Dendoff Springs Ltd.
12045 Old Yale Road
Surrey, British Columbia
Canada V3V 3X4

Phone: 604-580-3400
Toll-Free: 800-661-4205
Fax: 604-580-3600
Email: sales@dendoff.com

SPRING MATERIALS

In selecting spring material, several important considerations are:

- Magnetic Characteristics

  In some applications, even the minutest magnetic behavior can be detrimental.

  Magnetic permeability can be altered by cold work; therefore some variation can be expected.

Materials	Permeability at 200 Oersted Room Temperature
Air	**1**
Brasses, Bronzes	**Non Magnetic**
Carbon Steels	**>500**
Inconel Alloys	
600	**1.01**
625	**1.0006**
X-750	**1.0035**
Stainless Steels	
Type 301, spring temper	**>30**
Type 302, spring temper	**>12**
631 (17 – 7 PH)	**>40**
Titanium Alloys	**Non Magnetic**

- Elastic Modulus

  The modulus of elasticity in tension and shear is vital to spring design. For most steels and age-hardenable alloys, the modulus varies as a function of chemical composition, cold works and degree of aging. Usually variations are small and can be compensated for by an adjustment of the reference parameters of the spring design (number of active coils and coil diameter).

  For most materials, moduli are temperature-dependent and vary inversely with temperature by approximately 2% per 55˚ C (100˚F).

Design criteria are best specified at room temperature after having made appropriate compensation for the application temperature.
Certain nickel-chromium-iron alloys are designed to have a constant modulus over the temperature range from -5˚ to 65˚ C and are an exception.

For true isotropic materials, the elastic moduli in tension (E) and shear (G) are related through Poisson's ration by the expression:

$$\mu = \frac{E}{2G} - 1$$

so that, for common spring materials, any one of the parameters may be approximated using the other two.

ENVIRONMENTAL CONSIDERATIONS

The operating environment in which the springs are to be used is a most important consideration. The spring material must be compatible with the environment and be able to withstand the effects of temperature and corrosion without an excessive loss in spring performance.

Corrosion and elevated temperatures decrease spring reliability. However, that being said, the effect of temperature on spring materials can be predicted.

Temperature:

Applications in which temperatures are elevated may cause concern for stress relaxation, which creates a loss of load or available deflection that occurs when a springs is held or cycled under load.

Temperature will also affect modulus, tensile and fatigue strength. Stress and temperature are related exponentially to relaxation.

Other factors that can affect relaxation include:

- Alloy Type
- Residual Stress
- Heat Setting
- Grain Size

Corrosion:

Springs are subject to specific and general corrosion concerns, which will affect their life span and load-carrying ability. The two most common methods used to fight the effects of corrosion are:

- Specific spring material that is inert to the applicable environment. This is the most reliant protection, albeit costly.
- Protective coating, which are the most practical and cost-efficient solutions and include:

    Metallic coatings applied by electroplating and mechanical plating, such as zinc, cadmium and aluminum.

    Barrier Coatings applied such as paints, oils, wax, greases, & phosphate coatings.

Protective Material	Standard Salt Spray Test Resistance, hours	Description
Paints:		
Black Japan	**15 -20**	Dark coloured, usually dipped, cured by baking.
Lacquer	**30 – 100**	Usually applied by spraying. Air dried.
Enamel	**50 – 400**	Hard finish; applied by spray, brush or dip; cured by air or baking.
Paint	**25 - 300**	
Oils, Waxes	**1 – 300**	Lubricating, rust-inhibiting, hard drying & nondrying oils.
Phosphates with supplemental oils, waxes, etc.	**24 – 600**	Chemical treatment converting steel surface to iron phosphate crystalline surface. Affords a bond for oils & paints
Cadmium, Zinc	**24 - 100**	Electroplated or mechanically plated

SPRING WIRE

High Carbon Spring Wire

Material	Tensile Properties		Torsional Properties		Maximum Operating Temperature		Rockwell Hardness	Method of Manufacture Special Properties
	Min. Tensile Strength psi x 10^3 [MPa]	Modulus of Elasticity E psi x 10^6 [MPax10^3]	Design Stress % Min. Tensile	Modulus in torsion G psi x 10^6 [MPa x 10^3]	°F	°C		
Music Wire ASTM A228	230-399	30[207]	45	11.5 [79.3]	250	121	C41-60	Cold drawn high & uniform tensile. High quality springs
Hard Drawn ASTM A227	CLI 147-283 [1014-1951] CLI 171-324 [1179-2234]	30 [207]	40	11.5 [79.3]	250	121	C1-52	Cold drawn. Average stress applications. Lower cost springs & wire forms.
High Tensile Hard Drawn ASTM A679	238-350 [1641-2413]	30 [207]	45	11.5 [79.3]	250	121	C41-60	Cold drawn. Higher quality springs & wire forms.
Oil Tempered ASTM A229	CLI 165-293 [1138-2020] CLI 191-324 [1317-2234]	30 [207]	45	11.5 [79.3]	250.	121	C42-55	Cold drawn & heat treated before fabricated. General purpose spring wire.
Carbon Valve ASTM A230	215-240 [1482-1655]	30 [207]	45	11.5 [79.3]	250	121	C45-49	Cold drawn & heat treated before fabricated. Good surface condition & uniform tensile. Suitable for cyclic applications.

Carbon & Alloy-Specialty Spring Grade

Material	Tensile Properties		Torsional Properties		Maximum Operating Temperature		Rockwell Hardness	Method of Manufacture Special Properties
	Min. Tensile Strength psi x 10^3 [MPa]	Modulus of Elasticity E psi x 10^6 [MPax10^3]	Design Stress % Min. Tensile	Modulus in torsion G psi x 10^6 [MPa x 10^3]	°F	°C		
Grade B Carbon ASTM A1000	195-275 [1350-1897]	30 [207]	45	11.5 [79.3]	250	121	C45-49	Annealed & cold drawn or oil tempered, as specified.
Grade C Chrome Vanadium ASTM A1000	210-270 [1450-1860]	30 [207]	45	11.5 [79.3]	425	218	C41-55	Annealed & cold drawn or oil tempered, as specified.
Grade A Chrome Silicon ASTM A1000	231-305 [1590-2100]	30 [207]	45	11.5 [79.3]	475	245	C48-55	Annealed & cold drawn or oil tempered, as specified.
Grade D Chrome Vanadium ASTM A1000	245 – 320 [1690 – 2200]	30 [207]	45	11.5 [79.3]	450	230	C45-55	Annealed & cold drawn or oil tempered, as specified.

Alloy Steel Wire

Material	Tensile Properties		Torsional Properties		Maximum Operating Temperature		Rockwell Hardness	Method of Manufacture Special Properties
	Min. Tensile Strength psi x 10^3 [MPa]	Modulus of Elasticity E psi x 10^6 [MPax10^3]	Design Stress % Min. Tensile	Modulus in torsion G psi x 10^6 [MPa x 10^3]	°F	°C		
Chrome Vanadium ASTM A231	190-300 [1310-2069]	30 [207]	45	11.5 [79.3]	425	218	C41-45	Cold drawn & heat treated before fabrication. Used for shock loads & moderately elevated temperatures.
Chrome Vanadium Valve ASTM A232	205-290 [1414-2000]	30 [207]	45	11.5 [79.3]	430	220	C41-55	Cold drawn & heat treated before fabrication. Used for shock loads & moderately elevated temperatures
Chrome Vanadium Valve Modified ASTM A878	205-290 [1590-2100]	30 [207]	45	11.5 [79.3]	430	220	C41-45	Annealed & cold drawn, hardened & tempered before fabrication. Used for shock loads & moderately elevated temperatures.
Chrome Silicon ASTM A401	235 – 305 [1690 – 2100]	30 [207]	45	11.5 [79.3]	475	245	C48-55	Cold drawn & hardened & tempered before fabrication. For shock loading & moderately higher temperatures.
Chrome Silicon Valve ASTM A877	245-305 [1690-2100]	30 [207]	45	11.5 [79.3]	475	245	C48-55	Cold drawn & hardened & tempered before fabrication. For shock loading & moderately higher temperatures.

Stainless Steel Wire

Material	Tensile Properties		Torsional Properties		Maximum Operating Temperature		Rockwell Hardness	Method of Manufacture Special Properties
	Min. Tensile Strength psi x 10^3 [MPa]	Modulus of Elasticity E psi x 10^6 [MPax10^3]	Design Stress % Min. Tensile	Modulus in torsion G psi x 10^6 [MPa x 10^3]	°F	°C		
AISI 302/304 ASTM A 313	110-245 [758-1689]	28 [193]	35	10 [69.0]	550	288	C35-45	Cold drawn general purpose corrosion & heat resistant. Magnetic in spring temper.
AISI 316 ASTM A 313	110-245 [758-1689]	28 [193]	40	10 [69]	550	288	C35-45	Cold drawn. Heat resistant & better corrosion resistance than 302. Magnetic in spring temper.
17-7 PH ASTM A 303 [631]	Cond CH 235-335 [1620-2310]	29.5 [203]	45	11 [75.8]	650	343	C38-57	Cold drawn & precipitation hardened after fabrication. High strength & general purpose corrosion resistance. Slightly magnetic in spring temper.

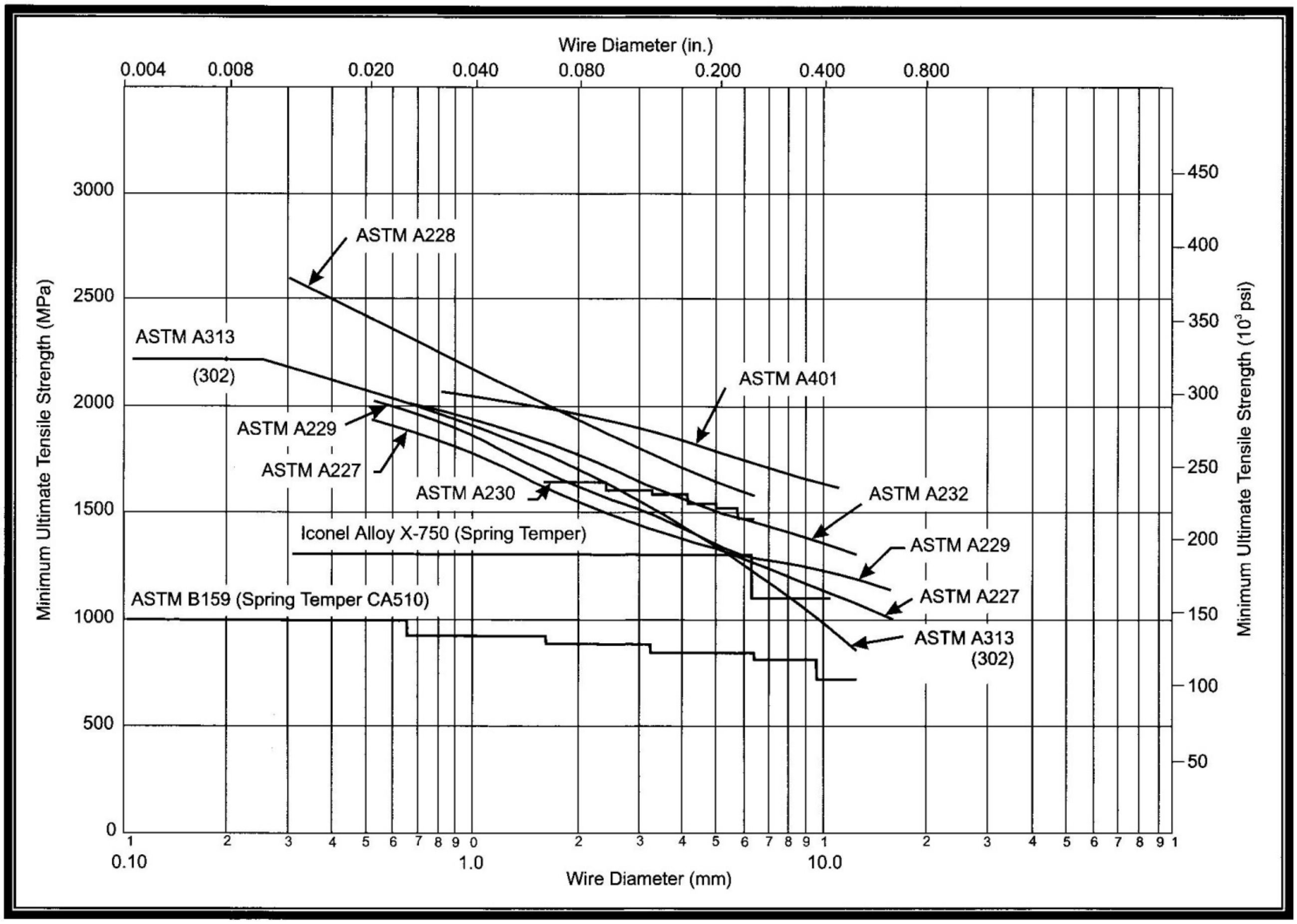
Non-Ferrous Alloy Wire

Material	Tensile Properties		Torsional Properties		Maximum Operating Temperature		Rockwell Hardness	Method of Manufacture Special Properties
	Min. Tensile Strength psi x 10^3 [MPa]	Modulus of Elasticity E psi x 10^6 [MPax10^3]	Design Stress % Min. Tensile	Modulus in torsion G psi x 10^6 [MPa x 10^3]	°F	°C		
Phosphor Bronze Grade A ASTM B 159	105-145 [724-1000]	15 [103]	40	6.25 [43.1]	200	93.3	B98-104	Cold drawn. Good corrosion resistance & electrical conductivity.
Beryllium Copper ASTM B197	150-230 [1034-1586]	18.5 [128]	45	7.0 [48.3]	400	204	C35-43	Cold drawn & may be mill hardened before fabrication. Good corrosion resistance & electrical conductivity. High physicals.
Monel 400 AMS 7233	145-180 [1000-1241]	26 [179]	40	9.5 [65.5]	450	232	C23-32	Cold drawn. Good corrosion resistance at moderately elevated temperature.
Monel K 500	160-200 [1103-1379]	26 [179]	40	9.5 [65.5]	550	288	C23-35	Excellent corrosion resistance at moderately elevated temperature.

High Temperature Alloy Wire

Material	Tensile Properties		Torsional Properties		Maximum Operating Temperature		Rockwell Hardness	Method of Manufacture Special Properties
	Min. Tensile Strength psi x 10^3 [MPa]	Modulus of Elasticity E psi x 10^6 [MPax10^3]	Design Stress % Min. Tensile	Modulus in torsion G psi x 10^6 [MPa x 10^3]	°F	°C		
A286 Alloy	160-200 [1103-1379]	29 [200]	35	10.4 [71.7]	950	510	C35-42	Cold drawn & precipitation hardened after fabrication. Good corrosion resistance at elevated temperature.
Inconel 600	100-230 [1172-1586]	31 [214]	40	11.0 [75.8]	700	371	c35-45	Cold drawn. Good corrosion resistance at elevated temperature.
Inconel 718	210-250 [1448-1724]	29 [200]	40	11.2 [77.2]	1100	593	C45-50	Cold drawn & precipitation hardened after fabrication. Good corrosion resistance at elevated temperature.
Inconel x750 AMS 5698, 5699	No. IT 155 Min. [1069] Spg. T 190-230 [1310-1586]	31 [214]	40	12 [82.7]	750-1100	399-593	C34-39 C42-48	Cold drawn & precipitation hardened after fabrication. Good corrosion resistance at elevated temperature

Minimum tensile strengths of spring wire:



Spring relaxation data for Various Materials: