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SHOT-PEENING PROCEDURES FOR HELICAL COMPRESSION SPRINGS

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Various shot-peening procedures for the manufacture of cold-wound helical compression springs were investigated to establish optimum shot-peening methods to increase the life endurance properties of springs. Production springs that are typical of small arms applications were fabricated from music wire and stainless steel materials. The springs were given different shot-peening treatments with the exception of control groups that were not shot-peened.

Effect of the various shot-peening procedures on spring life was evaluated by laboratory endurance tests. Recommended shot-peening procedures based on test results are given for the spring materials and stress conditions investigated in this project.

CONTENTS

SHOT-PEENING PROCEDURES FOR HELICAL COMPRESSION SPRINGS

OBJECTIVE

The objective of this program was to determine the optimum shot-peening procedures to increase the endurance properties of helical compression springs.

INTRODUCTION

A. Discovery of Shot-Peening

The improvement of fatigue properties of metal components by shot-peening was discovered by accident and in connection with compression springs. The process was originally developed as a cleaning operation and was called shot-blasting. According to J. O. Almen,[1] the beneficial effects of shot-peening were first observed by O. Burkhardt and J. P. Heiss who were trying to improve the fatigue durability of valve springs. Broken valve springs were quite common in those days before peening. Burkhardt and Heiss suspected that particles of scale which adhered to the wire surface might be a cause of failures and requested that a special lot of springs be thoroughly cleaned. When the order was delivered, they were disturbed to find that all the springs were "bruised" and roughened by the shot-blasting which had been used to clean them. Though they were dissatisfied with the appearance of the springs, they proceeded to test these springs and were surprised to discover that they out-performed all previous spring samples. Because this performance seemed incredible to the investigators as well as to the spring supplier that shot-blasting could improve spring life, they decided to repeat the tests. Again, the shot-blasted springs proved superior. The expression "shot-peening" was introduced to distinguish the controlled process for improvement of spring life from the haphazard shot-blasting operation which led to the original discovery.

In a short time, practically all spring manufacturers were convinced that shot-peening could greatly increase the endurance properties of springs. The practice of shot-peening then spread from the spring industry to other industries in which fatigue life of highly stressed parts is an important consideration. Some academic groups were more dubious at first, but eventually they recognized the beneficial effects of this practice; thus, today, shot-peening is discussed in many textbooks on strength of materials.

B. Beneficial Effects of Shot-Peening

Shot-peening improves the fatigue durability of metal parts by the altering of the surface layers in two different ways. First, the surface of the part is cold-worked by the pelting of the shot particles and thus its

[1] J. O. Almen:, "Effect of Residual Stresses on Rolling Bodies," S.A.E. Preprint 467A, Jan. 8, 1962.

physical properties are improved. The second result is more important, but not so obvious. It consists of prestressing the surface layers and inducing a residual compressive stress within the material. This residual stress will resist a subsequently applied tensile stress and must be counteracted before the material can be stressed in tension; thus, the load-carrying capacity of the material is increased.

C. Controlling Shot-Peening

The Almen strip is the basic control tool in shot-peening. It measures the effect of peening by the curvature produced on a standarized strip of spring steel which is peened on one side only. Holding fixture and gage used for measuring the curvature are also standarized. This is a very practical method, developed over 40 years ago by J. O. Almen of the Research Laboratories Division of General Motors Corporation. Three standard Almen strips are available that are designated N, A, and C with the following respective thicknesses: .031, .051, and .0938 inch. However, all the strips have the same rectangular shape of 3.000 inches by .750 inchs. An intensity given as .008A means that as a result of shot-peening, the arc height (curvature) on an A strip will measure .008 inch. An important consideration in shot-peening is "saturation". A surface of an Almen strip is considered saturated at a given intensity when additional peening produces no further appreciable curvature.

D. Proper Shot-Peening for Springs

Shot-peening procedures that would be most effective in prolonging spring life have not been established. Generally, specifications of a shot-peening process for a particular spring design depend mainly on the discretion of the project engineer and without assurance that it will be the optimum process. The aim of this report is to determine optimum shot-peening manufacturing specifications for helical compression springs of the type that are used in Army weapons. Emphasis will be placed on shot-peening of music wire springs since approximately 95 per cent of all small arms springs are fabricated from this material.

DISCUSSION

A. Material and Test Procedures

The helical compression springs that were used in this program were fabricated from the following spring tempered materials and given the specified stress-relieving treatments.

1. Music Wire, QQ-W-470
   Wire diameters, .035 and .080 inch
   Stress-Relieve-Heat at $450^{\circ}F \pm 10^{\circ}$ for 30 minutes

2. Stainless Steel, QQ-W-423, Comp. FS302
Wire diameters, .035 and .080 inch
Stress-Relieve-Heat at 600°F ± 25° for 30 minutes

Four basic spring designs were prepared for this project. Designs 1 and 2 were formed of .035 inch wire and with spring indices of 6 and 9, respectively. Designs 3 and 4 were formed of .080 inch wire and with spring indices of 6 and 9, respectively. Complete specifications for the four spring designs are given in the Appendix. Seventy springs of each design were fabricated from music wire material. Also, seventy springs each of Designs 1, 3, and 4 were fabricated from stainless steel material. Each group of seventy springs was divided into seven sets of ten springs each and given the following shot-peening treatments after the stress-relieving operation. Set No. 1 was selected as the control group and received no shot-peening.

Springs Coiled from .035 Inch Wire

Set No.	Shot Size (Inch)	Intensity (Arc Height)
1	No shot-peening	
2	.007	.004N-.006N
3	.007	.010N-.012N
4	.007	.016N-.018N
5	.011	.004N-.006N
6	.011	.010N-.012N
7	.011	.016N-.018N

Springs Coiled from .080 Inch Wire

Set No.	Shot Size (Inch)	Intensity (Arc Height)
1	No shot-peening	
2	.011	.002A-.004A
3	.011	.006A-.008A
4	.011	.010A-.012A
5	.017	.002A-.004A
6	.017	.006A-.008A
7	.017	.010A-.012A

All shot-peening was performed with cast-steel shot of hardness R_c 45-50 and in accordance with MIL-S-13165B.

A requirement of all wire material used in this program was that it had to be free from surface irregularities. Therefore, prior to coiling, the material was examined thoroughly for surface defects with the use of a microscope. No cracks or surface defects were observed and the material was accepted for coiling. After shot-peening, all springs were preset by the compression to solid height three times. Measurements were taken and recorded of the free height, load at assembled height, and load at minimum operating height of all springs.

Test fixtures for use on the Krouse spring tester for the endurance testing of the springs were designed and fabricated. A photograph of a test spring assembled onto the Krouse tester is shown in the Appendix. Testing was initially performed between the stress levels of 75,000 psi and 150,000 psi and at a rate of 1,000 cycles per minute. However, because of the lack of spring breakage, the stress conditions were subsequently intensified and the cyclic rate was increased to 1,200 r.p.m.

B. Test Results

The springs fabricated from music wire in accordance with Design 1 were tested at a rate of 1,000 compressions per minute between the heights of 1.966 inches and 1.243 inches which correspond to stress levels of 75,000 psi and 150,000 psi, respectively. Eight springs of Set 1 (control group) broke after an average of 141,375 cycles. However, practically all the springs in Set 2 through Set 7 sustained 500,000 cycles each and insufficient test data were generated on which to draw inferences as to the optimum shot-peening process. Therefore, to obtain comparative test data, 5 springs that had sustained 500,000 cycles each were selected from Sets 2 through 7 for additional testing. Test operating conditions were revised and made more severe so as to induce spring breakage. The cyclic rate was increased to 1200 compressions per minute. Furthermore, the spring test heights on the Krouse tester were changed to 2.500 inches (20,000 psi) and 1.200 inches (155,000 psi), thereby appreciably increasing the stress range through which the spring must work. Breakage occurred to all the music wire springs of Design 1 in the subsequent endurance testing. Test results for this group are shown in Table 1 on the Appendix.

Design 2 of music wire material was the second group of springs that was endurance tested. The initial test procedures for this group were revised to intensify the stress conditions to induce spring breakage. The springs were cycled between the heights of 2.480 inches (20,000 psi) and .810 inches (155,000 psi), and at a rate of 1200 cycles per minute. Test results for this group are shown in Table 2 in the Appendix.

Test results for Designs 3 and 4 of music wire material are shown in Tables 3 and 4, respectively. Endurance testing for these two groups was conducted between the stress levels of 20,000 psi and 135,000 psi, and with a cyclic rate of 1200 compressions per minute. Note that many springs of Design 4 sustained 1,000,000 cycles without breakage. If a spring sustained 1,000,000 cycles, it was considered to have indefinite life and the endurance testing was concluded. However, to measure the relative beneficial effect of the different shot-peening procedures, the average life of springs in Design 4 was computed by consideration of 1,000,000 cycles as the life of an unbroken spring.

In the endurance testing of the stainless steel springs, Design 1 was cycled between the stress levels of 75,000 psi and 150,000 psi, and at a rate of 1200 cycles per minute. Designs 3 and 4 were cycled between the stress levels of 20,000 psi and 138,000 psi, and also at a rate of 1200 cycles per minute. The testing of each spring was concluded either at breakage or at the completion of 500,000 cycles, whichever occurred first. Test results obtained with the stainless steel springs are shown in Tables 5, 6, and 7 in the Appendix.

The shot-peening treatments that were most effective in increasing the life of the music wire springs are shown in numerical order in Table 8. It also presents data on which to base a comprehensive type statement as to an optimum shot-peening procedure. The average life of each set of music wire springs is listed in Table 8 under its appropriate design group. However, the average life for Set 1 of Design 1 is not included since all the springs in this set had broken previously under moderate stress conditions. Also, the shot-peening procedure that was applied is indicated along the side of each set. A similar summary of the average life results obtained in the endurance testing of the stainless steel springs is shown in Table 9.

An examination of the life values given for spring Designs 1 and 2 in Table 8 shows that the most effective shot-peening treatment for music wire of .035 inch is the one applied to Set 2, i.e., a shot size of .007 inch and an intensity of .004N-.006N. Note that the next most beneficial treatment (Set 5) had the same intensity of .004N-.006N, but a larger shot particle. An inspection of the test data for Designs 3 and 4 indicates that the optimum shot-peening procedure for music wire of .080 inch consists of a shot size of .011 inch and an intensity of .006A-.008A. Again, note that the shot-peening process of the same intensity (Set 6) is the next most beneficial one for Design 4 and practically so for Design 3.

In a comparison of the designs of the same wire diameter, greater life benefits were obtained from shot-peening with Design 2 than with Design 1, and with Design 4 than with Design 3. This can be attributed to the spring index and the coil pitch which were much larger for Designs 2 and 4; thus, better coverage was possible in shot-peening the inside diameter of the spring. Also, with regards to surface accessibility, note that the most effective shot-peening procedure for each design involved the smaller shot size particles which offered more open passage between the coils; thus, better coverage of the inside diameter was attained. According to Henry O. Fuchs and Paul E. Bickel,[2] a general guide is that the shot size should be no larger than $\frac{1}{4}$ of the smallest opening through which the shot must pass.

[2]Henry O. Fuchs and Paul E. Bickel, "Shot-Peening of Springs," Article in Springs Magazine, May 1963

Review of the stainless steel spring test data shown in Table 9 does not indicate any reasonable alignment as was the case with the music wire results. A puzzling discrepancy occurs between Designs 3 and 4, in which the shot-peening process of .011 inch shot and .002A-.004A intensity ranks highest for Design 3 and poorest for Design 4. However, shot-peening does have a noticeable effect on the life of stainless steel springs as is shown in Table 9. A minimum of a threefold increase in spring life is gained even with the least effective shot-peening treatment.

Reasonable inferences that can be drawn from the test data as to optimum shot-peening procedures for stainless steel springs are given below:

For .035 inch wire - .007 shot, .010N-.012N intensity
For .080 inch wire - .011 shot, .010A-.012A intensity

CONCLUSIONS AND RECOMMENDATIONS

Effective shot-peen coverage of the inside diameter of helical compression springs can be attained by use of the smallest size shot particle that is practical.

The following shot-peening procedures are recommended:

For Music Wire Material

1. Wire size approximately .035 inch
   Stress range of 20,000 psi to 155,000 psi
   Shot size of .007 inch
   Intensity - .004N - .006N

2. Wire size approximately .080 inch
   Stress range of 20,000 psi to 135,000 psi
   Shot size of .011 inch
   Intensity - .006A - .008A

For Stainless Steel Material

1. Wire size approximately .035 inch
   Stress range of 75,000 psi to 150,000 psi
   Shot size of .007 inch
   Intensity - .010N - .012N

2. Wire size approximately .080 inch
   Stress range of 20,000 psi to 138,000 psi
   Shot size of .011 inch
   Intensity - .010A - .012A

APPENDIX

SPRING SPECIFICATIONS
DESIGN NO. 1

WIRE SIZE (IN.)	.035
OUTSIDE DIAMETER (IN.)	.245 ± .005
TOTAL COILS	30
TYPE OF ENDS	Closed and Ground
FREE HEIGHT, APPROX. (IN.)	2.69 (2.93)
MEAN ASSEMBLED HEIGHT (IN.)	1.966 (2.102)
LOAD AT MEAN ASSEMBLED HEIGHT (LB)	6.0 ± .6
MINIMUM OPERATING HEIGHT (IN.)	1.243 (1.270)
LOAD AT MINIMUM OPERATING HEIGHT (LB)	12.0 ± 1.2
LOAD - DEFLECTION RATE (LB/IN.)	8.3 (7.2)
MAXIMUM SOLID HEIGHT (IN.)	1.100
SPRING HELIX	L. H.

VALUES IN PARENTHESES APPLY ONLY TO SPRINGS FABRICATED FROM STAINLESS STEEL MATERIAL.

SPRING SPECIFICATIONS
DESIGN NO. 2

WIRE SIZE (IN.)	.035
OUTSIDE DIAMETER (IN.)	.350 ± .005
TOTAL COILS	18
TYPE OF ENDS	Closed and Ground
FREE HEIGHT, APPROX. (IN.)	2.73 (2.97)
MEAN ASSEMBLED HEIGHT (IN.)	1.805 (1.901)
LOAD AT MEAN ASSEMBLED HEIGHT (LB)	4.0 ± .4
MINIMUM OPERATING HEIGHT (IN.)	.876 (.832)
LOAD AT MINIMUM OPERATING HEIGHT (LB)	8.0 ± .8
LOAD - DEFLECTION RATE (LB/IN.)	4.3 (3.7)
MAXIMUM SOLID HEIGHT (IN.)	.680
SPRING HELIX	L. H.

VALUES IN PARENTHESES APPLY ONLY TO SPRINGS FABRICATED FROM STAINLESS STEEL MATERIAL.

SPRING SPECIFICATIONS

DESIGN NO. 3

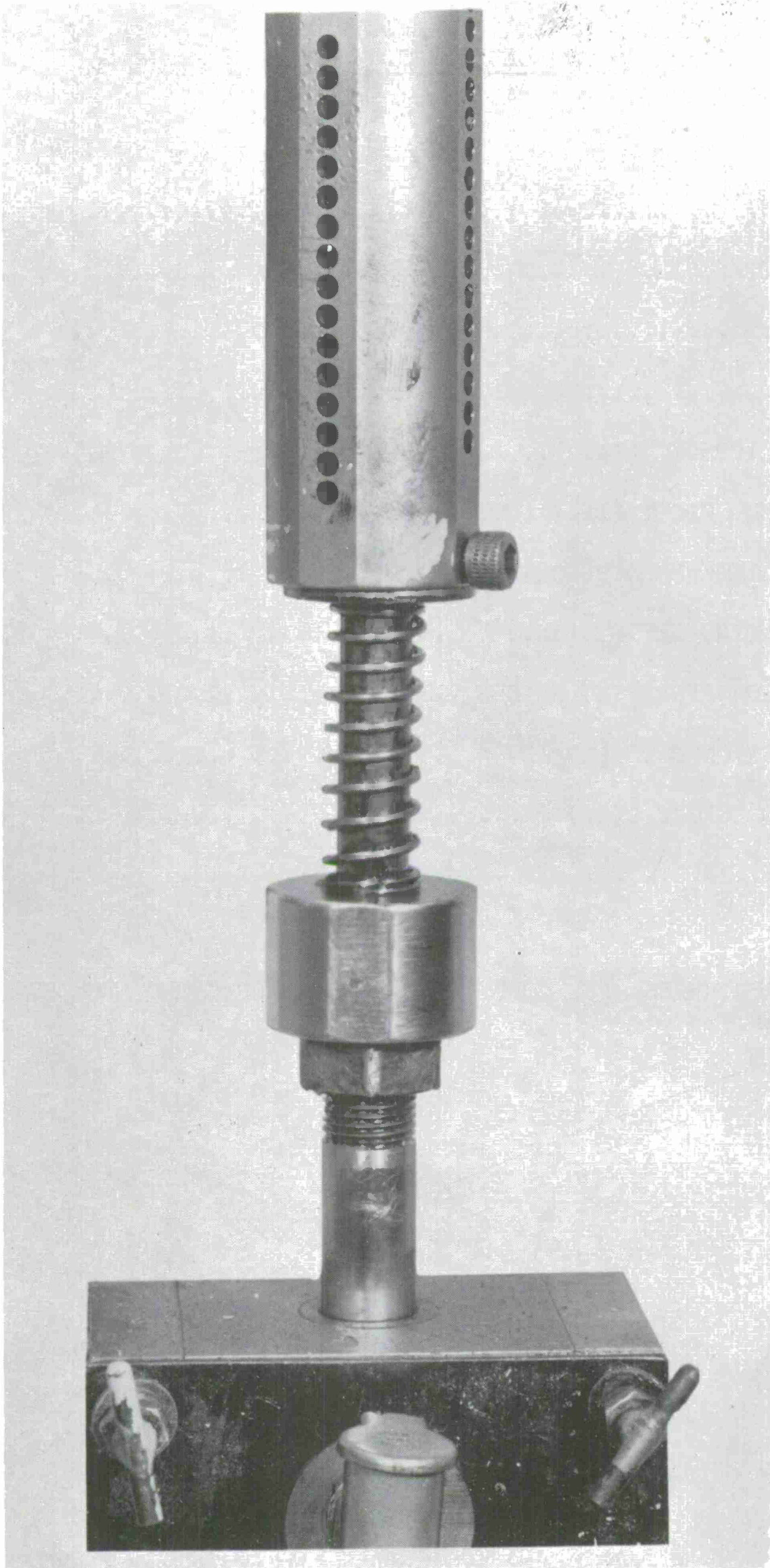
WIRE SIZE (IN.)	.080
OUTSIDE DIAMETER (IN.)	.560 ± .007
TOTAL COILS	15
TYPE OF ENDS	Closed and Ground
FREE HEIGHT, APPROX. (IN.)	2.73 (2.93)
MEAN ASSEMBLED HEIGHT (IN.)	2.070 (2.165)
LOAD AT MEAN ASSEMBLED HEIGHT (LB)	27 ± 3.0
MINIMUM OPERATING HEIGHT (IN.)	1.405 (1.400)
LOAD AT MINIMUM OPERATING HEIGHT (LB)	54 ± 6.0
LOAD - DEFLECTION RATE (LB/IN.)	41 (36)
MAXIMUM SOLID HEIGHT (IN.)	1.250
SPRING HELIX	L. H.

VALUES IN PARENTHESIS APPLY ONLY TO SPRINGS FABRICATED FROM STAINLESS STEEL MATERIAL.

SPRING SPECIFICATIONS
DESIGN NO. 4

WIRE SIZE (IN.)	.080
OUTSIDE DIAMETER (IN.)	.800 ± .008
TOTAL COILS	9.5
TYPE OF ENDS	Closed and Ground
FREE HEIGHT, APPROX. (IN.)	2.75 (2.95)
MEAN ASSEMBLED HEIGHT (IN.)	1.890 (1.957)
LOAD AT MEAN ASSEMBLED HEIGHT (LB)	18.0 ± 2.0
MINIMUM OPERATING HEIGHT (IN.)	1.027 (.964)
LOAD AT MINIMUM OPERATING HEIGHT (LB)	36 ± 4.0
LOAD - DEFLECTION RATE (LB/IN.)	21 (18)
MAXIMUM SOLID HEIGHT (IN.)	.810
SPRING HELIX	L. H.

VALUES IN PARENTHESES APPLY ONLY TO SPRINGS FABRICATED FROM STAINLESS STEEL MATERIAL.



PRODUCTION SPRING INSTALLED ON ENDURANCE TESTER

TABLE 1, TEST RESULTS

DESIGN 1, MUSIC WIRE SPRINGS

Wire size = .035 In. Spring index = 6.0

Number of Cycles at Spring Breakage

Spring/Set Number	2	3	4	5	6	7
1	59,500	41,500	24,700	45,100	36,400	54,200
2	50,600	32,800	77,400	51,000	39,600	42,100
3	23,300	46,400	25,500	36,400	37,400	41,000
4	84,400	27,400	36,900	60,800	48,500	38,500
5	52,400	39,600	30,800	52,100	42,700	53,800
Average Number of Cycles:	54,040	37,540	39,060	49,080	40,920	45,920

NOTE: Above listed springs were previously cycled 500,000 times, each under moderate stress conditions.

TABLE 2, TEST RESULTS
DESIGN 2, MUSIC WIRE SPRINGS

Wire size = .035 In. Spring index = 9.0

Number of Cycles at Spring Breakage

Spring/Set Number	1	2	3	4	5	6	7
1	59,900	184,900	79,500	81,500	131,900	50,800	63,500
2	67,800	47,400	49,700	57,000	74,400	70,300	36,900
3	66,400	81,200	66,200	67,300	66,400	66,700	108,400
4	66,900	99,200	53,100	65,200	60,600	74,800	61,200
5	56,700	105,700	88,000	97,900	59,200	78,500	73,000
Average Number of Cycles:	63,540	103,640	67,300	73,780	78,500	68,220	68,600

TABLE 3, TEST RESULTS

DESIGN 3, MUSIC WIRE SPRINGS

Wire size = .080 In. Spring index = 6.0

Number of Cycles at Spring Breakage

Spring/Set Number	1	2	3	4	5	6	7
1	171,100	138,000	345,500	196,700	185,400	135,200	206,100
2	185,500	142,600	478,000	197,500	315,200	220,100	230,700
3	121,900	228,400	311,600	190,800	164,100	231,300	379,100
4	114,500	116,200	216,000	116,700	297,700	462,100	241,500
5	123,000	160,000	364,000	159,500	155,300	206,500	223,100
Average Number of Cycles:	148,250	167,040	343,020	172,240	223,540	251,040	256,100

TABLE 4, TEST RESULTS
DESIGN 4, MUSIC WIRE SPRINGS

Wire size = .080 In. Spring index = 9.0

Number of Cycles at Spring Breakage

Spring/Set Number

Spring	1	2	3	4	5	6	7
1	108,100	526,600	1,000,000*	770,500	478,200	1,000,000*	658,500
2	108,400	1,000,000*	1,000,000*	1,000,000*	1,000,000*	1,000,000*	1,000,000*
3	79,900	375,000	1,000,000*	1,000,000*	1,000,000*	942,900	616,600
4	107,600	1,000,000*	1,000,000*	1,000,000*	299,700	1,000,000*	1,000,000*
5	103,300	1,000,000*	1,000,000*	1,000,000*	1,000,000*	1,000,000*	1,000,000*
Average Number of Cycles:	101,460	780,320	1,000,000	954,100	755,580	988,580	865,020

*Endurance-testing was terminated upon completion of 1,000,000 cycles

TABLE 5, TEST RESULTS
DESIGN 1, STAINLESS STEEL SPRINGS

Wire size = .035 In. Spring index = 6.0

Number of Cycles at Spring Breakage

Spring/Set Number	1	2	3	4	5	6	7
1	25,800	500,000	203,600	500,000	148,400	73,400	86,600
2	107,000	212,600	500,000	173,000	261,900	396,500	500,000
3	47,100	92,000	82,600	491,100	321,100	95,000	500,000
4	55,300	211,400	394,300	438,000	191,400	369,300	40,000
5	38,400	351,100	475,000	97,700	96,000	500,000	213,500
6	*	227,800	500,000	133,300	88,100	156,300	500,000
7	*	500,000	500,000	313,200	106,600	98,000	500,000
8	*	77,900	435,200	269,300	158,300	300,300	500,000
9	*	*	500,000	482,000	151,000	217,000	500,000
10	*	*	500,000	90,600	142,700	387,000	500,000
Average Number of Cycles:	54,720	271,600	409,070	298,820	166,550	259,280	384,000

*These springs were used to establish test conditions for the operating stress levels and cyclic frequency.

TABLE 6, TEST RESULTS
DESIGN 3, STAINLESS STEEL SPRINGS

Wire size = .080 In. Spring index = 6.0

Number of Cycles at Spring Breakage

Spring/Set Number	1	2	3	4	5	6	7
1	45,300	495,700	352,500	429,000	500,000	370,800	370,800
2	36,800	291,800	270,500	396,000	81,400	324,500	369,700
3	30,800	500,000	500,000	500,000	500,000	317,600	353,100
4	37,200	500,000	500,000	412,500	229,800	446,400	500,000
5	37,200	500,000	346,600	500,000	500,000	394,700	302,400
6	39,400	500,000	307,600	410,000	500,000	314,600	416,200
7	47,200	500,000	463,000	440,400	500,000	466,500	500,000
8	35,900	500,000	314,600	452,000	500,000	360,100	500,000
9	37,300	500,000	288,800	500,000	500,000	387,600	389,900
10	36,100	500,000	349,300	475,400	500,000	500,000	497,000
Average Number of Cycles:	38,320	478,750	369,290	451,530	431,120	388,280	419,910

TABLE 7, TEST RESULTS
DESIGN 4, STAINLESS STEEL SPRINGS

Wire size = .080 In. Spring index = 9.0

Number of Cycles at Spring Breakage

Spring/Set Number	1	2	3	4	5	6	7
1	40,200	188,400	150,200	133,100	500,000	194,500	230,300
2	47,200	164,200	203,200	265,000	500,000	182,200	232,400
3	37,500	41,700	129,400	281,500	233,500	163,700	152,200
4	38,300	224,100	285,800	241,100	500,000	229,000	225,200
5	40,200	175,400	294,000	256,000	330,200	92,000	208,900
6	35,400	87,800	121,200	169,800	500,000	204,500	218,800
7	51,600	72,500	177,400	275,500	280,000	238,200	225,700
8	28,800	85,300	76,800	241,500	486,200	274,500	210,000
9	39,800	85,200	110,700	205,200	269,700	196,300	280,400
10	42,100	142,900	211,000	221,000	216,400	193,000	249,200
Average Number of Cycles:	40,110	126,750	175,970	228,970	381,650	197,790	223,310

TABLE 8, AVERAGE LIFE OF SPRING SETS

Music Wire Springs

DESIGN NO. 1

Set No.	Average Life (Cycles)	Shot Size (In.)	Intensity
2	54,040	.007	.004N-.006N
5	49,080	.011	.004N-.006N
7	45,920	.011	.016N-.018N
6	40,920	.011	.010N-.012N
4	39,060	.007	.016N-.018N
3	37,500	.007	.010N-.012N

DESIGN NO. 2

Set No.	Average Life (Cycles)	Shot Size (In.)	Intensity
2	103,640	.007	.004N-.006N
5	78,500	.011	.004N-.006N
4	73,780	.007	.016N-.018N
7	68,600	.011	.016N-.018N
6	68,220	.011	.010N-.012N
3	67,300	.007	.010N-.012N
1	63,540	Not Shot-Peened	

DESIGN NO. 3

Set No.	Average Life (Cycles)	Shot Size (In.)	Intensity
3	343,020	.011	.006A-.008A
7	256,100	.017	.010A-.012A
6	251,040	.017	.006A-.008A
5	223,540	.017	.002A-.004A
4	172,240	.011	.010A-.012A
2	167,040	.011	.002A-.004A
1	148,250	Not Shot-Peened	

DESIGN NO. 4

Set No.	Average Life (Cycles)	Shot Size (In.)	Intensity
3	1,000,000	.011	.006A-.008A
6	988,580	.017	.006A-.008A
4	954,100	.011	.010A-.012A
7	865,020	.017	.010A-.012A
2	780,320	.011	.002A-.004A
5	755,580	.017	.002A-.004A
1	101,460	Not Shot-Peened	

TABLE 9, AVERAGE LIFE OF SPRING SETS

Stainless Steel Springs

DESIGN NO. 1

Set No.	Average Life (Cycles)	Shot Size (In.)	Intensity
3	409,070	.007	.010N-.012N
7	384,000	.011	.016N-.018N
4	298,820	.007	.016N-.018N
2	271,600	.007	.004N-.006N
6	259,280	.011	.010N-.012N
5	166,550	.011	.004N-.006N
1	54,720	Not Shot-Peened	

DESIGN NO. 3

Set No.	Average Life (Cycles)	Shot Size (In.)	Intensity
2	478,750	.011	.002A-.004A
4	451,530	.011	.010A-.012A
5	431,120	.017	.002A-.004A
7	419,910	.017	.010A-.012A
6	388,280	.017	.006A-.008A
3	369,290	.011	.006A-.008A
1	38,320	Not Shot-Peened	

DESIGN NO. 4

Set No.	Average Life (Cycles)	Shot Size (In.)	Intensity
5	381,650	.017	.002A-.004A
4	228,970	.011	.010A-.012A
7	223,310	.017	.010A-.012A
6	197,790	.017	.006A-.008A
3	175,970	.011	.006A-.008A
2	126,750	.011	.002A-.004A
1	40,110	Not Shot-Peened	

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Rock Island Arsenal, Rock Island, IL 61201

SHOT-PEENING PROCEDURES FOR HELICAL COMPRESSION SPRINGS

Prepared by: Henry P. Swieskowski

Technical Report No.

23 pages, Incl Figures & Tables

1. Shot-Peening
2. Manufacturing Methods
3. Helical Springs
4. Increased Life
5. Endurance Tests

Various shot-peening procedures for the manufacture of cold wound helical compression springs were investigated to establish optimum shot-peening methods to increase the life endurance properties of springs. Production springs that are typical of small arms applications were fabricated from music wire and stainless steel materials. The springs were given different shot-peening treatments with the exception of control groups that were not shot-peened. Effect of the various shot-peening procedures on spring life was evaluated by laboratory endurance tests. Recommended shot-peening procedures based on test results are given for the spring materials and stress conditions that were investigated in this project.

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