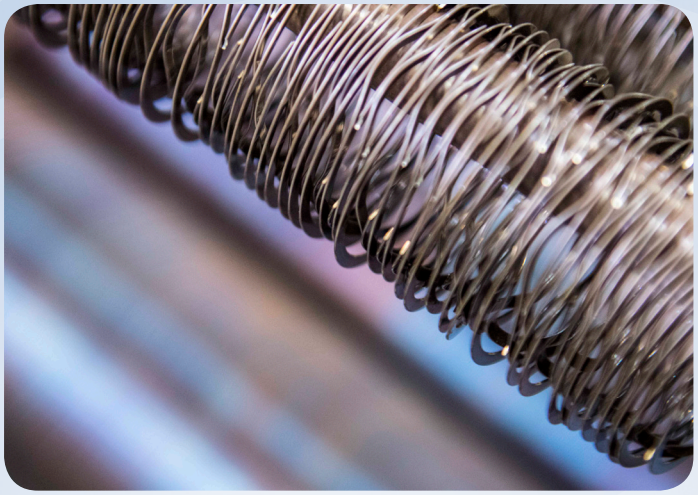
TECHNICAL GUIDE

Material Selection Guide: Key Factors to Consider



- Materials Selection Overview
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SMALLEY®
THE ENGINEER'S CHOICE™

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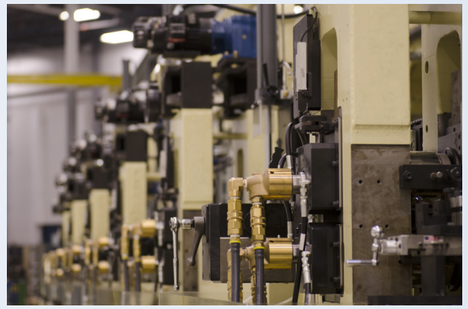
Smalley's raw material warehouse allows us to shorten lead time and go from protyoyping to production volumes quickly. Our finished parts warehouse has thousands of standard parts ready to ship. Now that's vertical integration!



Vertical integration allows Smalley to have quick access to a large variety of raw material to be rolled to flat in-house with any specifications designated by the client.

Choosing the Right Material

Specifying the correct material for your application can prevent additional cost and failure in your operation down the road. Identifying the best suited standard or exotic alloys early in the design process can ensure that you have the right fit for your environment and budget.

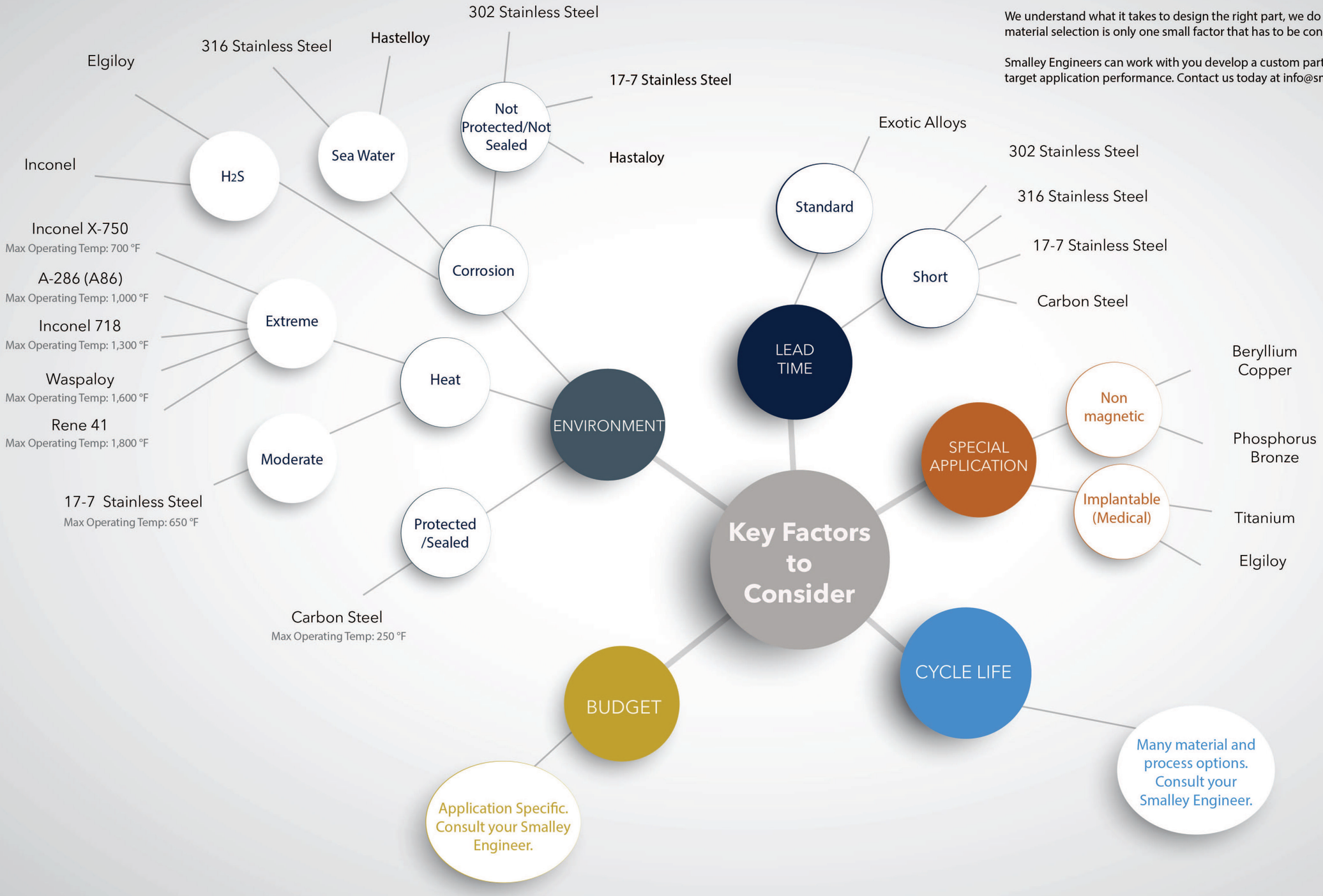
The number of materials offered by Smalley can be slightly intimidating so we developed a quick guide to help you through the process. Having some general knowledge of what is commonly available for use in Smalley flat wire products should also alleviate some questions during the ordering process.

Carbon steel is the most commonly specified material. Stainless steels, although more costly than carbon steel, provide far superior corrosion resistance and have higher temperature operating limits. The five main factors to keep in mind are the following:

1. **Budget**
2. **Cycle Life**
3. **Environment**
4. **Lead Time**
5. **Special Applications**

All of these factors should be determined prior to choosing a material to ensure target application performance, stability and strength.

Material Selection Key



SMALLEY

We understand what it takes to design the right part, we do it everyday! Typically, material selection is only one small factor that has to be considered.

Smalley Engineers can work with you develop a custom part that will help you reach target application performance. Contact us today at info@smalley.com

Materials Table

Material	Material Thickness (in)	Minimum Tensile Strength (psi)	Shear Strength (psi)	Maximum Recommended Operating Temp. (°F)	Modulus of Elasticity (psi)
CARBON STEEL					
OIL TEMPERED SAE 1070 - 1090	.006 - .014	269,000	153,000	250	30 X 10[6]
	.0141 - .021	255,000	145,000		
	.0211 - .043	221,000	126,000		
	.0431 & larger	211,000	120,000		
HARD DRAWN SAE 1060 - 1075	.006 - .030	230,000	130,000		
	.0301 - .110	181,000	103,000		
	.1101 - .220	156,000	89,000		
AISI 302					
AMS-5866	.002 - .022	210,000	119,000	400	28 X 10[6]
	.0221 - .047	200,000	114,000		
	.0471 - .062	185,000	105,000		
	.0621 - .074	175,000	100,000		
	.0741 - .089	165,000	94,000		
	.0891 & larger	155,000	88,000		
AISI 316					
ASTM A313[1]	.002 - .023	195,000	111,000	400	28 X 10[6]
	.0231 - .048	190,000	108,000		
	.0481 - .061	175,000	99,000		
	.0611 & larger	170,000	97,000		
17-7 PH/CH900					
CONDITION CH900 AMS-5529		240,000[2]	137,000[2]	650	29.5 X 10[6]
A-286					
AMS-5810		180,000[2]	105,000[2]	1000	31 X 10[6]
Inconel[5] Alloy X-750					
Spring Temper AMS-5699[3]		220,000[2]	125,000[2]	700	31 X 10[6]
No.1 Temper Rc 35 Maximum AMS-5699[1,3]		136,000 REF	77,000	700	
No.1 Temper AMS-5698		155,000[2]	88,000[2]	1000	
Inconel[5] Alloy 718					
AMS-5596[1]		180,000[2]	102,000[2]	1300	29.6 X 10[6]
Elgiloy[5]					
AMS-5876[1,3]	≤ 0.004	300,000[2]	171,000[2]	800	30 X 10[6]
	.0041 - .019	290,000[2]	165,000[2]		
	.0191 - .025	280,000[2]	159,000[2]		
	.0251 - .100	270,000[2]	154,000[2]		
Beryllium Copper					
Temper TH02 ASTM B197[1]		185,000[2]	128,000[2]	400	18.5 X 10[6]

NOTE: Additional materials available include Phosphor Bronze, C-276, 410 Stainless Steel, MONEL[5] K-500, MONEL[5] 400, Waspaloy and others. Please consult Smalley Engineering 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 Smalley Engineering 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 Types

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 maximized 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 colors including blue, black and gray.

Shown from left to right: Beryllium Copper, Carbon Steel, Stainless Steel, Carbon Steel, Phosphorus Bronze, and Inconel

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-gray color.

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-gray color.

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 650°F (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 color as a result of open-air heat treatment, although atmosphere controlled heat treatment provides a bright color.

Materials Table

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 700˚F. The National Association of Corrosion Engineers (NACE) approves this hard temper to specification MR0175 (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 1000˚F. 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-gray color and exhibit no magnetism.

A286 Alloy

In applications up to 1000˚F, 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-gray color.

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 650˚F and provide over 100% more cycles (in fatigue resistance) than carbon steel, without breakage."

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

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 maximize spring characteristics.

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

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

Finishes

Standard Smalley Finishes		
Type	**Specification**	**Information**
Black Oxide	MIL-DTL-13924, Class 1	Black oxide is intended more for cosmetic appearance than for corrosion resistance.
Zinc Plating	Zinc Plate, ASTM B633, Type V, Fe/Zn 5, SC1 (Colorless) Zinc Plate, ASTM B633, Type VI, Fe/Zn 5, SC1	Zinc plating is used on carbon steel to increase the corrosion resistance of the product. Zinc plating is often used as a cost effective and ecologically friendly alternative to Cadmium plating.
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.
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.
Zinc Phosphate		This finish is sometimes referred to as "Parkerizing" and appears gray-black in color.
Vapor Degrease/ Ultrasonic Clean	MIL-DTL-16232, Type Z, Class 2	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.
Vibratory Deburr/Hand Deburr		This process is completed to break the sharp corners and achieve a blended/ matte finish.

Want to learn more? We would love to hear from you.

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The Smalley Advantage

By being an industry leader in the retaining ring field Smalley is at the forefront of innovation and design. Our approach of offering performance, cost-effectiveness, and convenience is something that can only benefit the ultimate success of a project. With custom engineering services also available Smalley has the retaining ring solution for almost any application.

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