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MATERIAL PROPERTIES

The highest grades of spring-wire materials are used in fabricating our springs. To create cost-effective warehousing of our stock spring inventory for our customers, we can only offer material certifications for custom-made springs. Stock spring certificates of conformance to geometric tolerances set by the Spring Manufacturers Institute (SMI) can be copied from that offered in the "Regulatory Requirements and Certificates of Compliance" section of this catalog, or are available upon request. See the "Custom Spring" section of this catalog if material trace certifications or unique materials are required.

Wire materials offered for our stock springs are listed below, with comments on their most outstanding features.

Music wire - Recommended for small springs which are subjected to high stresses and suddenly-applied loads

Hard-drawn - For average stress applications

Oil-tempered - General purpose use where spring's index is not less than 5

Stainless Steel - Corrosion resistant for outdoor use, magnetic in spring temper, about 15% less stiff than carbon steel for a given wire size

Phosphor-Bronze - Good electrical conductivity and corrosion resistance and about 1/3 to1/2 as strong as steel

Beryllium-Copper - Good electrical conductivity and corrosion resistance and about 1/2 as strong as steel

Spring Characteristics

Spring Life

If a spring in question is not subjected to shock loads, rapid cycling, temperature extremes, corrosion, etc., and the total wire stress does not surpass the suggested maximum percentage of the involved material's minimum tensile strength (MTS) found in the following table "Properties of Common Spring Materials", then an estimate of 100,000 to 1,000,000 cycles (deflections) with infrequent breakage could be realized. A service life of over 1,000,000 cycles with infrequent failures may be expected if the wire maximum stress is reduced by approximately another 10% of the table's recommended values.

Other than simply reducing the applied load or deflection, there are many factors that contribute to significantly extending a commercial spring's service-life. Such enhancement generally increases the cost.

Specifications for critical applications that require a maximum life with no failures in fatigue are of no practical use and should be replaced with specifications that detail the user's test conditions in terms of expected life based on empirically-derived statistical failure rates.

In all applications, it should be assumed that a certain percentage will fail early. An attempt should be made to minimize any significant negative effects that an occasional early failure may have on the performance of the product. Regardless of how much time, effort and money that is spent to insure long life, it is nearly impossible to guarantee that there will be no failures in a given production lot of springs; particularly when subjected to severe operating conditions.

One important method we use to extend the life of a custom compression spring is shot peening. This procedure can extend the fatigue life by 30 percent or more. It should be noted that extension springs are normally not candidates for shot peening. Neither are compression springs with wire diameters under .040 of an inch (due to buckling). The spring must be large enough to allow peening of the inside surfaces. Our Custom Spring Department can advise you regarding this procedure.

The "Minimum Tensile Strength of Wire Materials" tables are presented in this section of the catalog. These tables contain the minimum expected tensile strengths for available wire sizes.

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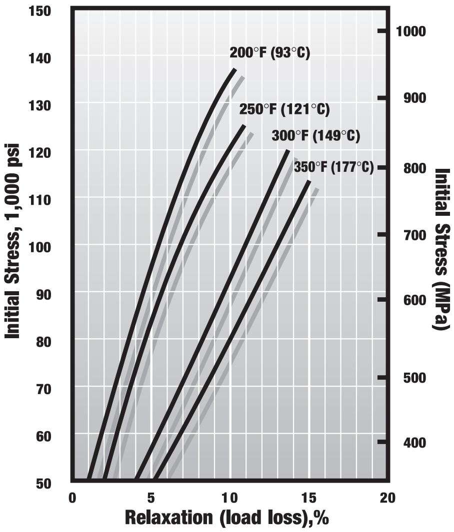
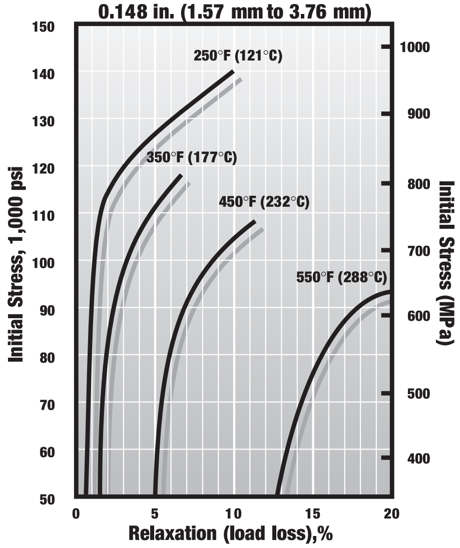
Temperature Effects

When extension and compression springs are subjected to heat while under stress there is some loss of their load carrying capability. The extent of this loss is related to the temperature reached and to the stress the given spring material is under. The loss-due-to-heat characteristics are presented in the data below. These data reflect the loss trends more than they represent the absolute load losses for all spring configurations.

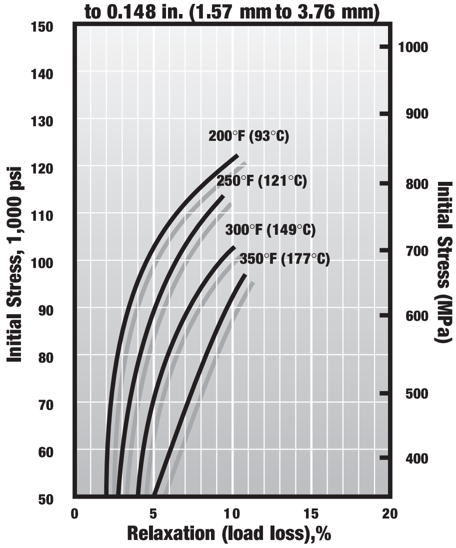
Music wire, 0.062 in. (1.57 mm)



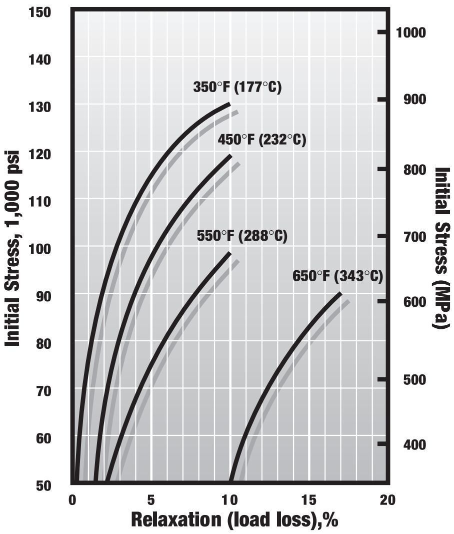
Chrome-silicon wire, 0.062 in. to 0.148 in. (1.57 mm to 3.76 mm)



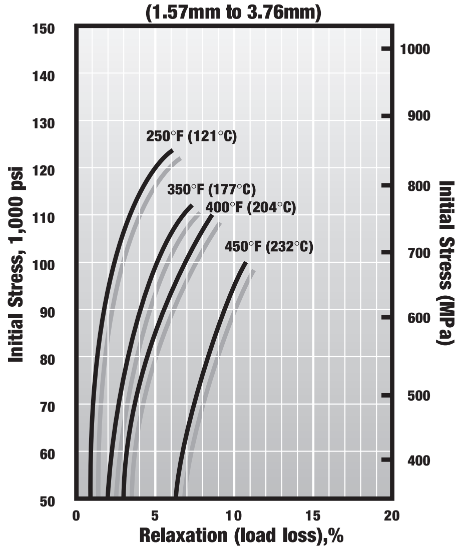
Carbon valve spring wire, 0.062 in. to 0.148 in. (1.57 mm to 3.76 mm)



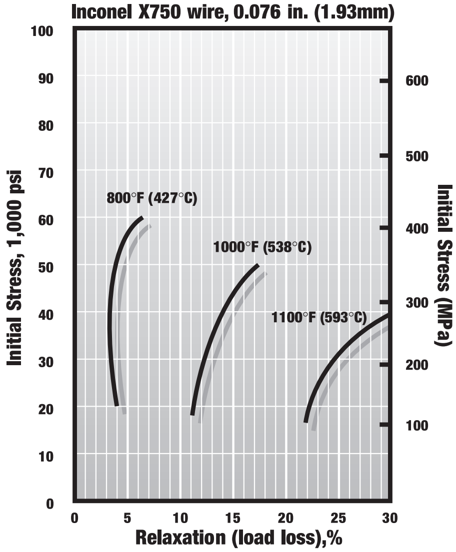
302 stainless-steel wire, 0.062 in. (1.57mm)



Chrome vanadium wire, 0.062 in. (1.57mm to 3.76mm)



Inconel X750 wire, 0.076 in. (1.93mm)



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METRIC CONVERSIONS

Compression, Extension and Flat Spring Loads (force):

1	gram	(gm)	=	0.0353 oz	=	0.0022 lbs	=	0.0098 N		
1	kilogram	(kgm)	=	35.2740 oz	=	2.2046 lbs	=	9.8066 N		
1	ounce	(oz)	=	28.3495 gm	=	0.0283 kgm	=	0.2780 N		
1	pound	(lbs)	=	453.5924 gm	=	0.4536 kgm	=	4.4482 N		
1	newton	(N)	=	3.5969 oz	=	0.2248 lbs	=	102.0 gm	=	0.102 kgm

Torsion Spring Loads (Torque):

1	oz-in	=	28.3495 gm-in 7.0616 N-mm	= =	72.0079 gm-cm 0.0071 N-m	=	0.0625 lbs-in
1	lbs-in	=	16. oz-in 453.5924 gm-in	= =	1152.1247 gm-cm 112.9848 N-mm	= =	1.1521 kgm-cm 0.1130 N-m
1	N-m	=	141.6119 oz-in 0.1020 kgm-m	=	8.8507 lbs-in	=	10.1972 kgm-cm
1	kgm-cm	=	13.8880 oz-in	=	0.8680 lbs-in	=	0.0981 N-m

For Stress:

1	Pascal (Pa)	=	1 N/m^2	=	0.000145 lbs/in^2	
1	lbs/in^2	=	6894.7570 Pa	=	0.0703 kgm per cm^2	(100,000 psi = 689.47570 MPa)
1	kgm per cm^2	=	98,066.5 Pa	=	14.2233 psi	
1	MegaPascal (MPa)	=	1,000,000 Pa	=	1 MegaNewton/m^2 =	145.0377 psi

For Lengths:

1	mm	=	0.03937 in		
1	cm	=	0.3937 in		
1	in	=	25.4 mm	=	2.54 cm
1	m	=	39.37 in		

Conversion of Forces

oz	lbs	gm	N
1/64	.001	.443	.0043
1/32	.0019	.886	.0087
1/16	.0039	1.772	.0174
1/8	.0078	3.544	.0348
1/4	.0156	7.087	.0695
1/2	.0313	14.175	.1390
1	.0625	28.350	.278
2	.125	56.699	.556
3	.1875	85.049	.834
4	.250	113.398	1.112
5	.3125	141.748	1.390
10	.625	283.495	2.780

gm	oz	lbs	N
.1	.0035	.00022	.00098
.2	.0071	.00044	.00196
.3	.0106	.00066	.00294
.5	.0176	.00110	.00490
1	.0353	.0022	.0098
2	.0705	.0044	.0196
3	.1058	.0066	.0294
4	.1411	.0088	.0392
5	.1764	.0110	.0490
10	.3527	.0220	.0981
15	.5291	.0331	.1471
25	.8818	.0551	.2452

lbs	oz	gm	N
.1	1.6	45.359	.4448
.2	3.2	90.718	.8896
.3	4.8	136.08	1.334
.5	8.0	226.80	2.224
1	16	453.59	4.448
2	32	907.18	8.896
3	48	1,360.78	13.345
4	64	1,814.37	17.793
5	80	2,267.96	22.241
10	160	4,535.92	44.482
15	240	6,803.89	66.723
25	400	11,393.81	111.206

N	oz	lbs	gm
.1	.3597	.0225	10.20
.2	.7194	.0450	20.39
.3	1.0791	.0674	30.59
.5	1.7985	.1124	50.99
1	3.597	.2248	101.97
2	7.194	.4496	203.94
3	10.791	.6744	305.91
4	14.388	.8992	407.89
5	17.985	1.1240	509.86
10	35.969	2.2481	1,019.72
15	53.954	3.3721	1,529.57
25	89.924	5.6202	2,549.29

Fraction to Decimal Conversion

1/64	.015625	33/64	.515625
1/32	.03125	17/32	.53125
3/64	.046875	35/64	.546875
1/16	.0625	9/16	.5625
5/64	.078125	37/64	.578125
3/32	.09375	19/32	.59375
7/64	.109375	39/64	.609375
1/8	.125	5/8	.625
9/64	.140625	41/64	.640625
5/32	.15625	21/32	.65625
11/64	.171875	43/64	.671875
3/16	.1875	11/16	.6875
13/64	.203125	45/64	.703125
7/32	.21875	23/32	.71875
15/64	.234375	47/64	.734375
1/4	.25	3/4	.75
17/64	.265625	49/64	.765625
9/32	.28125	25/32	.78125
19/64	.296875	51/64	.796875
5/16	.3125	13/16	.8125
21/64	.328125	53/64	.828125
11/32	.34375	27/32	.84375
23/64	.359375	55/64	.859375
3/8	.375	7/8	.875
25/64	.390625	57/64	.890625
13/32	.40625	29/32	.90625
27/64	.421875	59/64	.921875
7/16	.4375	15/16	.9375
29/64	.453125	61/64	.953125
15/32	.46875	31/32	.96875
31/64	.484375	31/64	.984375
1/2	.5	1	1.

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MINIMUM TENSILE STRENGTH OF WIRE SPRING MATERIALS

FERROUS in psi x 10^3

WIRE DIA (In.)	MUSIC WIRE	HARD DRAWN	OIL TEMP.
0.008	399	307	315
0.009	393	305	313
0.010	387	303	311
0.011	382	301	309
0.012	377	299	307
0.013	373	297	305
0.014	369	295	303
0.015	365	293	301
0.016	362	291	300
0.017	362	289	298
0.018	356	287	297
0.019	356	285	295
0.020	350	283	293
0.021	350	281	
0.022	345	280	
0.023	345	278	289
0.024	341	277	
0.025	341	275	286
0.026	337	274	
0.027	337	272	
0.028	333	271	283
0.029	333	267	
0.030	330	266	
0.031	330	266	280
0.032	327	265	
0.033	327	264	
0.034	324	262	
0.035	324	261	274
0.036	321	260	
0.037	321	258	
0.038	318	257	
0.039	318	256	
0.040	315	255	
0.041	315	255	266
0.042	313	254	
0.043	313	252	
0.044	313	251	
0.045	309	250	
0.046	309	249	

WIRE DIA (In.)	MUSIC WIRE	HARD DRAWN	OIL TEMP.
0.047	309	248	259
0.048	306	247	
0.049	306	246	
0.050	306	245	
0.051	303	244	
0.052	303	244	
0.053	303	243	
0.054	303	243	253
0.055	300	242	
0.056	300	241	
0.057	300	240	
0.058	300	240	
0.059	296	239	
0.060	296	238	
0.061	296	237	
0.062	296	237	247
0.063	293	236	
0.064	293	235	
0.065	293	235	
0.066	290		
0.067	290	234	
0.069	290	233	
0.070	289		
0.071	288		
0.072	287	232	241
0.074	287	231	
0.075	287		
0.076	284	230	
0.078	284	229	
0.079	284		
0.080	282	227	235
0.083	282		
0.084	279		
0.085	279	225	
0.089	279		
0.090	276	222	
0.091	276		230
0.092	276	220	
0.093	276		

WIRE DIA (In.)	MUSIC WIRE	HARD DRAWN	OIL TEMP.
0.094	274		
0.095	274	219	
0.099	274		
0.100	271		
0.101	271		
0.102	270		
0.105	270	216	225
0.106	268		
0.109	268		
0.110	267		
0.111	267		
0.112	266		
0.119	266		
0.120	263	210	220
0.123	263		
0.124	261		
0.129	261		
0.130	258		
0.135	258	206	215
0.139	258		
0.140	256		
0.144	256		
0.145	254		
0.148	254	203	210
0.149	253		
0.150	253		
0.151	251		
0.160	251		
0.161	249		
0.162	249	200	205
0.177	245	195	200
0.192	241	192	195
0.207	238	190	190
0.225	235	186	188
0.250	230	182	185
0.3125		174	183
0.375		167	180
0.4375		165	175
0.500		156	170

MINIMUM TENSILE STRENGTH OF WIRE SPRING MATERIALS

STAINLESS STEEL in psi x 10^3

WIRE DIA (In.)	302 SST	17-7 SST
.008	325	345
.009	325	
.010	320	345
.011	318	340
.012	316	
.013	314	
.014	312	
.015	310	340
.016	308	335
.017	306	
.018	304	
.019	302	
.020	300	335
.021	298	330
.022	296	
.023	294	
.024	292	
.025	290	330
.026	289	325
.027	287	
.028	286	
.029	284	
.030	282	325
.031	280	320
.032	277	

WIRE DIA (In.)	302 SST	17-7 SST
.033	276	
.034	275	
.035	274	
.036	273	
.037	272	
.038	271	
.039	270	
.040	270	
.041	269	320
.042	268	310
.043	267	
.044	266	
.045	264	
.046	263	
.047	262	
.048	262	
.049	261	
.051	261	310
.052	260	305
.055	260	
.056	259	
.057	258	
.058	258	
.059	257	
.060	256	

WIRE DIA (In.)	302 SST	17-7 SST
.061	255	305
.062	255	297
.063	254	
.065	254	
.066	250	
.071	250	297
.072	250	292
.075	250	
.076	245	
.080	245	292
.092	240	279
.105	232	274
.120	225	272
.125		272
.131		260
.148	210	256
.162	205	256
.177	195	
.192		
.207	185	
.225	180	
.250	175	
.375	140	

COPPER-BASE ALLOYS in psi x 10^3

Phosphor Bronze (Grade A)	
Wire Dia. Range – in. (mm)	
0.007-0.025 (0.18-0.64)	145
0.025-0.062 (10.65-1.53)	135
0.063 and over (1.59 and over)	130
Beryllium Copper	
(alloy 25 pretemp)	
0.005-0.040 (0.13-1.02)	180
0.041 and over (1.03 and over)	170
Spring Brass	
all sizes	129

NICKEL-BASE ALLOYS in psi x 10^3

Inconel (Spring Temper)	
Wire Dia. Range – in. (mm)	
up to 0.057 (1.45)	185
0.057-0.114 (1.46-2.89)	175
0.114-318 (2.90-8.08	170
Inconel X	
Spring Temper	After Aging
190	220

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PROPERTIES OF COMMON SPRING MATERIALS

	MATERIAL	NOMINAL ANALYSIS	TENSILE PROPERTIES: MINIMUM TENSILE STRENGTH P.S.I. X 10^3	TENSILE PROPERTIES: MODULUS ELASTICITY E P.S.I. X 10^6	TORSIONAL PROPERTIES[2]: DESIGN STRESS[1] % MINIMUM TENSILE	TORSIONAL PROPERTIES[2]: MODULUS IN TORSION G P.S.I. X 10^6	MAXIMUM TEMPERATURE °F	MAXIMUM TEMPERATURE °C	ROCKWELL HARDNESS	METHOD OF MANUFACTURE CHIEF USES SPECIAL PROPERTIES
HIGH CARBON SPRING WIRE	Music Wire ASTM A 228	C .70-1.00% Mn .20-.60%	230-399	30	45	11.5	250	121	C41-60	Cold drawn high and uniform tensile. High quality springs and wire forms.
	Hard Drawn ASTM A 227	C .45-.85% Mn .60-1.30%	CLI 147-283 CLII 171-234	30	40	11.5	250	121	C31-52	Cold drawn. Average stress applications. Lower cost springs and wire forms.
	Oil Tempered ASTM A 229	C .55-.85% Mn .60-1.20%	CLI 165-293 CLII 191-324	30	45	11.5	250	121	C42-55	Cold drawn and heat treated before fabrication. General purpose spring wire.
ALLOY STEEL WIRE	Chrome Vanadium ASTM A 231	C .48-.53% Cr .80-1.10% V .15 Min%	190-300	30	45	11.5	425	218.5	C41-55	Cold drawn and heat treated before fabrication. Used for shock loads and moderately elevated temperature.
	Chrome Silicon ASTM A 401	C .51-.59% Cr .60-.80% Si 1.20-1.60%	235-300	30	45	11.5	475	246	C48-55	Cold drawn and heat treated before fabrication. Used for shock loads and moderately elevated temperature.
STAINLESS STEEL WIRE	AISI 302/304 ASTM A 313	Cr 17.-19.% Ni 8.-10%	125-325	28	30-40	10	550	288	C35-45	Cold drawn general purpose corrosion and heat resistant. Magnetic in spring temper.
	AISI 316 ASTM A 313	Cr 16.-18.% Ni 10.-14.% Mo 2.-3.%	110-245	28	40	10	550	288	C35-45	Cold drawn. Heat resistant and better corrosion resistance than 302. Magnetic in spring temper.
	17-7 PH ASTM A 313 (631) AMS 5678-B	Cr 16.-18.% Ni 6.5-7.5% Al .75-1.5%	Cond CH 235-335	29.5	45	11	650	343	C38-57	Cold drawn and precipitation hardened after fabrication. High strength and general purpose corrosion resistance. Slightly magnetic in spring temper.
NON-FERROUS ALLOY WIRE	Phosphor Bronze Grade A ASTM B 159	Cu 94.-96.% Sn 4.-6.%	105-145	15	40	6.25	200	93.3	B98-104	Cold drawn. Good corrosion resistance and electrical conductivity.
	Beryllium Copper ASTM B 197	Cu 98% Be 2%	150-230	18.5	45	7.0	400	204	C35-42	Cold drawn and may be mill hardened before fabrication. Good corrosion resistance and electrical conductivity. High physicals.
HIGH TEMPERATURE ALLOY WIRE	Inconel x 750 AMS 5698, 5699	Ni 73.% Cr 15.% Fe 6.75%	No. IT 155 Min. Spg. T 190-230	31	40	12	700	372	C34-39 C42-48	Cold drawn and precipitation hardened after fabrication. Good corrosion resistance at elevated temperature.

1. See "Minimum Tensile Strength of Wire Material" in this catalog.
2. Maximum design stress target for wire in bending (torsion springs) is usually 75% of MTS.