Material Types

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Selecting the proper material for an application requires a general knowledge of what is commonly available for use in Smalley flat wire products.

Specifying the correct material can prevent additional cost and failure in operation. Carbon steel is the most commonly specified material. Stainless steel, although more costly than carbon steel, provide far superior corrosion resistance and have higher temperature operating limits.

Carbon Steel

Oil Tempered

SAE 1070-1090 high carbon tempered spring steel is a standard material for spiral retaining rings and wave springs. Tensile strength and yield strength are maximised as a result of the oil tempered martensitic structure.

Hard Drawn

SAE 1060-1075 high carbon cold drawn spring steel is a standard material for snap rings. Hard drawn carbon steel has no scale as it receives its strength from the drawing process.

In either temper, carbon steel is best suited in applications having a protected environment as it corrodes if not lubricated or atmospherically sealed. Additional corrosion protection can be added with special finishes. Rings and springs are normally supplied with an oil dip finish providing protection during shipment and for shelf storage.

- Carbon steel is highly magnetic and can be a variety of different colours including blue, black and grey.

Stainless Steel

302 Stainless Steel

302 is the standard stainless steel for spiral retaining rings. This widely used material is specified because of its combination of corrosion resistance and physical properties. 302 obtains its spring temper condition by cold working. Though it is categorized as being a nonmagnetic stainless, 302 becomes slightly magnetic as a result of cold working. It is not hardenable by heat treatment.

- 302 has a silver-grey colour.

316 Stainless Steel

Nearly identical in physical properties and heat resistance to 302, 316 provides additional corrosion resistance, particularly against pitting, due to its molybdenum chemical content. 316 is generally used in food, chemical and sea water applications.

316 shows less magnetism than 302. However, as with 302, magnetism increases as the wire is cold reduced. This stainless grade is also not hardenable by heat treatment.

- 316 has a silver-grey colour.

17–7 PH Condition CH900 Stainless Steel

Similar in corrosion resistance to type 302, this alloy is used almost exclusively for wave springs, yet offers both high tensile and yield strengths for special ring applications. In fatigue and high stress applications, 17-7 out performs even the finest grade of carbon steel.

Spring properties are achieved by precipitation hardening Condition C to Condition CH900. As a result, the material may be subjected to a temperature of 343˚C without a loss of spring properties. 17-7 PH Condition CH900 exhibits magnetism similar to high carbon steel.

- After precipitation hardening, 17-7 has a blue, brown or silver colour as a result of open-air heat treatment, although atmosphere controlled heat treatment provides a bright colour.

Material Types

Super Alloys

Inconel X-750*

This nickel-chromium alloy is used most commonly in high temperature and corrosive environments. Two commonly specified tempers of Inconel are described below.

Most commonly, Inconel X-750 is precipitation heat treated to a spring temper condition. In this state, it has temperature resistance to 371˚C. The National Association of Corrosion Engineers (NACE) approves this hard temper to specification MR-01-75 (Rc50 maximum) for spiral retaining rings and wave/compression springs.

#1 temper, which requires a longer heat treatment than spring temper, has a lower tensile strength but provides temperature protection to 538˚C.

Both spring temper and #1 temper may be heat treated in either an open air or atmosphere controlled furnace. Open air heat treatment may produce oxidation, which often results in a slight black residue. An atmosphere controlled environment eliminates oxidation and produces a component with no residue.

- Rings and springs manufactured from this grade of Inconel have a blue/silver-grey colour and exhibit no magnetism.

A286 Alloy

In applications up to 538˚C, this alloy exhibits similar properties to Inconel X-750. Its spring temper condition is obtained by precipitation hardening. A286 may be heat treated similar to spring temper and #1 temper Inconel.

- This material exhibits no magnetism and has a blue/ silver-grey colour.

Elgiloy*

Known for its excellent resistance to corrosive environments and use at elevated temperatures, this relatively new spring material is now readily available from Smalley. Commonly used in oil industry applications, Elgiloy shows improved reliability over other NACE approved materials by resisting sulfide stress cracking.

Additionally, Elgiloy is said to out perform "over 600% better than 17-7 PH in load retention at 343˚C and provide over 100% more cycles (in fatigue resistance) than carbon steel, without breakage."

- Elgiloy exhibits no magnetism and is blue-brown in colour as a result of heat treatment.

*INCONEL X-750 is a registered trademark of Special Metals Corporation.
ELGILOY is a registered trademark of Combined Metals of Chicago.

Coppers

Beryllium Copper Alloy #25

Normally specified in a hard temper, this alloy produces excellent spring properties due to a combination of low modulus of elasticity and high ultimate tensile strength. The alloy gains its physical properties by precipitation hardening. In contrast to other copper alloys, beryllium copper has the highest strength and offers remarkable resistance to loss of physical properties at elevated temperatures.

- Beryllium copper is nonmagnetic. Its electrical conductivity is about 2-4 times as great as phosphor bronze

Phosphor Bronze, Grade A

Phosphor bronze offers fair spring properties, fair electrical conductivity and is rated a step below beryllium copper in performance. It is purchased in a spring temper condition to maximise spring characteristics.

- Phosphor bronze is hardenable only by cold working. This material is also nonmagnetic.

Materials Table

The table below presents the more common alloys used by Smalley Steel Ring Company.

Material	Material Thickness (mm)	Minimum Tensile Strength (N/mm^2)	Shear Strength (N/mm^2)	Maximum Recommended Operating Temp.[4] (°C)	Modulus of Elasticity (N/mm^2)	Chemical	Afnor	Number-DIN
CARBON STEEL								
Oil Tempered SAE 1070 - 1090	0,152 - 0,356	1855	1055	121	206843	Carbon Steel XC67 to XC75	Not applicable	1,1231 - 1,1248[1]
	0,357 - 0,533	1758	1000					
	0,534 - 1,092	1524	869					
	≥1,093	1455	827					
Hard Drawn SAE 1060 - 1075	0,152 - 0,762	1586	896					
	0,763 - 2,794	1248	710					
	2,795 - 5,588	1076	614					
AISI 302								
AMS-5866	0,051 - 0,559	1448	820	204	193053	X10 CrNi 18-8	Not applicable	1,4310
	0,560 - 1,194	1379	786					
	1,195 - 1,575	1276	724					
	1,576 - 1,880	1207	689					
	1,881 - 2,261	1138	648					
	2,262 - 2,413	1069	607					
AISI 316								
ASTM A313[1]	0,051 - 0,584	1344	765	204	193053	X 5 CrNiMo 17-12-2	Z 7 CND 17-12-2	1,4401
	0,585 - 1,219	1310	745					
	1,220 - 1,549	1207	683					
	≥1,550	1172	669					
17-7 PH								
CONDITION CH900 AMS-5529	ALL	1655[2]	945[2]	343	203395	X 7 CrNiAl 17-7	Z 9 CNA 17-07	1,4568
A-286								
AMS-5810	ALL	1241[2]	724[2]	538	213737	X 6 NiCrTiMoVB 25-15-2	Z6NCTDV25-15	1,4980
INCONEL[5] ALLOY X-750								
SPRING TEMPER AMS-5699[3]	ALL	1517[2]	862[2]	371	213737	NiCr 15 Fe 7 TiAl	NC 15 Fe 7 TA	2,4669
No. 1 TEMPER "Rc 35 MAXIMUM" AMS-5699[1,3]	ALL	938[2] REF	531[2]	371				
No. 1 TEMPER AMS-5698	ALL	1069[2]	607[2]	371				
INCONEL[5] ALLOY 718								
AMS-5596[1]	ALL	1241[2]	703[2]	704	204085	NiCr 19 NbMo	NC 19 FeNb	2,4668
ELGILOY[5]								
AMS-5876[1,3]	≤ 0,102	2068[2]	1179[2]	427	206843	CoCr20 Ni16 Mo7	Not applicable	Not applicable
	0,103 - 0,483	1999[2]	1138[2]					
	0,484 - 0,635	1931[2]	1096[2]					
	0,636 - 2,54	1862[2]	1062[2]					
BERYLLIUM COPPER								
TEMPER TH02 ASTM B197[1]	ALL	1276[2]	883[2]	204	127553	CuBe2	Not applicable	2,1247

NOTE: Additional materials available include Phosphor Bronze, C-276, 410 Stainless Steel, MONEL5 K-500, MONEL5 400, Waspaloy and others. Please consult TFC engineering team for further details.

[1] Referenced for chemical composition only. [2] Values obtained after precipitation hardening. [3] Conforms to NACE Standard MR-01-75.
[4] Exceeding these temperatures will cause increased relaxation. Consult TFC engineering team for High Temperature applications.
[5] ELGILOY is a registered trademark of Combined Metals of Chicago. INCONEL and MONEL are registered trademarks of Special Metals Corporation.
HASTELLOY is a registered trademark of Haynes International.

Material Finishes

Material Finishes

Oil Dip

This is the standard finish for all Smalley products produced from carbon steel. The oil provides resistance to corrosion in transport and normal storage. The oil dip finish should not be considered a permanent finish.

Black Oxide

MIL-DTL-13924, Class 1

This finish provides a flat black finish. Black oxide is intended more for cosmetic appearance than for corrosion resistance.

Cadmium Plating

Cadmium Plate, AMS-QQ-P-416, Type I, Class 2,
Cadmium Plate w/Chromate Dip, AMS-QQ-P-416, Type II, Class 2

Cadmium plating is used on carbon steel to increase the corrosion resistance of the product. The process of cadmium plating spiral retaining rings is costly and subjects the ring to the possibility of hydrogen embrittlement. Smalley offers stainless steel as the preferable option to cadmium.

Passivation

AMS 2700, Method 1, Type 2, Class 3

Passivation is an optional cleaning operation for stainless steel. It provides a bright finish and increased corrosion resistance. Passivation dissolves iron particles and other substances, which have become imbedded in the surface of stainless steel during production. If not dissolved, these foreign particles could promote rusting, discolouration or even pitting.

In theory, the corrosion resistance of stainless steel is due to the thin, invisible oxide film that completely covers the surface of the ring and prevents further oxidation. Removing the contaminates prevents breaks in the oxide film for optimum corrosion resistance.

Zinc Phosphate

MIL-DTL-16232, Type Z, Class 2

This finish is sometimes referred to as "Parkerizing" and appears grey-black in colour. The corrosion resistance of phosphate is superior to black oxide but inferior to cadmium plating or stainless steel. Phosphate can not be applied to stainless steel.

Vapor Degrease/Ultrasonic Clean

This is the standard cleaning and finish for all stainless steels. The process removes oil and other organic compounds from the material surface by use of a chlorinated solvent. The solvent effectively removes oil and grease from the exposed surfaces of the ring or spring. Ultrasonics are used in forcing the solvent to act between the turns of the ring.

Vibratory Deburr/Hand Deburr

Though all circumferential surfaces and edges of Spirolox Rings are smooth, sharp corners are always present on the gap ends due to the cut-off operation. To break the sharp corners, achieving a blended/smooth surface finish, rings may either be vibratory or hand deburred to meet your specifications.

Materials

Specifications

Federal, aerospace and other regulating agencies have prepared several specifications for sheet and strip materials, but few have been published for flat wire.

Smalley procures its material to internally generated specifications. In addition to controlling tensile strength, rigid inspection procedures have been established to check for edge contour, physical imperfections, camber, cross-section and chemical composition.

Ultimate Tensile Strength

To check the spring properties of wire, Ultimate Tensile Strength is the preferred test method over hardness because spring temper flat wire develops different hardnesses at various indentation points.

As a result of cold rolling, the top and bottom surfaces ("A") become harder as they are more severely worked than the round edge areas ("B"). Tensile tests are more consistent as they evaluate the entire crosssection, not a single point as in a hardness test.