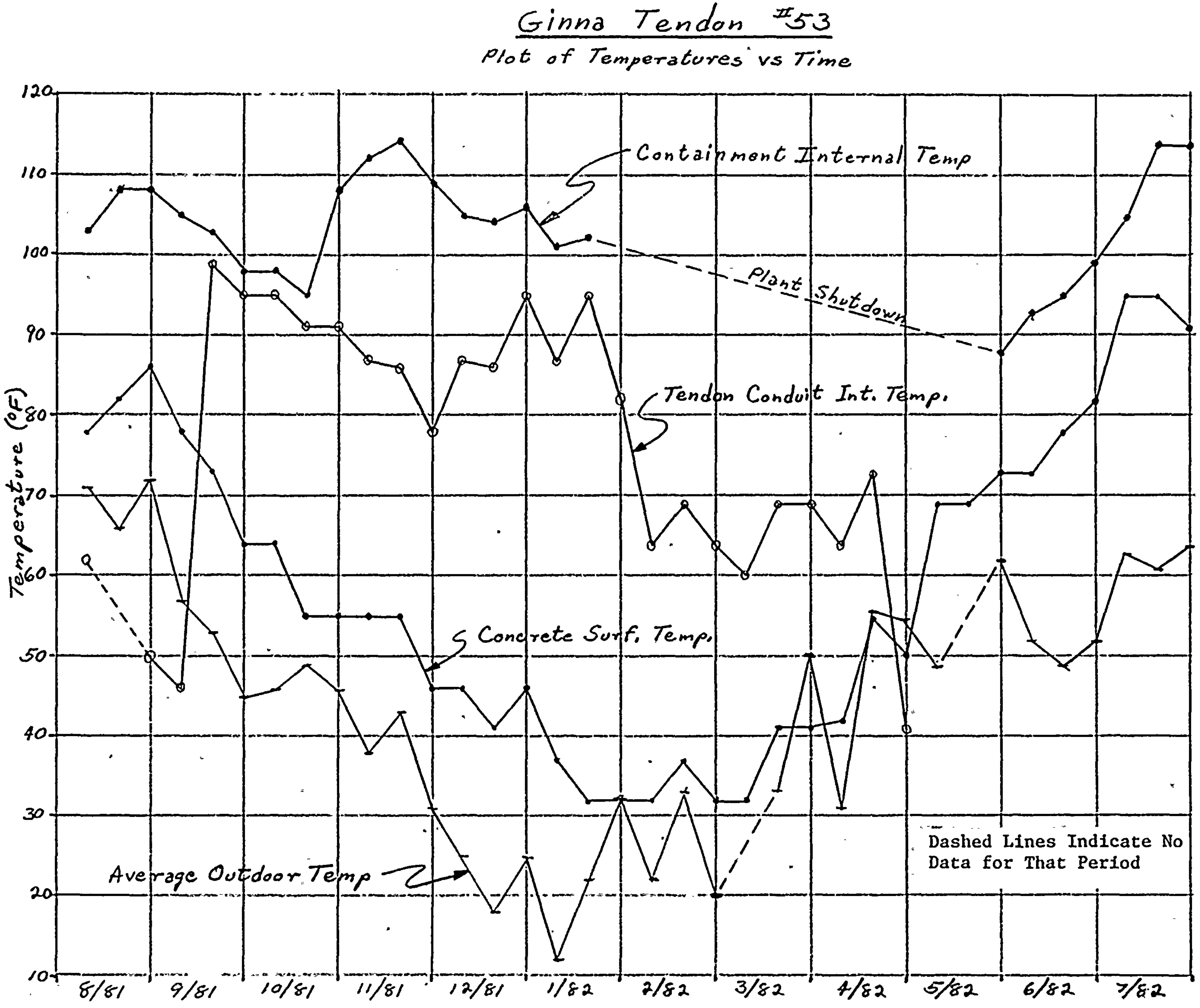
Months from start	Meas. Force F (K)	Temp. Deg. F	Stress Relax. SR (K)	F+SR (K)	F+SR Ave. (K)
0	702	82	0	702	
0	698	86	0	698	699
0	696	78	0	696	
1	698	73	1	699	
1	698	64	1	699	699
1	698	64	1	699	
2	698	55	1	699	
2	700	55	1	701	700
2	700	55	1	701	
3	700	55	2	702	
3	700	46	2	702	703
3	702	42	2	704	
4	702	37	2	704	
4	702	46	2	704	704
4	702	37	2	704	
5	702	32	3	705	
5	704	32	3	707	706
5	704	32	3	707	
6	704	37	4	708	
6	702	32	4	706	707
6	702	32	4	706	
7	702	41	4	706	
7	702	41	4	706	705
7	700	37	4	704	
8	702	55	5	707	
8	700	50	5	705	706
8	700	64	5	705	
9	694	69	5	699	
9	694	73	5	699	699
9	694	73	5	699	
10	692	78	6	698	
10	692	82	6	698	697
10	690	91	6	696	
11	688	95	7	695	
11	686	91	7	693	694
11	686	95	7	693	

TABLE 4

Force and Temperature Data

Tendon 133

Months from start	Meas. Force F (K)	Temp. Deg. F	Stress Relax. SR (K)	F+SR (K)	F+SR Ave. (K)
0	726	78	0	726	
0	722	73	0	722	723
0	720	--	0	720	
1	722	--	1	723	
1	722	69	1	723	723
1	722	55	1	723	
2	722	55	2	724	
2	722	51	2	724	724
2	722	50	2	724	
3	722	51	2	724	
3	722	51	2	724	725
3	724	41	2	726	
4	722	42	3	725	
4	722	37	3	725	725
4	722	41	3	725	
5	722	32	4	726	
5	720	27	4	724	725
5	720	27	4	724	
6	720	32	5	725	
6	720	37	5	725	725
6	720	32	5	725	
7	720	32	6	726	
7	720	41	6	726	726
7	720	37	6	726	
8	720	32	6	726	
8	720	46	6	726	726
8	720	--	6	726	
9	716	64	7	723	
9	716	69	7	723	723
9	716	73	7	723	
10	714	73	8	722	
10	714	73	8	722	721
10	712	77	8	720	
11	708	91	9	717	
11	706	95	9	715	715
11	704	86	9	713	



Ginna Tendon #53
Plot of Temperatures vs Time
Temperature (°F)
120
110
100
90
80
70
60
50
40
30
20
10
Containment Internal Temp
Plant Shutdown
Tendon Conduit Int. Temp.
Concrete Surf. Temp.
Average Outdoor Temp
Dashed Lines Indicate No Data for That Period
8/81
9/81
10/81
11/81
12/81
1/82
2/82
3/82
4/82
5/82
6/82
7/82

FIGURE 2

Ginna Tendon #93

Plot of Temperatures vs Time

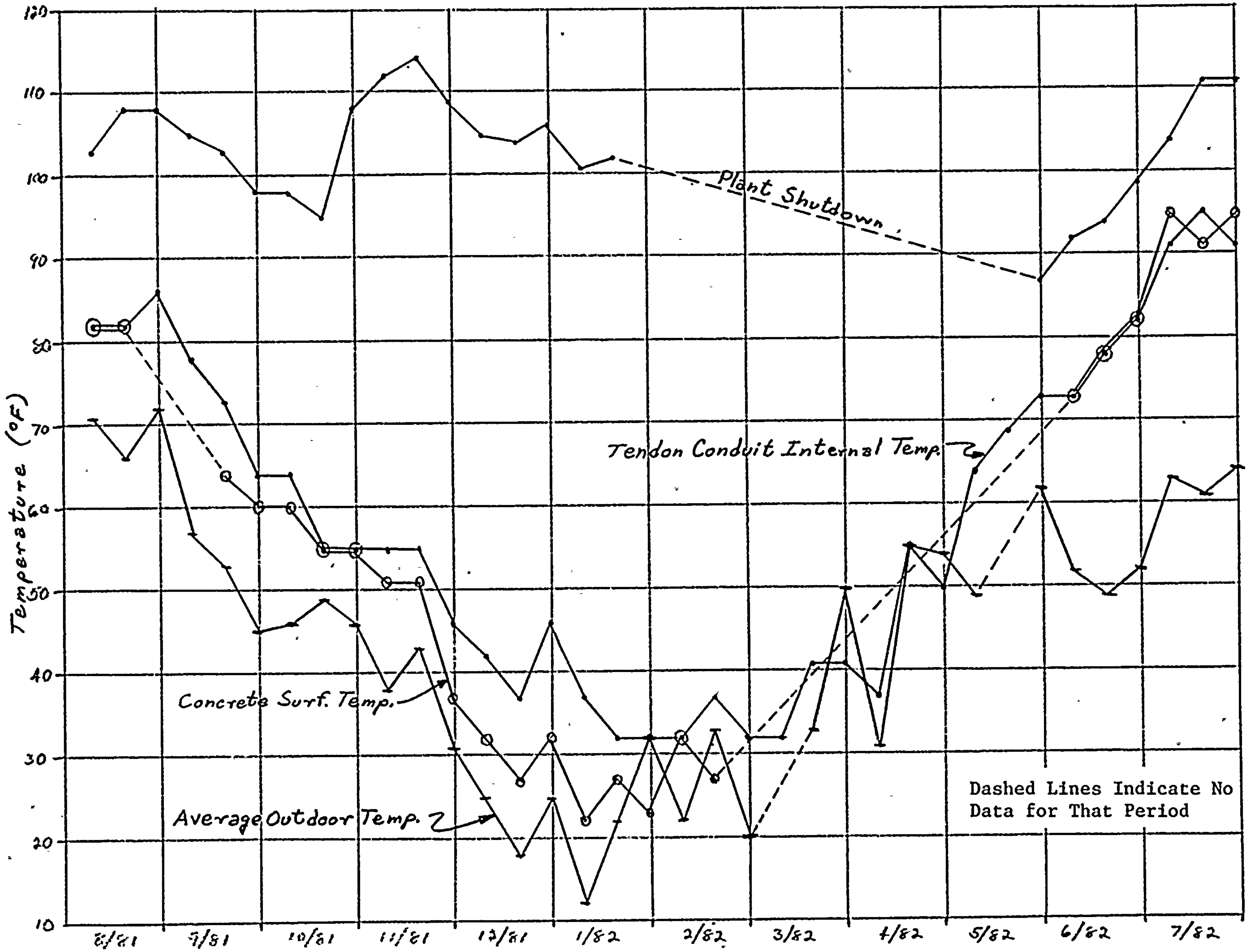


FIGURE 3

Ginna Tendon #126

Plot of Temperatures vs Time

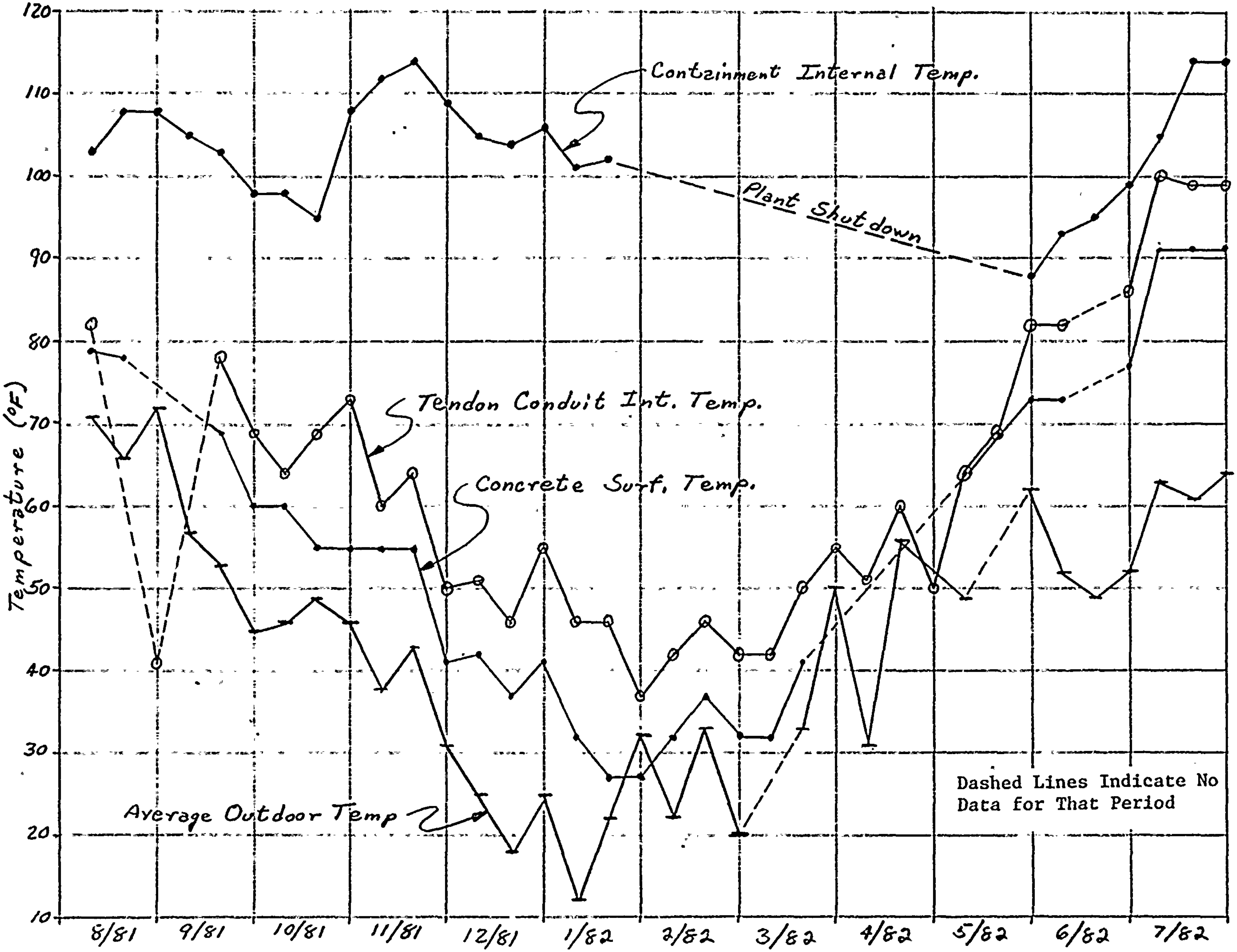
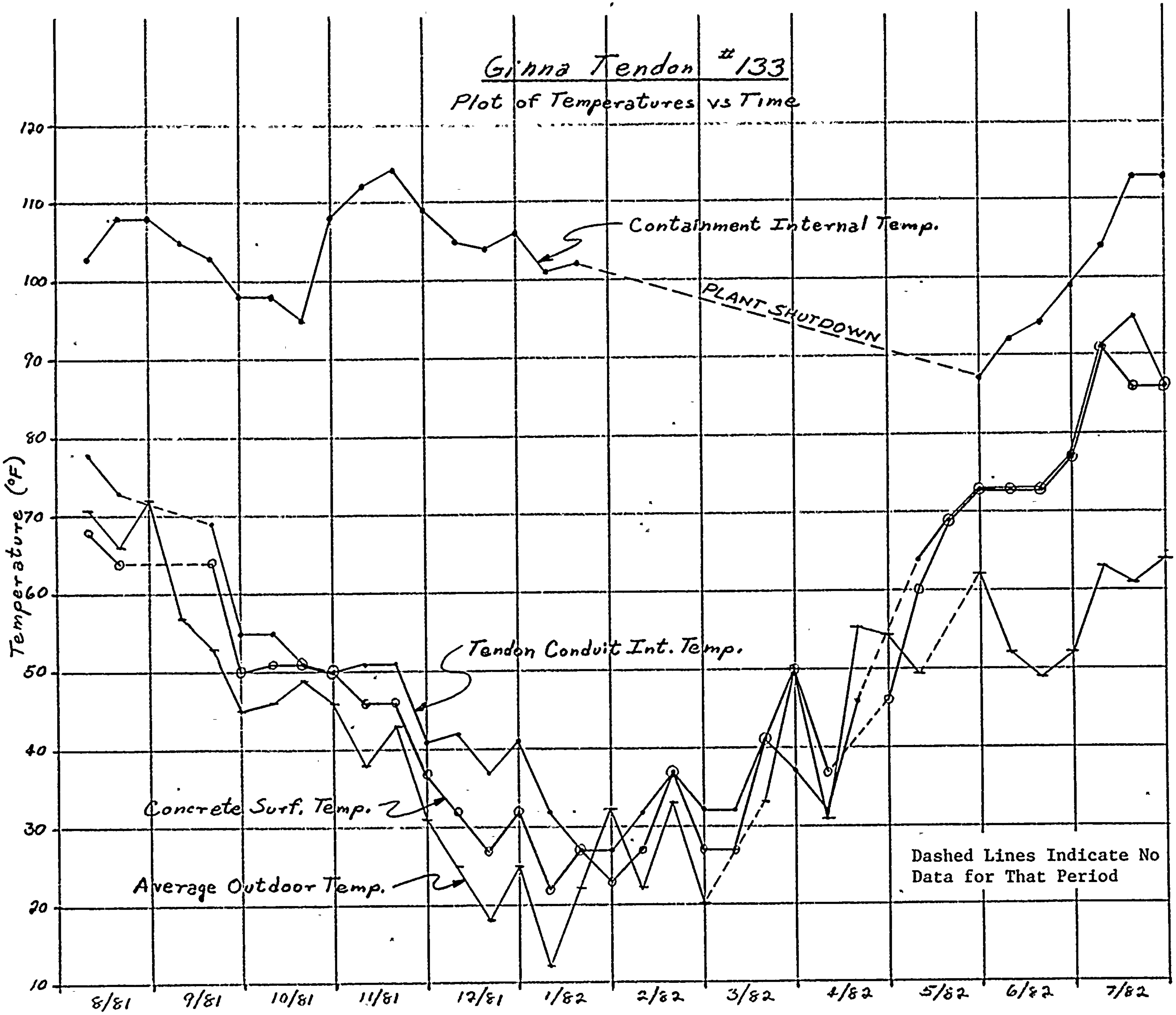


FIGURE 4



Ginna Tendon #133
Plot of Temperatures vs Time
Temperature (°F)
120
110
100
90
80
70
60
50
40
30
20
10
Containment Internal Temp.
PLANT SHUTDOWN
Tendon Conduit Int. Temp.
Concrete Surf. Temp.
Average Outdoor Temp.
Dashed Lines Indicate No
Data for That Period
8/81
9/81
10/81
11/81
12/81
1/82
2/82
3/82
4/82
5/82
6/82
7/82

FIGURE 5

Ginna Tendon #13

Plot of Temperatures vs Time

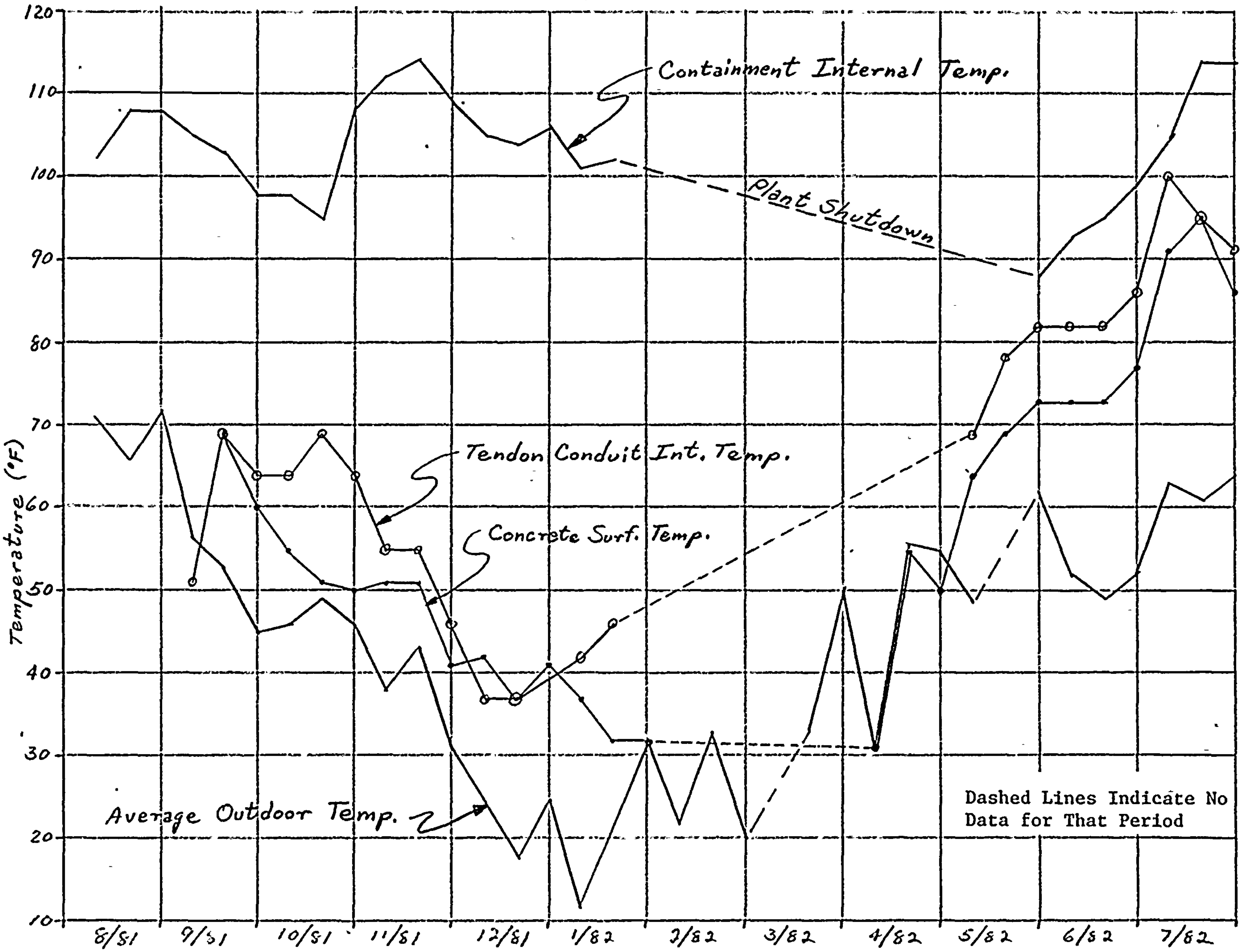


FIGURE 1

	MADE	GILBERT ASSOCIATES, INC.
	CHK'D.	ENGINEERS AND CONSULTANTS
	SQ. CF.	READING, PENNA.
	CF. DFN.	
	ENG.	WORK ORDER / SIZE / DRAWING / REV.
	REV. CH. APP. DATE	

TENDON #13

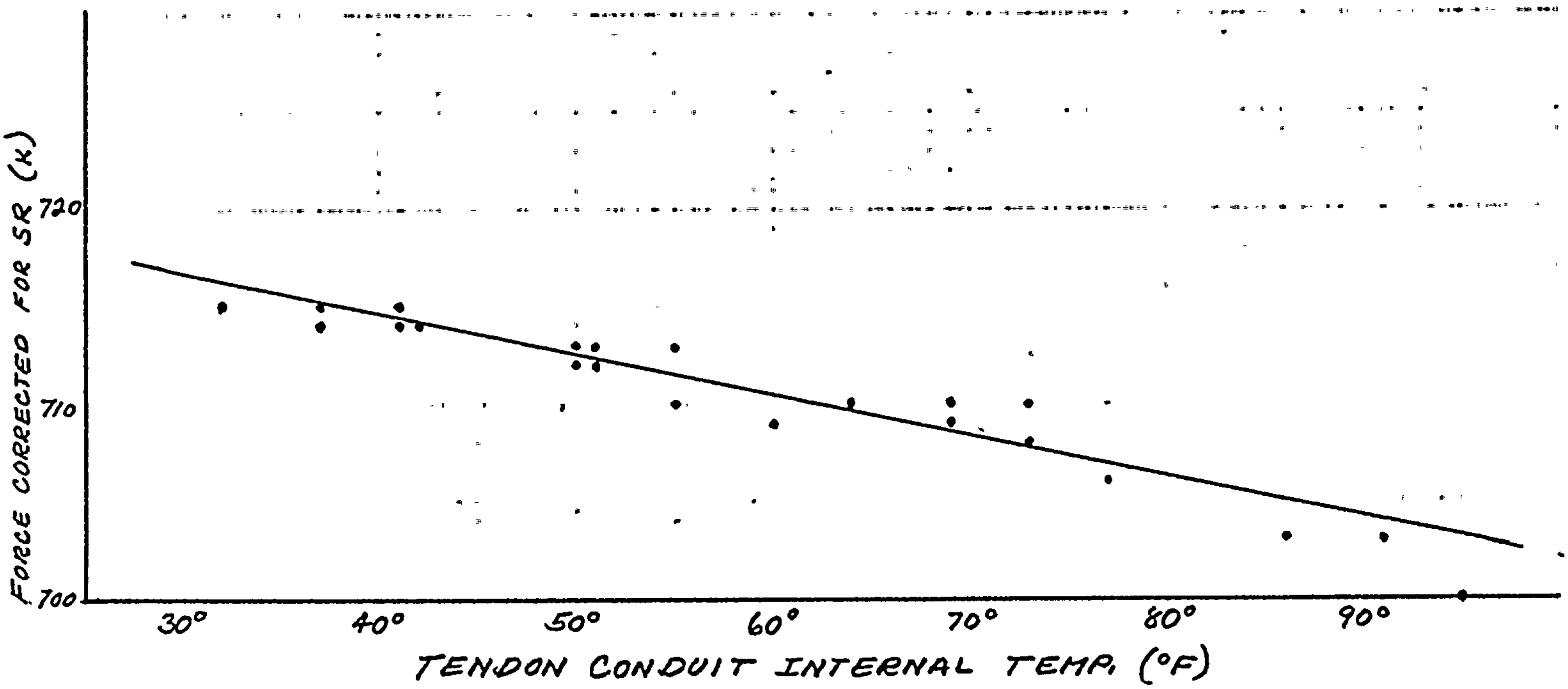


FIGURE 6a

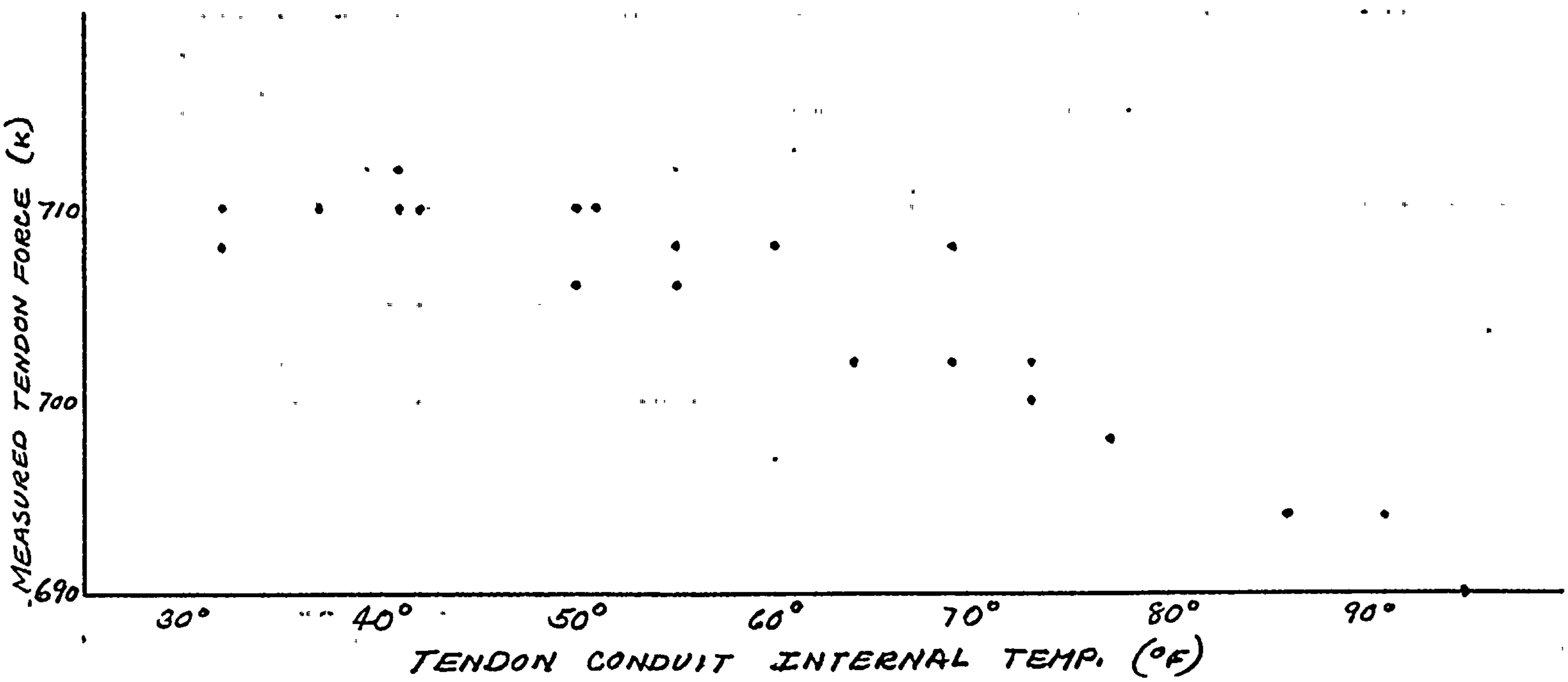


FIGURE 6b

TENDON #53

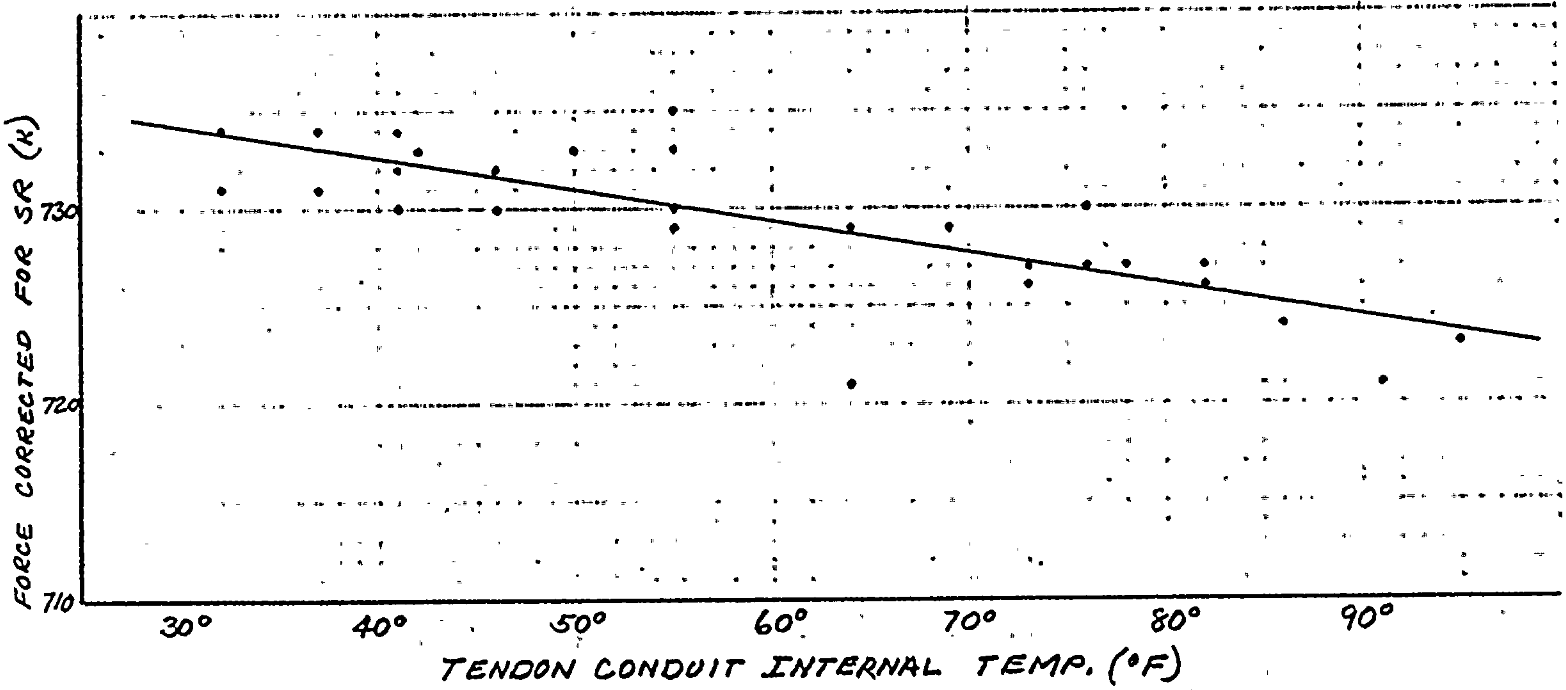


FIGURE 7a

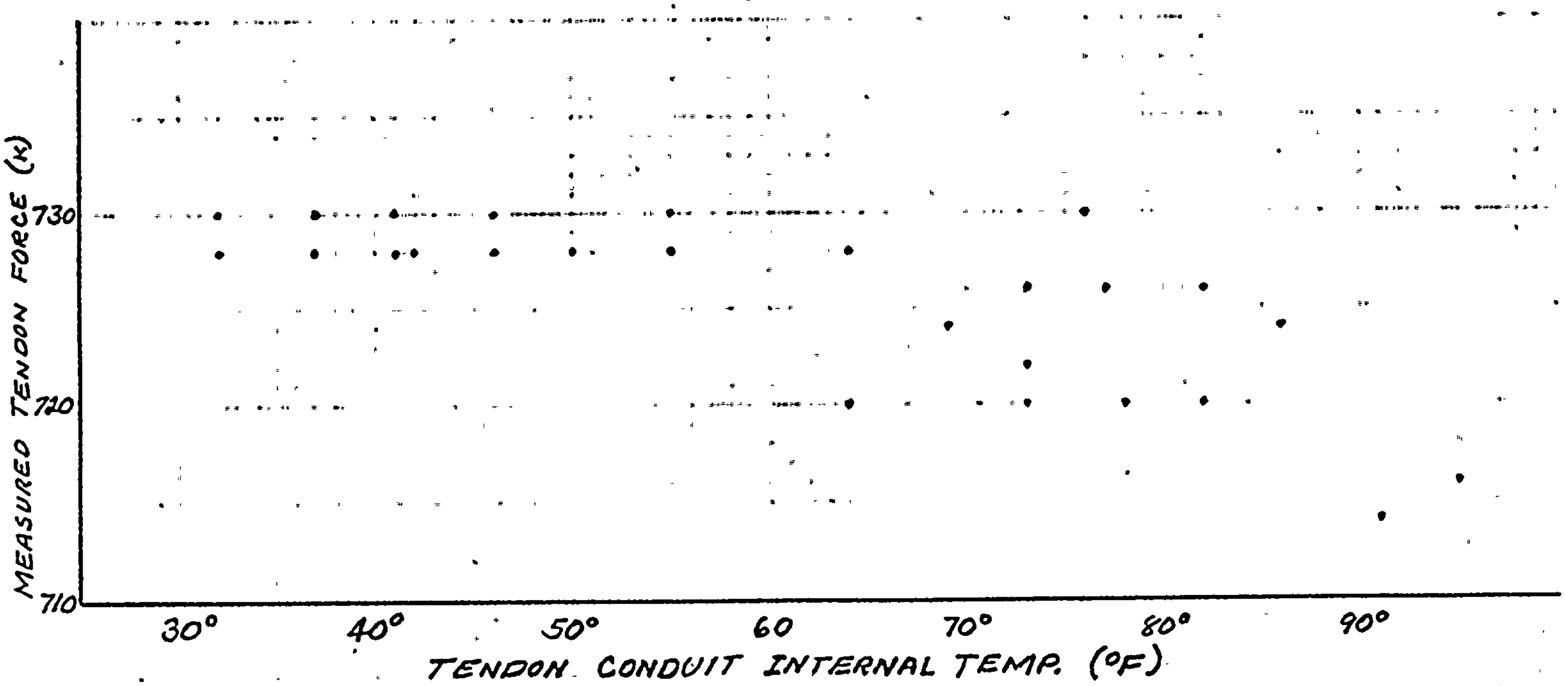


FIGURE 7b

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	CF. DFN.	
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	REV. CH. APP. DATE	

TENDON #93

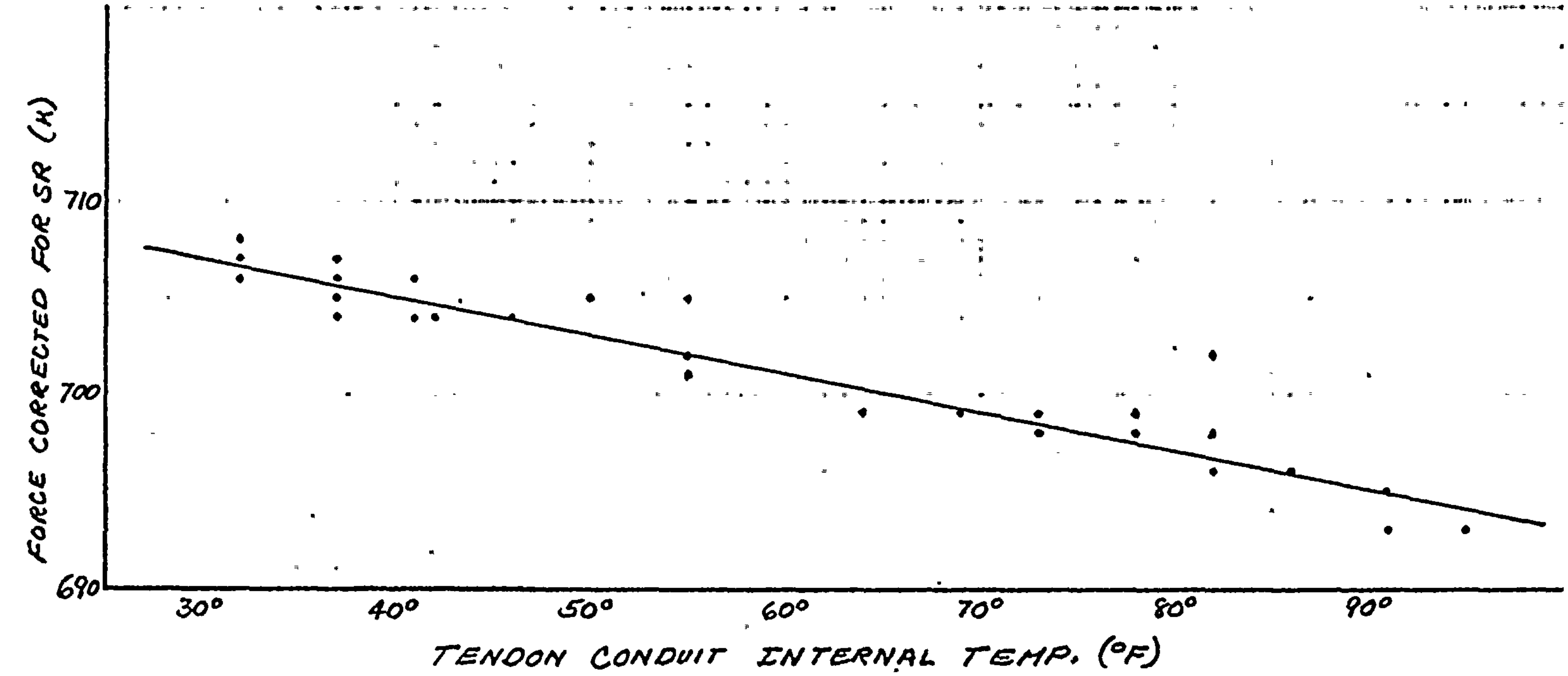

FIGURE 8a

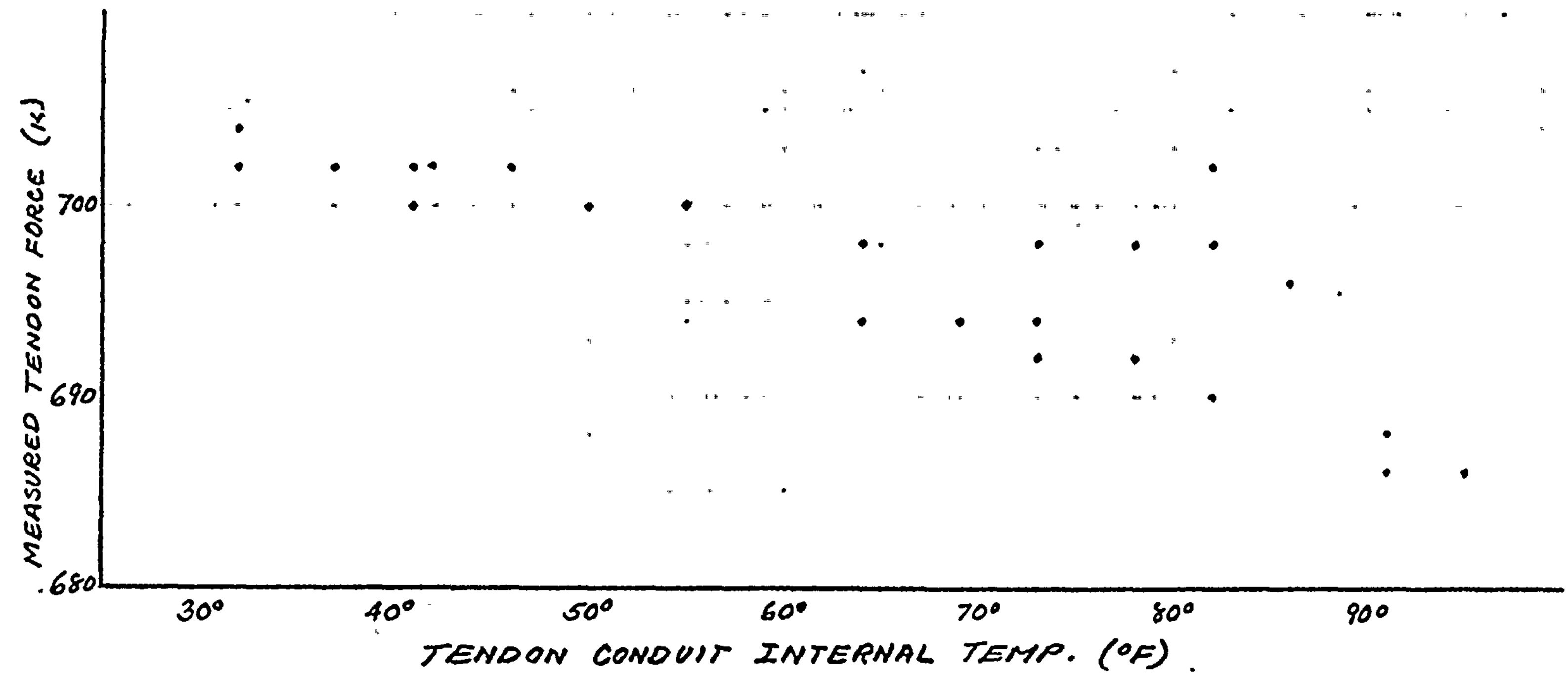

FIGURE 8b

	MADE	GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PENNA.
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	CF. DFN.	
	ENG.	WORK ORDER / SIZE / DRAWING / REV.
	REV. CH. APP. DATE	

TENDON #133

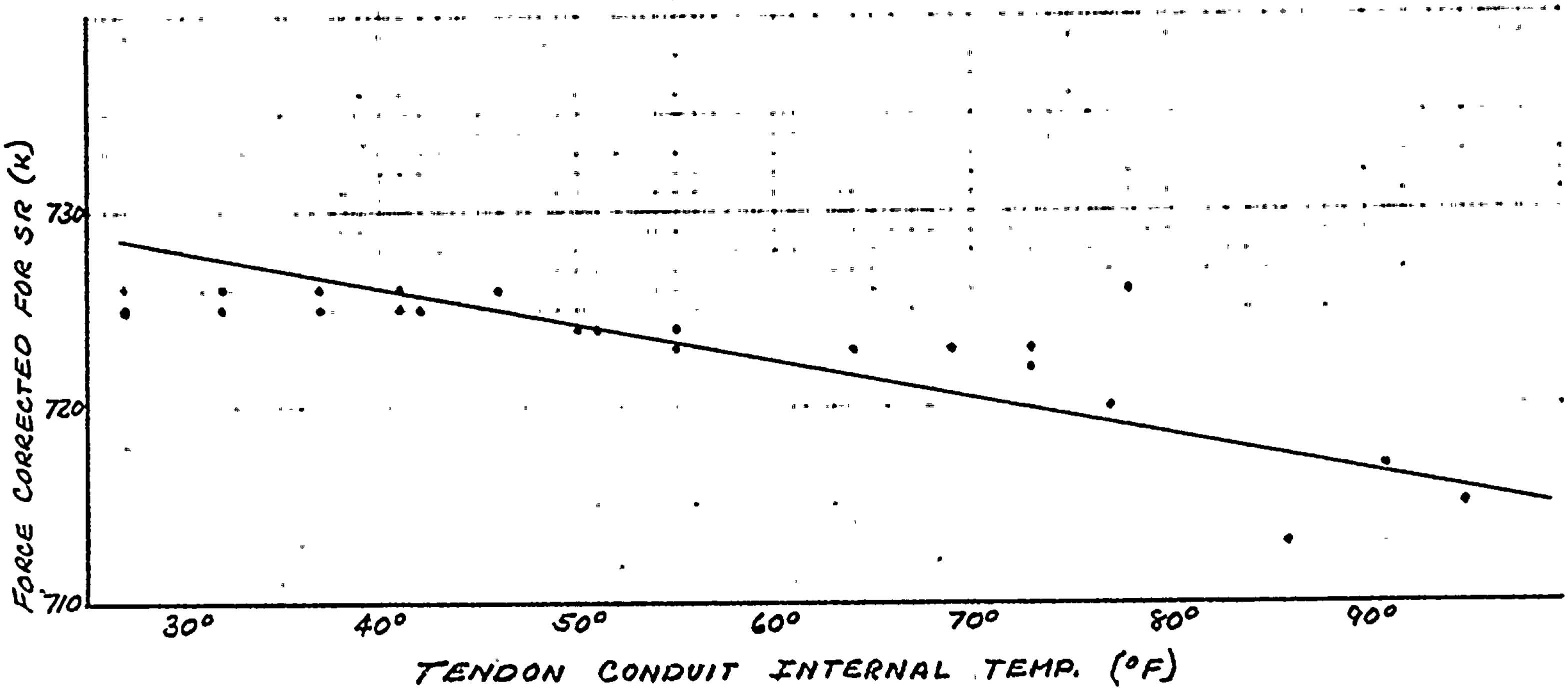


FIGURE 9a

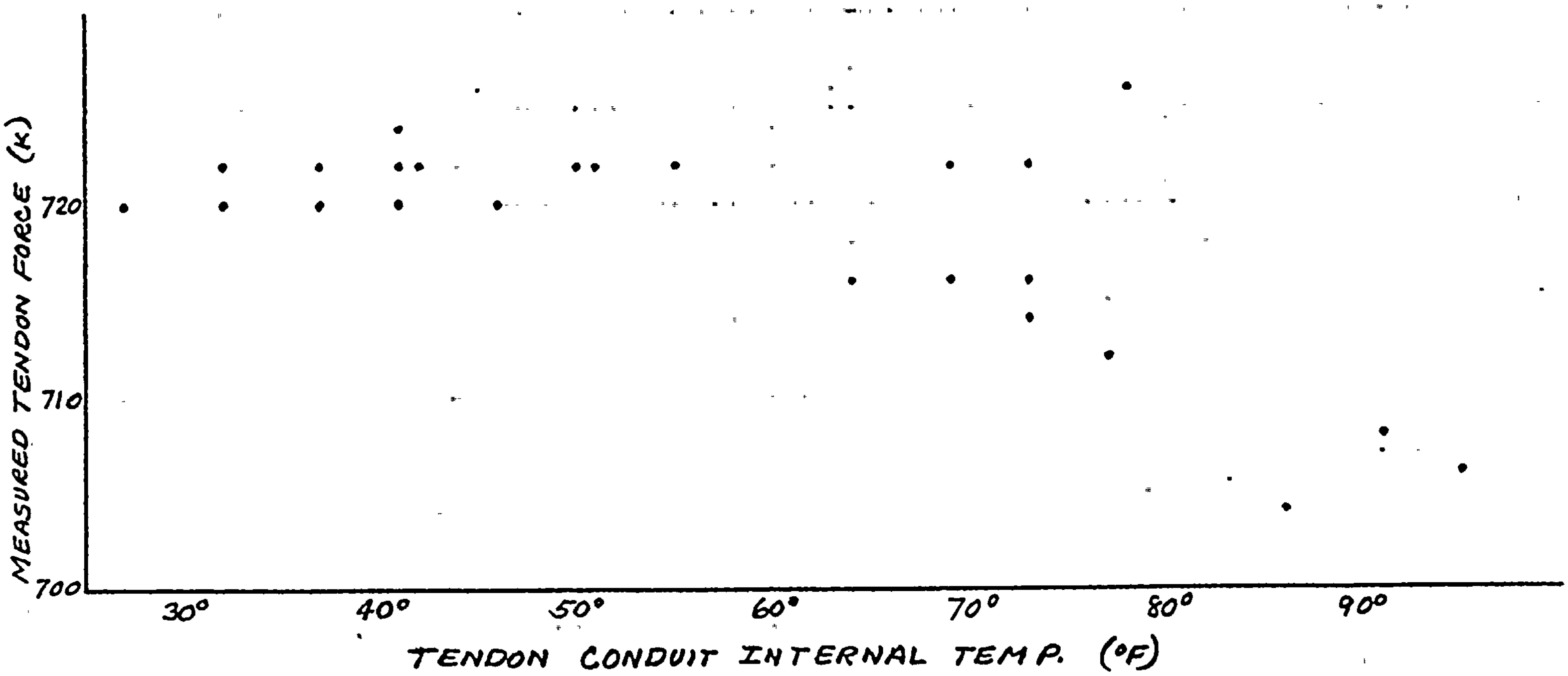


FIGURE 9b.

FIGURE 10

Monthly Average Tendon Force
Force vs. Time
for TENDON 13

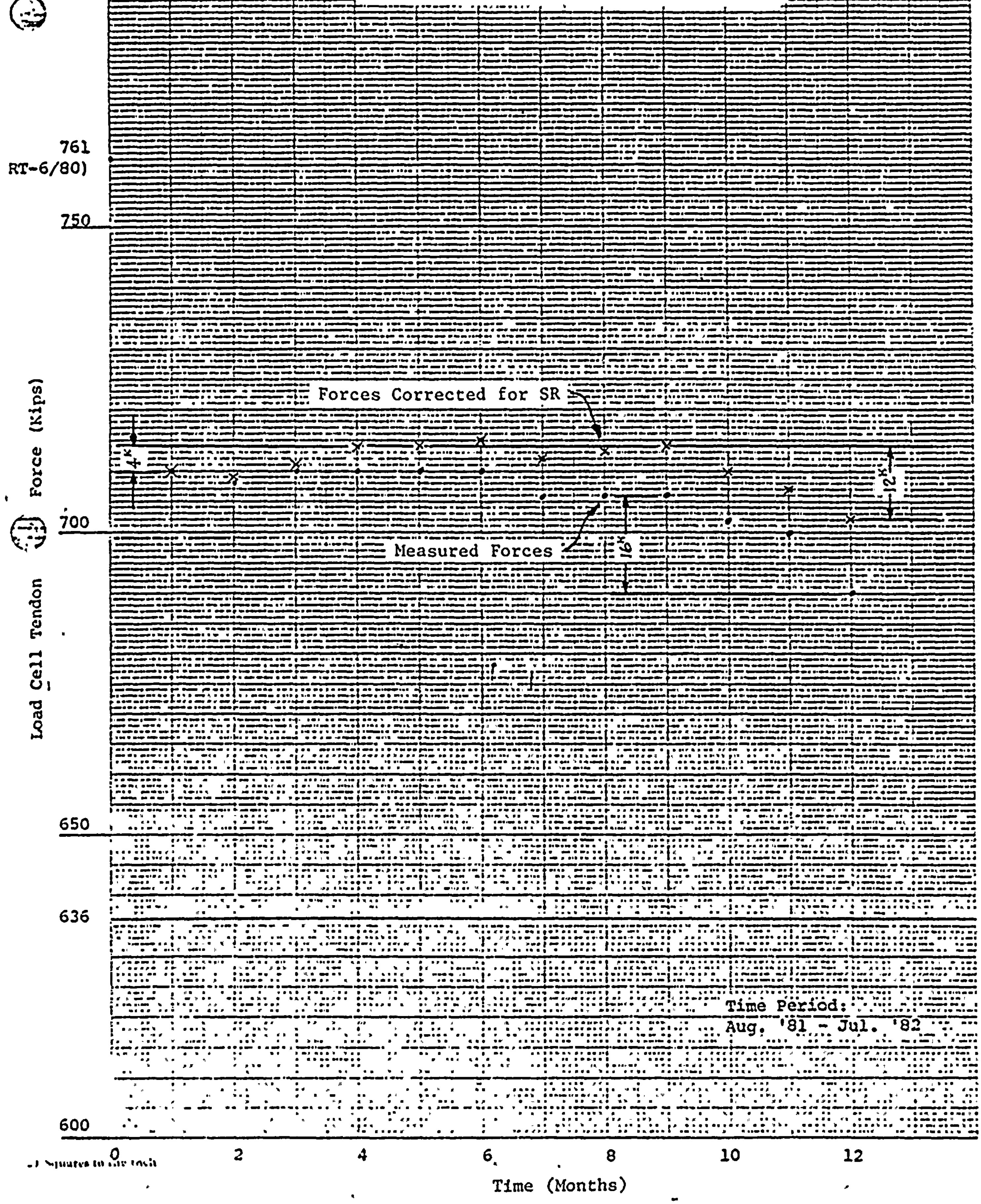


FIGURE 11

Monthly Average Tendon Force vs. Time for TENDON 53

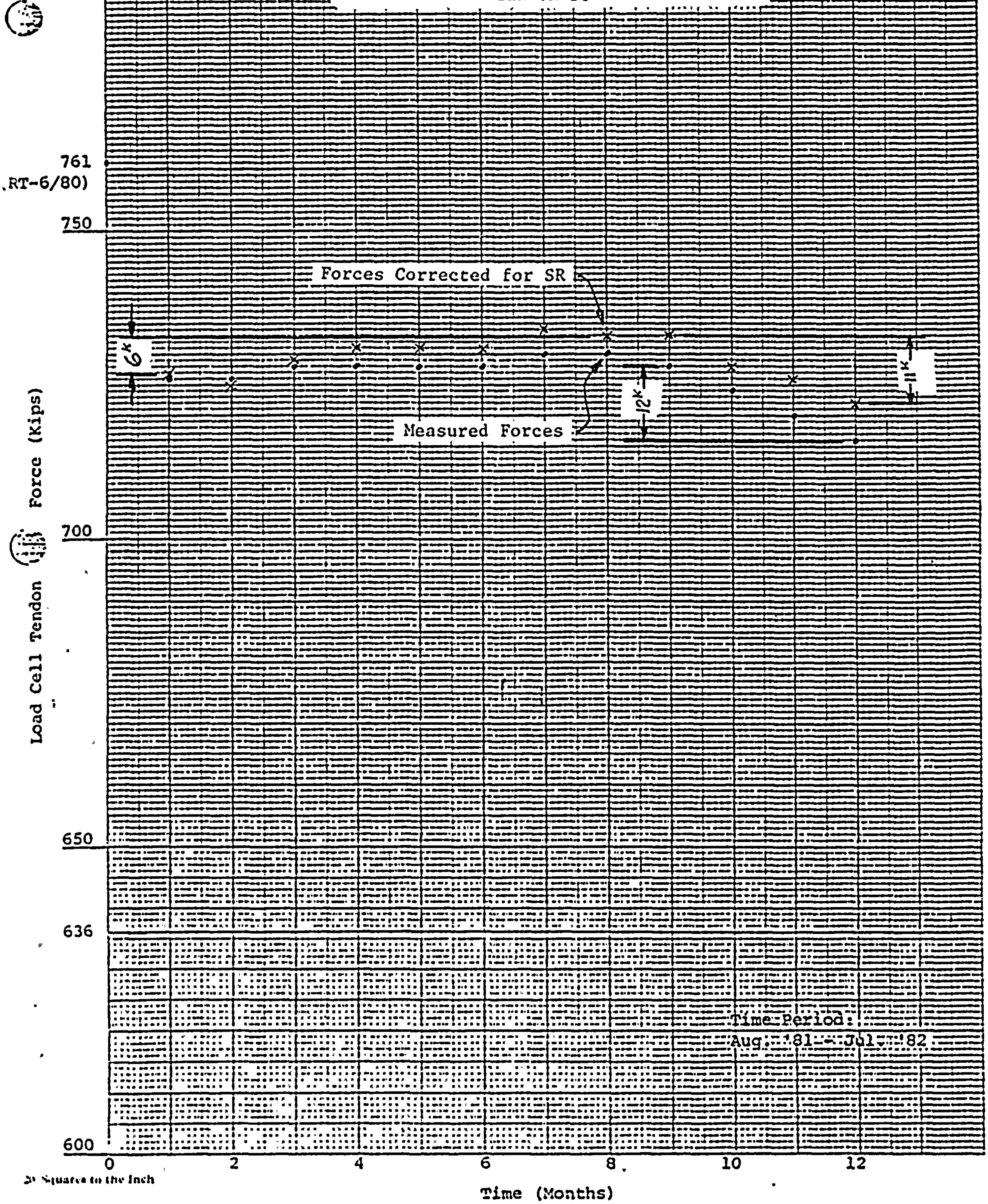


FIGURE 12

Monthly Average Tendon
Force vs. Time
for TENDON 93

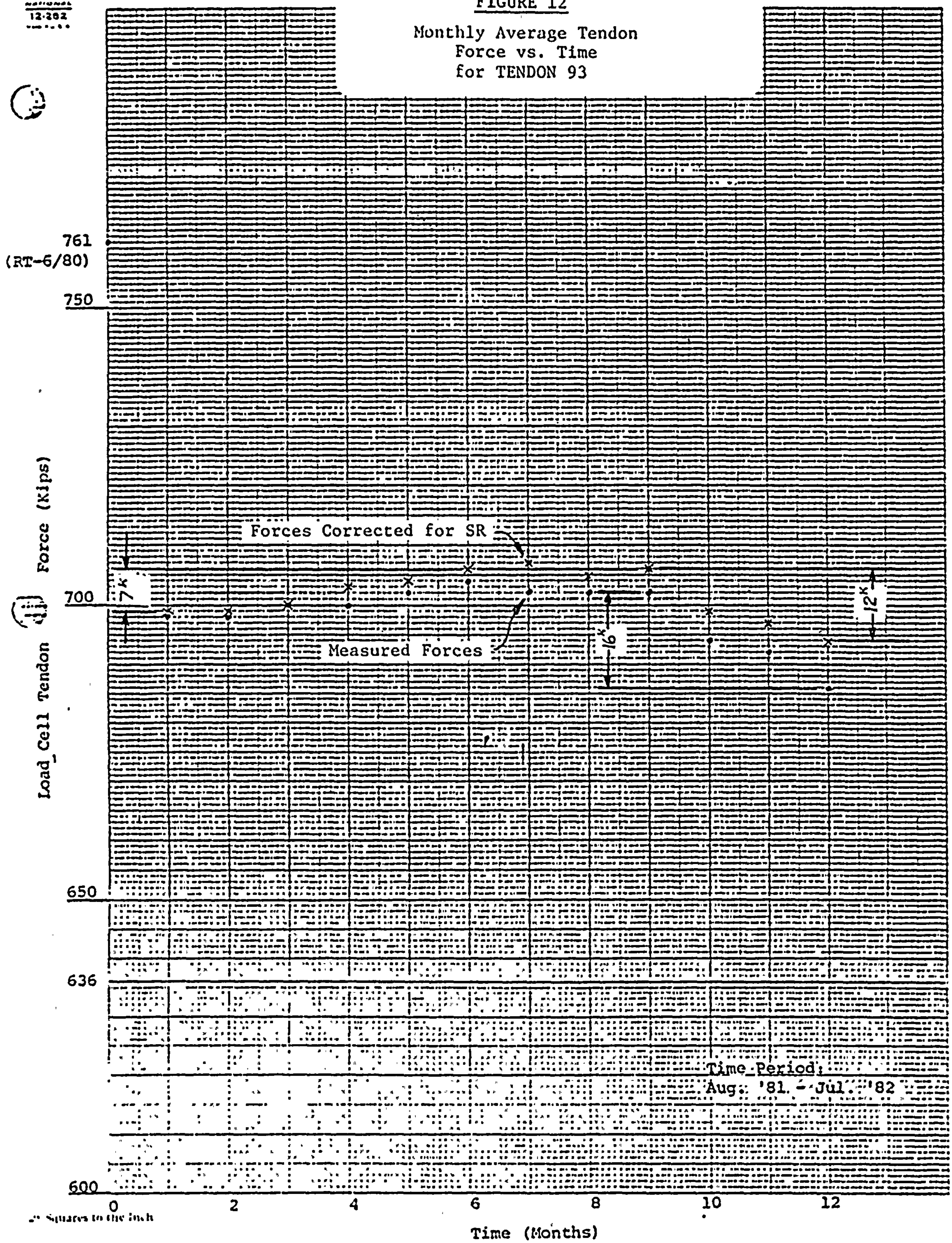
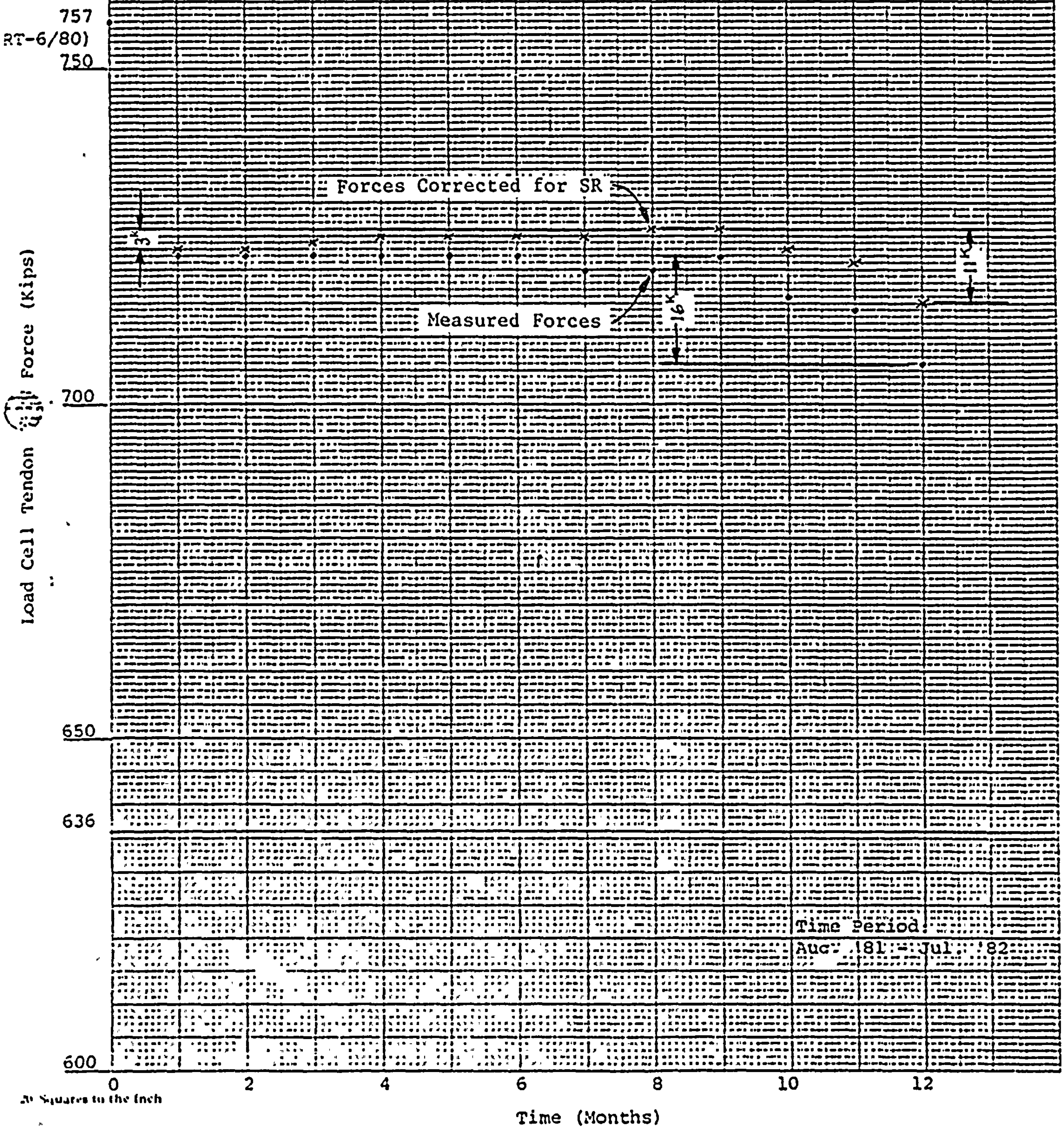


FIGURE 13

Monthly Average Tendon Force vs. Time for TENDON 133



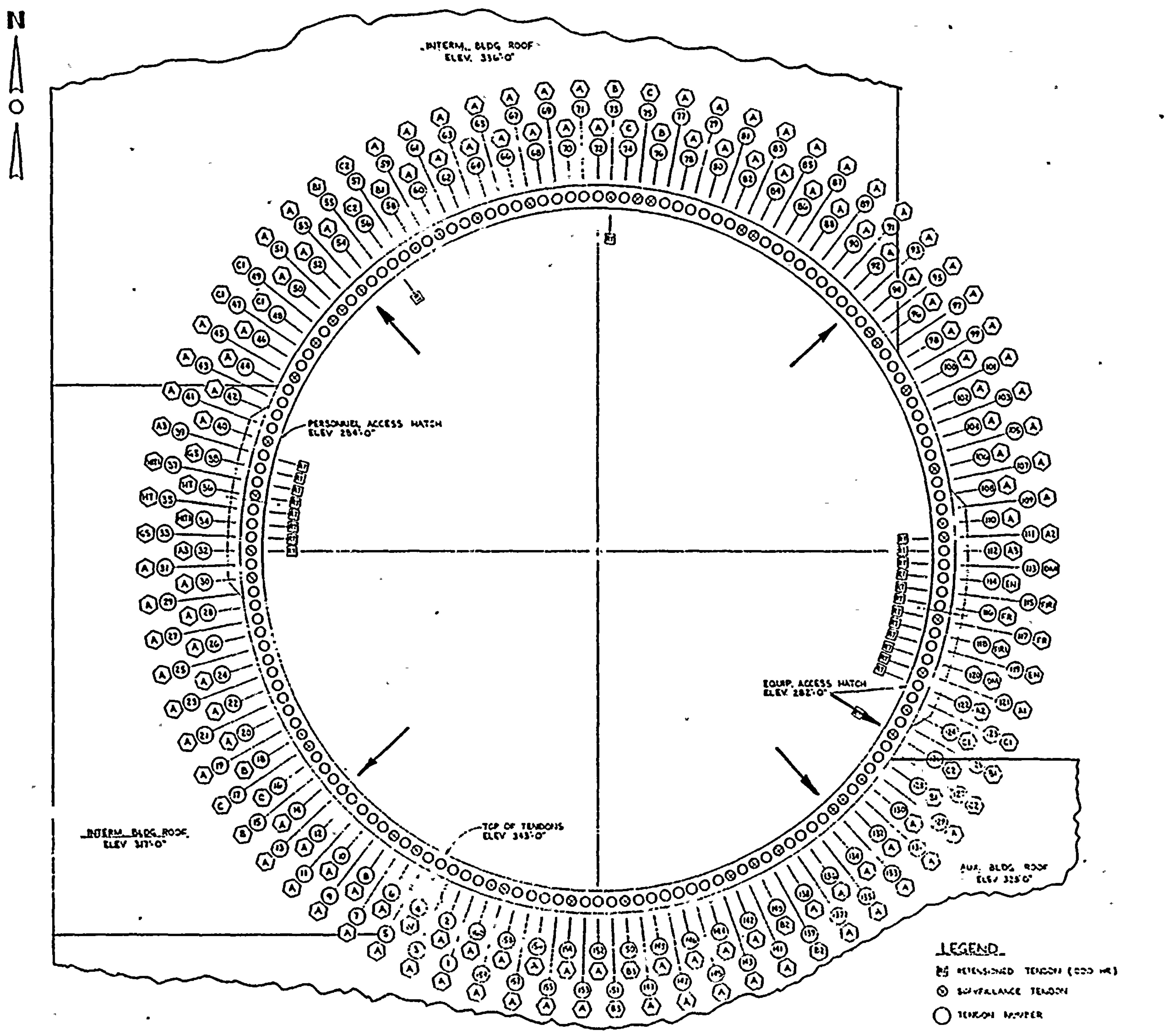


FIGURE 14
Tendon Locations