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TEST REPORT, HAWK LAUNCHER SHOCK ABSORBER SPRING,
PART NUMBER 9089062, SPRING RATE AND RESIDUAL
DEFLECTION TESTS

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U.S. ARMY MISSILE COMMAND

Redstone Arsenal, Alabama 35898

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I. INTRODUCTION

The helical compression spring, Part No. 9089062, is a component of the HAWK Launcher shock absorber.

The spring serves to return the shock absorber piston to the extended (i.e., ready) position when the piston is released after being compressed.

The shock absorber, Part No. 9091309, was redesigned in 1979, and the improved version is designated as Part No. 11567877. The spring, Part No. 9089062, is used in both configurations.

During piston return time tests conducted at Redstone Arsenal on 3 April and 10 April 1980, the shock absorber did not meet the piston return criteria specified in Note 8, Drawing 11567877, Revision A (see Technical Report RL-81-8). The spring and trapped air pressure supply the piston return force. After the shock absorber tests, the free length of the springs was found to be below the minimum specified by the spring drawing.

The tests described by this report were conducted to determine the spring dimensional and load/compression characteristics.

II. SPRING TDP REQUIREMENTS

Drawing 9089062 specifies the following spring requirements:

Material:	Music wire per QQ-W-470
Wire Dia	= .112 inches
Max O.D.	= 1.138 inches
Min I.D.	= .822 inches
Active Coils	= 26
Free Length	= $11.05 \pm .30$ inches = 10.75 min, 11.35 max
Max Solid Ht	= 3.14, Spring must return to free length without set
Spring Rate	= 9.0 ± 1.4 pounds/inch = 9.6 min, 10.4 max
Load	= 66.3 ± 9.9 pounds at a compressed length of 3.70 inches
Stroke	= $3.84 \pm .10$ inches

The drawing requirements for load and deflection are shown graphically in Figure 1.

III. TEST ITEM CONFIGURATION

Two groups of springs were tested. Group A consisted of springs removed from shock absorbers after the shock absorber tests in April. These springs have seen several use cycles during these tests and an unknown length of

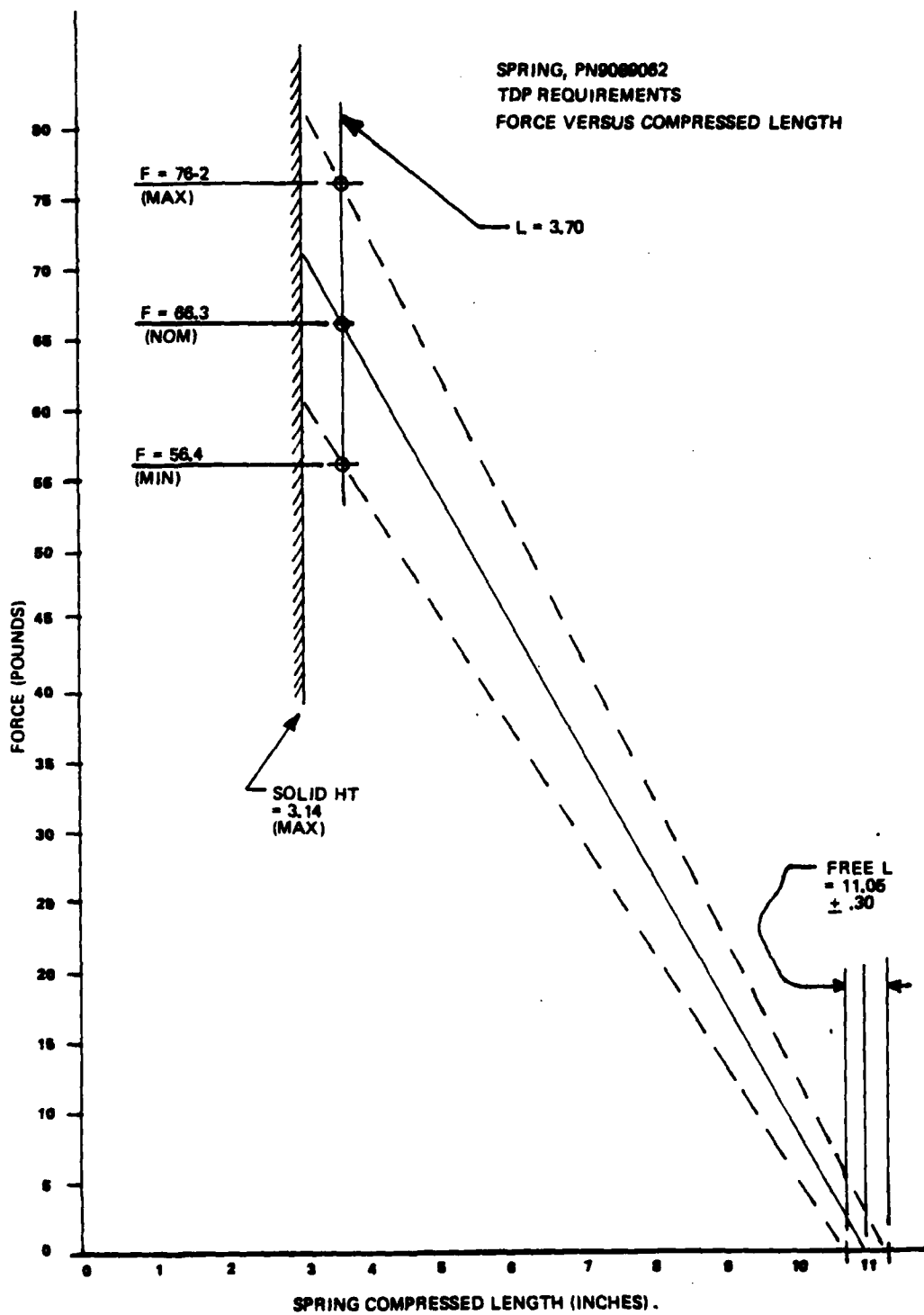


Figure 1. TDP requirements.

service prior to these tests. Group A springs are believed to be several years old and to have been subject to hundreds of service load cycles.

Group B springs were obtained from Mr. Rick Henderson of Letterkenny Army Depot. They are new springs delivered from the manufacturer.

IV. TEST EQUIPMENT

The tests were conducted at Building 5400, Redstone Arsenal, Alabama. An Instron Universal testing machine was furnished and operated by Mr. Ray Parker of DRSMI-EMO. A two piece special test fixture, as shown in Figure 2, was designed and fabricated for the tests. The spring compressed length was measured using a steel scale graduated in hundredths of an inch, and the spring compression load was taken from the strip chart on the testing machine. A 500-pound load cell was used with the machine calibrated at 200 pounds full scale.

V. TEST PROCEDURE

Prior to each test, the spring free length was measured, and the spring was mounted in the test fixture, as shown in Figure 2. The machine crosshead was then driven downward, thus compressing the spring. At each data point, the crosshead was stopped to record data. The fixture clearance (see Figure 2) was measured, and by adding 2.00 inches, the spring compressed length was obtained and recorded. The force required to hold the spring at this length was obtained from the testing machine strip chart and recorded.

The Group A (old) springs were obtained by disassembling shock absorbers and removing the springs. The springs retained the same sample code number used for the shock absorbers in the previous tests (see Technical Report RL-81-8). At the conclusion of the tests, the spring was reassembled into the same shock absorber.

Group B springs were individually packaged and had not been used previously.

At the conclusion of the Group A tests, one shock absorber assembly was tested by placing the shock absorber in the testing machine in a vertical position and compressing the piston. Load and piston movement were recorded at several data points.

VI. TEST RESULTS

The results of the Group A (old) springs are shown in Table 1. Only one cycle is shown in Table 1. All subsequent cycles showed results which were identical within the repeatability of the test fixture and test equipment. There was no significant reduction in free length. Each of the three Group A springs had a free length of .25 to .30 inches below the minimum allowed by the drawing.

The spring rates shown at the bottom of Table 1 were calculated from the test data shown in Table 1 and were calculated for the range of compressed lengths of 3.70 to 10.00. The following equation was used:

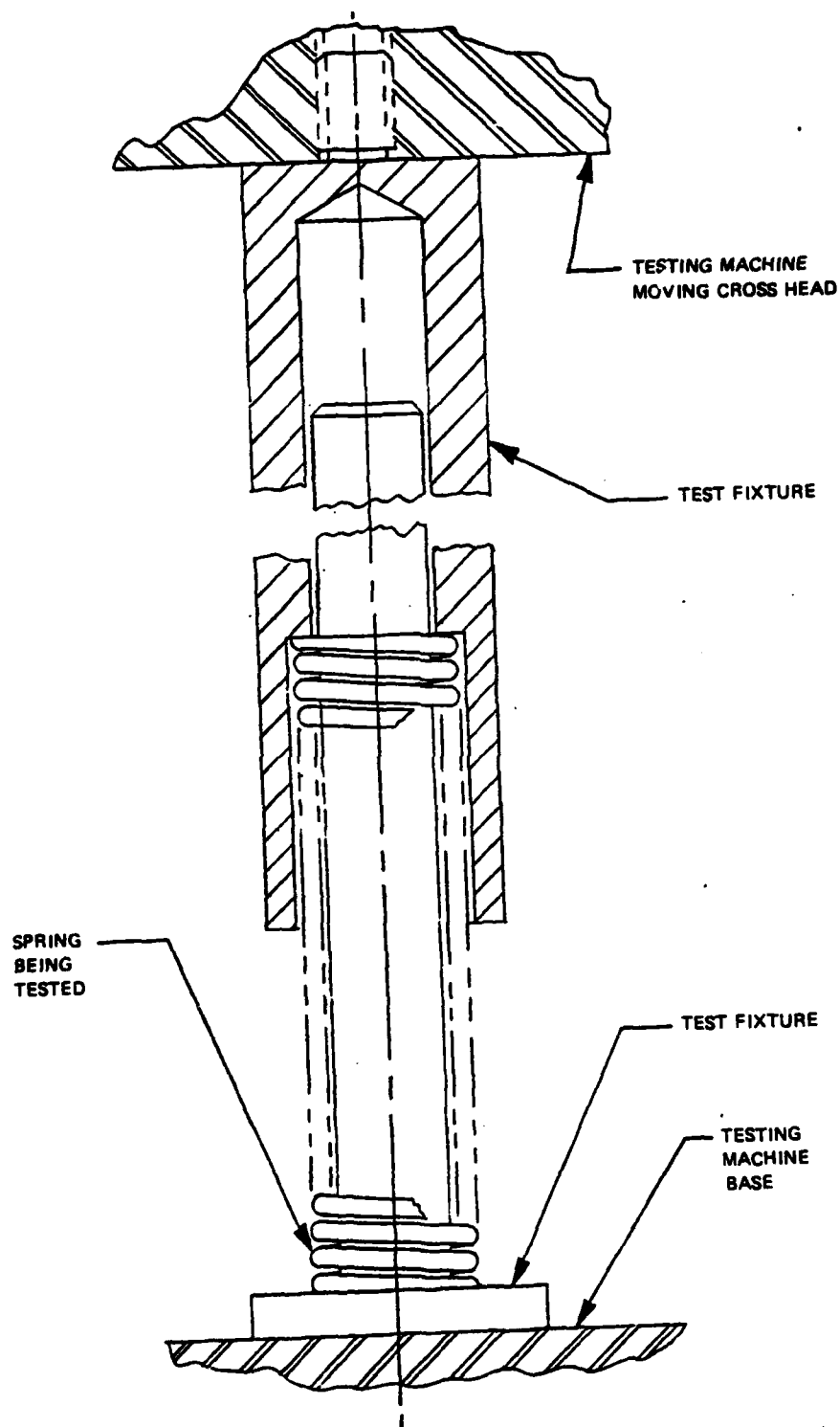


Figure 2. Test set up.

TABLE 1. TEST RESULTS FOR GROUP A (OLD) SPRINGS TESTED ON 24 APRIL 1980

Compressed Length (Inches)	Load (Pounds)		
	Sample 3A	Sample 4	Sample 6
10.50	0	0	0
10.00	4.6	4.0	4.2
9.50	9.2	8.6	9.0
9.00	13.7	12.9	13.8
8.50	18.3	17.4	18.6
8.00	23.1	22.0	23.2
7.50	27.3	26.8	27.9
7.00	32.2	31.0	32.7
6.50	37.1	36.1	37.3
6.00	41.5	40.1	42.7
5.50	46.2	45.0	47.3
5.00	51.1	50.2	52.5
4.50	56.0	54.9	57.8
4.00	60.8	60.4	61.9
3.70	64.0	63.2	65.6
3.50	65.6	64.7	67.3
3.12	Solid	Solid	Solid
Free Length (inches)	10.50	10.45	10.45
Spring Rate Pounds/Inch	9.43	9.45	9.75

$$S.R. = \frac{(\text{Load at 3.70 C.L.}) - (\text{Load at 10.00 C.L.})}{(10.00 - 3.70)}$$

The spring rate for all three Group A springs was within tolerance and was slightly higher than nominal.

The test results for Group B (new) springs are shown in Table 2. For each of the three Group B springs there was a significant reduction in the spring free length during the first load cycle. In each subsequent cycles there was little or no change in free length. The free length both before and after the tests was within the drawing tolerance.

The spring rate from the 3.70 to 10.00 inch compressed height is shown at the bottom of Table 2. All spring rates were within tolerance. Group B springs had a slightly higher spring rate than Group A springs.

Figure 3 shows graphically the variation in spring rate for a Group A and a Group B spring with the TDP requirement superimposed.

The results of the shock absorber compression test are shown in Table 3 and Figure 4. This was a relatively crude test, and as can be seen in Figure 4, the results were rather erratic. The primary cause of the variations in load is probably due to friction in the shock absorber seals.

The total resistance to piston compression is composed of four components: friction, spring compression, trapped air pressure, and fluid flow resistance. In a slow application such as this test, the fluid flow resistance is not a factor, even though in a rapid application of force it is the dominant factor. During piston return the spring and trapped air forces are retarded by friction and fluid flow resistance.

From a dimensional analysis of the shock absorber, the following nominal conditions are calculated:

Piston Position	Spring Compressed Length (inches)	Spring Force (pounds)	Spring Compression (inches)	Spring % Compression
Extended	7.54	31.6	3.51	44%
Compressed	3.69	66.2	7.36	93%
Where: Spring Force = (Free L. - Compl. L.) (Spring Rate) Spring Compression = (Free L. - Compl. L.) Spring % Compression = $\frac{(\text{Free L.} - \text{Compl. L.})}{(\text{Free L.} - \text{Solid Ht.})}$				

TABLE 2. TEST RESULTS FOR GROUP B (NEW) SPRINGS TESTED ON 19-20 MAY 1980

Compressed Length (inches)	Free Length (inches), Load (pounds), Solid Height (inches), and Change in Free Length (inches)								
	Sample 1			Sample 2			Sample 3		
	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3
Free Length	11.15"	10.96"	10.96"	11.14"	10.75"	10.73"	11.14"	10.96"	10.95"
10.5	5.8			5.8	2.8				
10.0	10.3	8.9	9.3	10.3	6.9	6.4	10.7	9.3	9.7
9.5	15.3								
9.0	20.2	18.8							
8.5	25.1								
8.0	30.2	28.5	28.8	28.2	24.5	24.5	30.0	28.7	28.1
7.5	35.1								
7.0	40.7	38.3							
6.5	45.7								
6.0	50.1	48.8	49.1	42.0	43.0	43.0	50.3	48.6	48.7
5.5	56.2								
5.0	61.2	58.9							
4.5	65.8								
4.0	71.1	69.3		61.0	61.5		61.3	69.2	70.5
3.7	74.9	73.7	74.8	65.5	65.8	64.9	63.8	72.1	72.1
3.5	77.0								
Solid Ht	3.26			3.17	3.17	3.17	3.23	3.23	3.23
Free Length	10.96	10.96	10.96	10.75	10.73	10.70	10.96	10.95	10.93
Free Length	.19	0	0	.39	.02	.03	.18	.01	.02
Spring Rate (lbs/inch)	10.25	10.29	10.40	8.76	9.35	9.29	8.43	9.97	9.90

TABLE 3. TEST RESULTS FOR COMPLETE SHOCK ABSORBER ASSY TESTED ON 24 APRIL 1980

Shock Absorber Sample No. 4

Piston Travel (inches)	Load (Pounds)
0	—
.23	18
.53	29
.73	41
.93	38
1.23	51
1.53	56
1.83	55
2.23	84
2.53	81
2.83	84.5
3.23	102
3.33	117
3.43	121

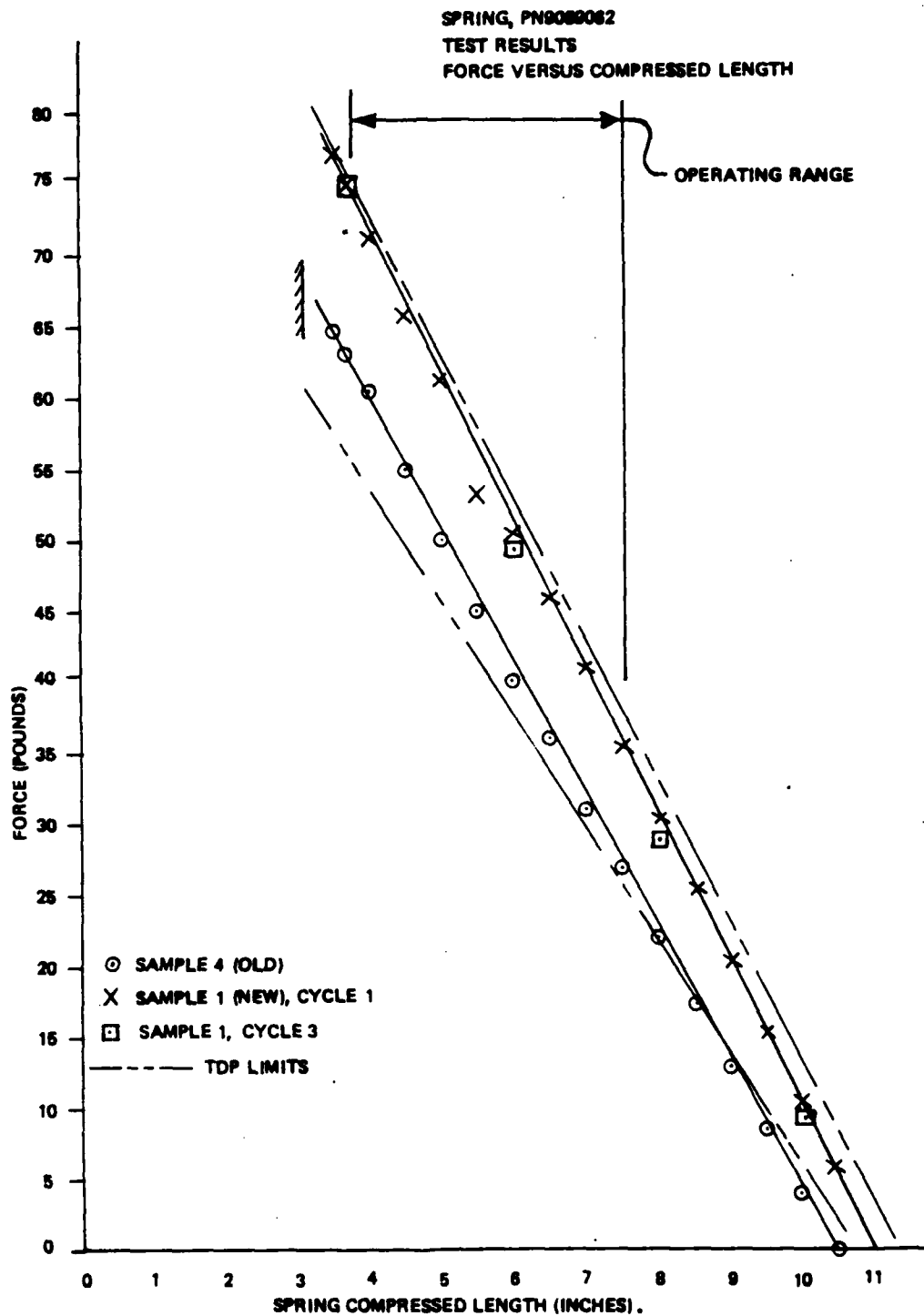
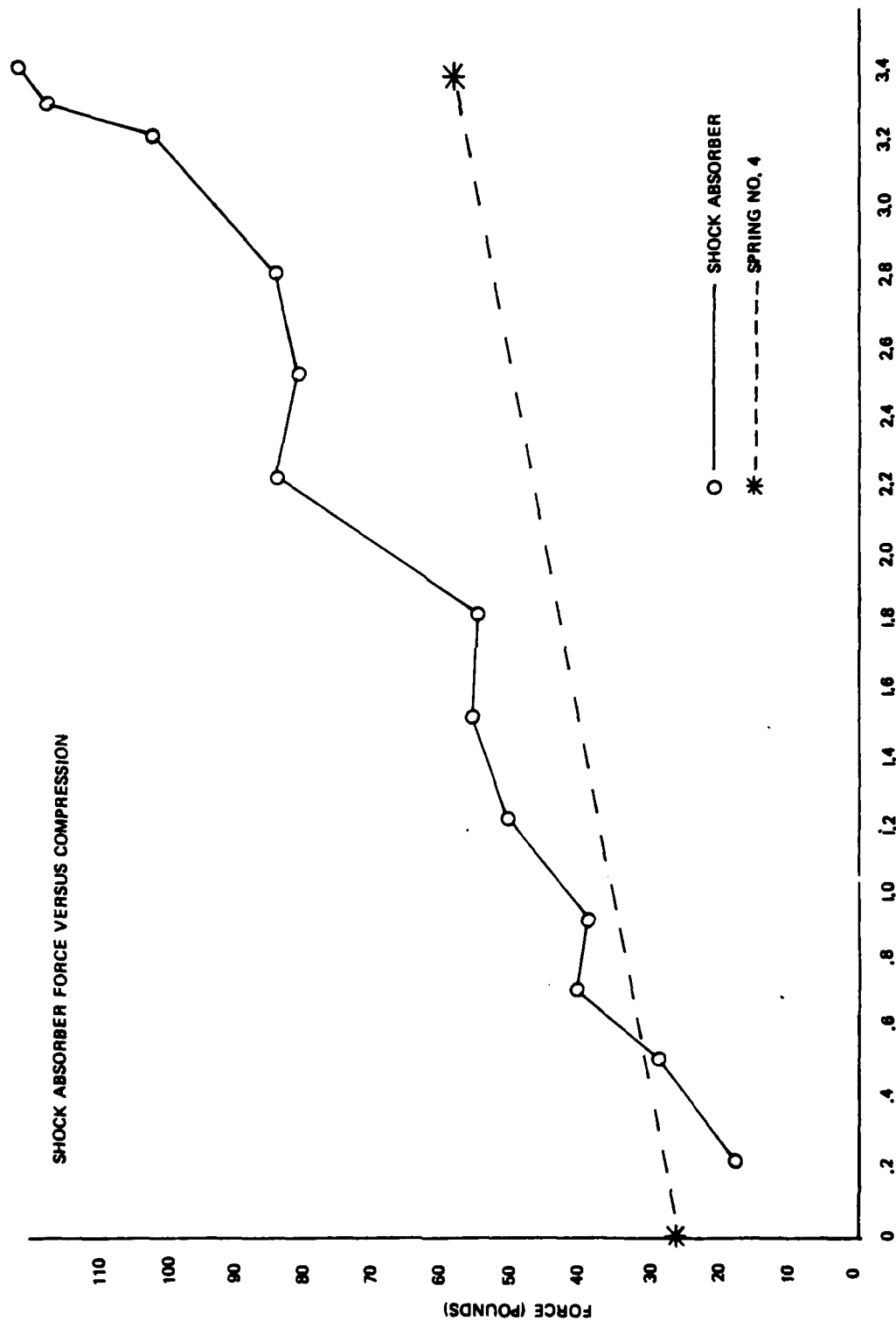


Figure 3. Test results, spring.



SHOCK ABSORBER COMPRESSION (INCHES).

Figure 4. Test results, shock absorber.

As shown in the preceding table, in the shock absorber with piston extended, the spring is compressed to about 44% of its capacity and exerts a force of about 31.6 pounds. When the piston is fully compressed, the spring is compressed to 93% of its capacity and exerts a force of about 66.2 pounds. As can be seen in Table 3, shock absorber assembly no. 4 when tested exerted a piston return force of 121 pounds at a piston compression of 3.43 inches, which is approximately 90% of full compression.

When the piston is near full extension, the spring is the dominant force. The force exerted by the trapped air pressure rises faster than the spring force when the piston is compressed. This can be seen in Figure 4 as the higher slope of the plot of the entire shock absorber compared to the plot of spring force, and by the fact that the spring rate of 32.2 for the entire shock absorber is more than twice as large as the spring constant of 9.0 for the spring alone. At full compression the spring load and the trapped air pressure load are approximately equal.

Loss of oil would reduce the effects of trapped air pressure. The shock absorber tested was filled with the normal complement of 250 ml of oil.

VII. CONCLUSIONS

1. All springs conformed to the TDP in all characteristics tested with the exception of the free length. The old springs were slightly below the minimum allowed by the TDP. The new springs exhibited significant permanent set on the first cycle and a lesser amount on subsequent cycles. All the new springs tested were within tolerance both before and after testing.
2. For all springs tested the spring rates were within tolerance and the load versus compressed height was within tolerance throughout the spring operating range.
3. Problems in meeting piston return time requirements were not related to fabrication deficiencies in the springs.

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