Smalley®
Steel Ring Company

50 FIFTY YEARS

SMALLEY WAVE SPRINGS

SPIROLOX RETAINING RINGS

CONSTANT SECTION RINGS

STOCK SIZES | Over 10,000 Standards
Carbon & Stainless Steel

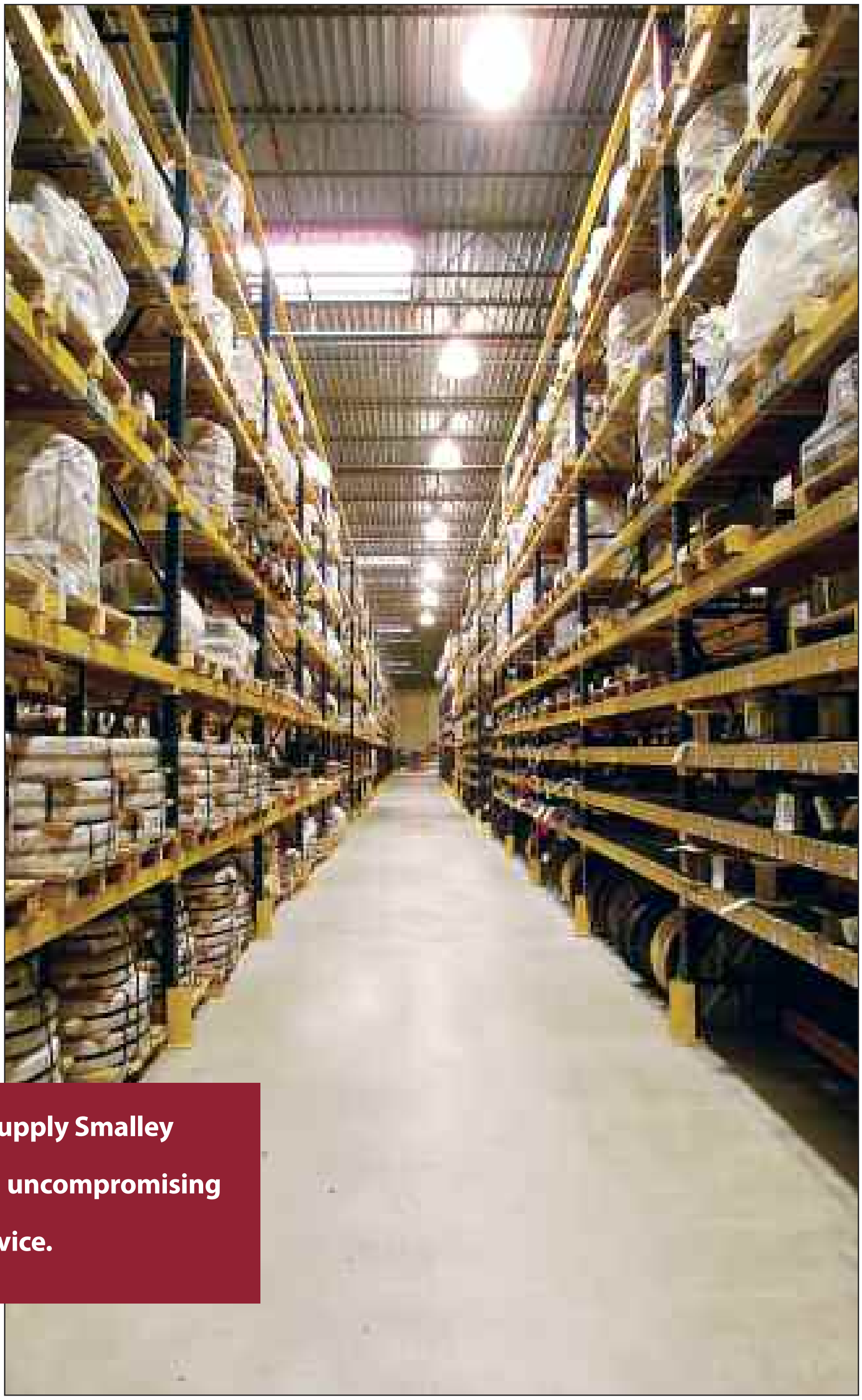
SPECIAL DESIGNS | .200" to 120"
5 mm to 3,000 mm
No-Tooling-Charges™

ENGINEERING & PARTS CATALOG

www.smalley.com
847.719.5900
info@smalley.com

Raw Material

As we meet the increasing demand for more raw material sizes, the flat wire rolling mill operation in our plant continues to grow. Years ago, Smalley began a vertical integration that has evolved into the production of hundreds of material cross-sections in a wide variety of alloys.



Our goal… to supply Smalley customers with uncompromising quality and service.

Manufacturing

Edgewinding, also known as "The No-Tooling-Cost Process", is our precision forming operation that coils pre-tempered flat wire on edge to create a near-perfect circle. (Visualize a Slinky®, the coiled metal toy which has delighted generations of children.) Circular-Grain metallurgy gives our products strength and stability far superior to that of conventional retaining rings and wave washers which are simply stamped through the metal grain. Smalley edgewound products can be coiled to your exact specification in any diameter and with any number of turns (layers or coils), effectively eliminating material waste.

As flexible as it is precise, our edgewinding process accommodates your design changes without the need for additional tooling and die modifications. This facilitates your developmental work, allowing us to produce your low-quantity custom orders and your working prototypes quickly and economically. Even after your initial prototype is produced, or in mid-stream production, our edgewinding process allows us to alter your design or dimensions with simple machine adjustments or a change in raw material size. After the revised specifications are approved, we complete and document the final setup. Then, we quickly resume production of your order, whether it consists of one part or one million.

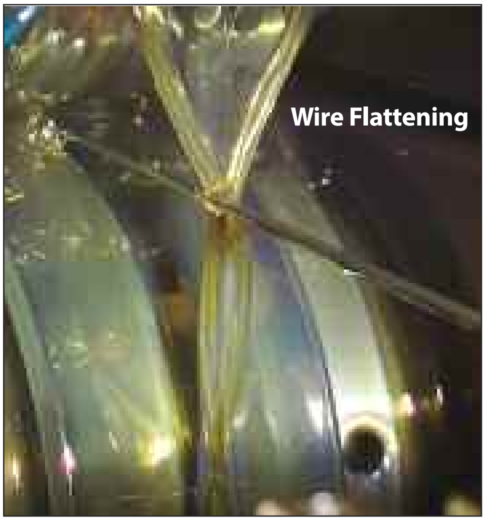

Edgewinding Process


Conventional Stamping Process

Prototypes

About the easiest way to test a theoretical design is to produce a working prototype — a task at which Smalley excels. A prime example is the development of a custom wave spring. We can adjust dimensions, by changing the number of waves and the number of turns, and trying different combinations of spring variables. Finally, we test for function, before production, so we know we have it right.

Smalley-produced prototypes are also the most economical way to provide results on a trial-and-error basis. From one to a thousand pieces, we can produce, try, modify, and reproduce your design as often as necessary — all without special tooling costs.


Wire Flattening

Finished Parts Warehouse

Smalley maintains a substantial parts inventory of every cataloged/standard retaining ring and wave spring — in both carbon and stainless steel. We do this to meet our JIT deliveries as well as any immediate requirement that you may have. In the rare circumstance that our inventory runs low, we can quickly replenish any item overnight.

In addition to our finished parts, we house a vast inventory of raw material sizes, stocked in thousands of pounds of flat wire. We are always ready to meet your needs for a quick turnaround in low to high quantities of existing or new designs.

Free

Need a Sample?

We offer free samples of any ring or spring found in our catalog.
See page 138.

Customer Service

Smalley is dedicated to giving you the most positive, efficient and economical service possible, each and every day. We continually train our staff on every important aspect of our business. We can split shipments to suit your "just-in-time" delivery requirements. We offer you lower prices for your annual higher-usage orders. Please contact us directly for complete details and ideas on how you can purchase economically.

General Sales Information

Description:

The product descriptions in this catalog are intended to provide the user with practical information for application selection. Since it is not possible to include complete detail on all parts, please contact Smalley for any information not included in the description which may be critical for a specific application.

Quotations:

We will provide written or verbal quotations as requested.

Returns:

Parts not stocked which must be specially manufactured are not returnable except by special arrangement and will be subject to cancellation charges. Stocked parts may be returned for credit at a standard restocking charge (subject to condition). All returns of stocked parts must be made within 30 days from date of receipt of material.

Delivery:

Parts carried in stock normally will be shipped within 48 hours after receipt of an order. Special parts are normally delivered in 3 weeks (if no special processes are required) or as previously arranged.

Certifications:

Standard Certificate of Conformance will be supplied at no charge. Material and other Certifications for plating, load, etc. will be furnished as quoted.

Transportation:

As specified by the customer. In the absence of instructions, the shipping method will be selected by us. Insurance will be provided only at the customer's request.

Terms:

1/10/NET 30 on open accounts. For consideration of an open account, customers are requested to supply banking information and at least 3 commercial credit references.

Go to **www.smalley.com** for Terms and Conditions, which apply.

F.O.B.:

Factory, Lake Zurich, Illinois, USA

Packaging:

Rings and springs 1$\frac{5}{16}$" in diameter and under are bulk packaged. Rings and springs 1$\frac{3}{8}$" and over in diameter are generally tube (coin) packaged in lengths 10 to 18 inches.

Smalley is the proud recipient of the GM Quality Excellence Award and the GM Supplier of the Year Award.

Engineering & Design Assistance

Smalley's engineering staff is always ready to address your application requirements. Usually, the sooner we are able to review what you need, the easier the solution will be. Please call us today.

We invite you to draw upon our resources. Over the years, Smalley engineers have built an extensive library of over 25,000 applications while designing rings and springs in mechanical components and assemblies. In addition, we offer computer-aided spring-design alternatives to meet your specifications.

There are many more options that we would be pleased to review with you once your design criteria are established. We are ready to help you with the selection of a standard part from our vast inventory, or to modify a standard part to meet your exact needs.

We are pleased to offer you additional step-by-step resources. The "Special Designs" section of this catalog will help you determine basic retaining ring and wave spring specifications. We also invite you to try the design section on our website for step-by-step interactive design guidelines and options. As you can see, we are well-equipped to help you develop the best design solution possible, just as we have for thousands of other companies in diverse industries.

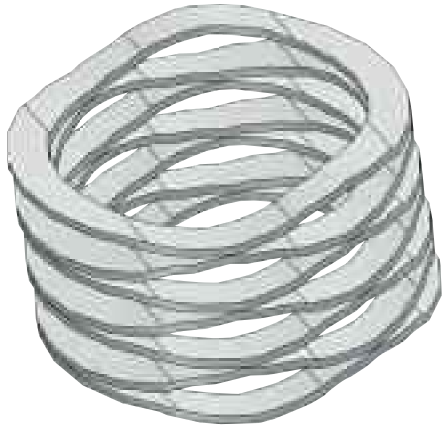
Specials

At Smalley, specials are standard. It's easy to get a custom part from Smalley. With No-Tooling-Charges, die costs, or other fixture charges, we can manufacture a new ring or spring design in just two weeks or to meet your delivery schedules.

Fast, precise, and economically — that's how Smalley produces rings and springs, in short runs or high volumes. If you can't find a standard part to meet your needs from the wide selection in our catalog, please contact our engineering department for immediate assistance with your special design requirements. And please note: Smalley Rings and Springs are available from .200" to 120" in diameter.

CAD Downloads

Visit our website for CAD downloads in 90 different formats. It's easy to search and select a standard part for a quick upload to your computer.



Quality Policy

Smalley has established, and is continuously improving upon, a program that is designed to meet the following objectives:

- **Total product conformance in terms of drawings, specifications and contractual requirements.**
- **100% on-time delivery performance.**
- **Superior products with exceptional value.**
- **Prompt, professional and courteous response in every facet of design, manufacturing, sales, and customer service.**
- **Continued development and use of the latest technology.**

Quality Assurance

Smalley's Total Quality Management philosophy dictates our commitment to quality and customer satisfaction. While this commitment has earned us official certification (ISO 9001, ISO/TS 16949, AS 9100 and ISO 14001), quality assurance and customer satisfaction mean much more at Smalley. They are tradition; the very foundation upon which we have built our company. From the beginning, we have never lost sight of our goal: "to supply Smalley customers with uncompromising quality and service."

Smalley is committed to a quality policy that requires conformance to specification with controlled lot variation about the target, statistical quality control, defect prevention, and annual improvement in process and product. This is a company-wide commitment involving every Smalley employee. Each person works towards excellence, individually and cooperatively, to provide superior products and services.

A history of quality and strict compliance with military and aerospace standards has earned Smalley an approved supplier status with many leading original equipment manufacturers worldwide. Smalley has worked diligently to become their preferred source for Spirolox Retaining Rings and wave springs.

In accordance with the requirements of ISO 9001, ISO/TS 16949, AS 9100 and ISO 14001, we have established and are continuously improving our quality systems. Use of the latest technology, including statistical tools, has helped us achieve and maintain the world-class quality associated with the Smalley name for more than 50 years.

Smalley uses statistical quality control tools to assure the capability and stability of our coiling process. To begin with, we identify common dimensions to monitor and special causes of variation in the product. Then, we collect and analyze data on these critical dimensions. We perform disciplined sampling and take measurements during in-line and final inspection, and yet again, during pre-shipping inspection.

We make formal SQC in-house training programs mandatory for many Smalley employees involved with manufacturing.

This training has noticeably developed quality awareness and responsibility at all levels. Our employees have a clear understanding of what is expected, a means of regulating their processes and checking their output, and statistical tools to determine when machine adjustments are required.

Smalley's machine capability studies help us identify sources of variation before they become a problem. We analyze the capabilities of all production machinery in primary and secondary operations, heat treating, and finishing. In addition, we follow our own meticulous procedures to determine the reproducibility and repeatability of our gauging systems.

Due to the careful documentation of our quality, many Smalley customers have found that they can reduce or even eliminate their incoming inspections of our product. Many of our accounts have also revised their policy of dual sourcing and confidently rely on Smalley as their single source of Spirolox Retaining Rings, wave springs, constant section rings, linear springs and other wire forms.

Defect prevention, or near-zero defects, is a key goal at Smalley. We use the latest automated inspection techniques to monitor production. As a result, we are constantly studying the causes of variation, improving upon and developing processes with capability indexes (Cpk) exceeding 1.33.

Continuous improvement is an integral part of Smalley's quality plan. We require each of our departments to design and implement projects to improve their respective systems.

All Springs Are Not Equal®

Smalley Wave Springs offer the unique advantage of space savings when used to replace coil springs. By reducing spring operating height, wave springs also produce a decrease in the spring cavity. With a smaller assembly size and less material used in the manufacturing process, a cost savings is realized.

Wave springs operate as load bearing devices. They take up play and compensate for dimensional variations within assemblies. A virtually unlimited range of forces can be produced whereby loads build either gradually or abruptly to reach a predetermined working height. This establishes a precise spring rate in which load is proportional to deflection.

Functional requirements are necessary for both dynamic and static spring applications. Special performance characteristics are individually built into each spring to satisfy a variety of precise operating conditions. Typically, a wave spring will occupy an extremely small area for the amount of work it performs. The use of this product is demanded, but not limited to tight axial and radial space constraints.

SMALLEY WAVE SPRING COIL SPRING

Product Performance

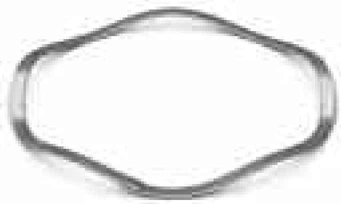
With their smooth, circular coiled sinusoidal wave form, and rolled round edges of pre-tempered raw material, Smalley's edgewound Wave Springs offer many advantages over die stamped products.

Loads and spring rates are more accurate, more predictable, and may be toleranced better than 50 percent tighter than stampings. The force of a Smalley Wave Spring will increase at a uniform rate throughout most of its available deflection.

By any criteria, Smalley Wave Springs offer their users higher dependability and better performance. Since they are produced from full hard, pre-tempered raw material, there is no risk of distorting the spring during a hardening heat treatment. By contrast, subsequent manufacturing procedures for stamped wavy washers can lead to problems such as fatigue cracking and inaccurate or inconsistent loading between springs. All told, the metallurgy, the mechanical properties and the uniform dimensional stability of the Smalley edgewound Wave Spring provide a component for precision quality applications.

Wave Spring Types

Gap Type Wave Spring



Overlap Type Wave Spring

Gap & Overlap Type

Conventional Gap and Overlap Type Wave Springs are used in a wide variety of applications. For short deflections and low-medium forces, they function with precision and dependability.

These two types of Smalley Wave Springs permit radial expansion or growth in diameter within a cavity, without the binding or hang-up normally associated with die stamped wave washers. Just as their terms imply, the gap type is split to retain a gap between the ends, while the overlap type has overlapping ends. Thus, the ends are free to move circumferentially as the spring outside diameter grows during compression.

For example, the O.D. of a Gap Type Wave Spring would fit .020 loose per side in a bore. Its I.D. clears a shaft by .010 per side. As the spring is deflected, the O.D. and I.D. grow larger until the O.D. contacts the bore. Continued deflection causes the gap ends to move closer together while the O.D. presses against the bore. An Overlap Type Wave Spring permits this type of cycling action in a similar manner.

Crest-to-Crest®

Crest-to-Crest Wave Springs are prestacked in series, decreasing the spring rate proportionally to the number of turns. Uses are typically applications requiring low-medium spring rates and large deflections with low-medium forces. Among major advantages, this design eliminates the need to keep the wave crests aligned. The need to use a key locating device, or to insert a shim between individual springs is not necessary. Because the spring is integrally formed, the wave peaks hold their configuration.

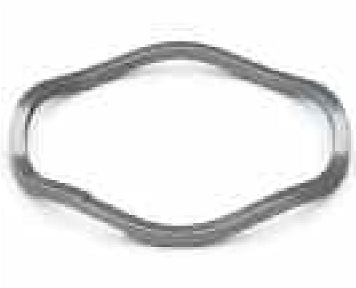
As a replacement for helical compression springs, Crest-to-Crest springs can develop similar forces, yet occupy one-half (½) or less the axial space. This allows for strict space constraints. Crest-to-Crest Wave Springs will maintain the same force and load specifications of a conventional round wire spring, but with the advantages of resultant lowered and compacted operating heights, free heights, and solid heights.

continued

Wave Spring Types (cont'd)

Crest-to-Crest with Optional Shim Ends

Crest-to-Crest Wave Springs are also available with squared-shim ends. Shim ends provide a 360˚ contact surface when compared to the wave point contact of plain ends. The shim-ends, under load, more evenly distribute the spring's force upon adjacent components. This feature is similar to the concept of double-disc grinding springs for a flat surface. Shim ends have also been used to affix springs to mating components, as a flat locating surface that may be attached by various methods in the assembly.

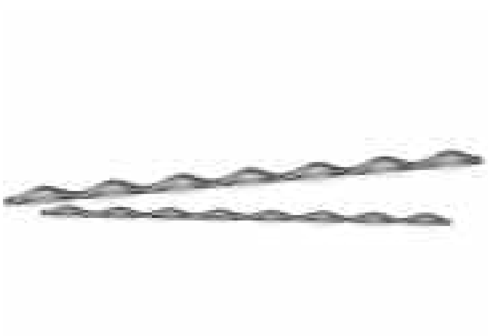


Nested

Nested Wave Springs are pre-stacked in parallel from one continuous filament of flat wire. The need to stack individual springs for higher loads is no longer necessary. Nested springs result in a spring rate that increases proportionally to the number of turns. They can exert tremendous forces, yet maintain the precision of a circular-grain wave spring. In many applications, Nested Wave Springs replace Belleville Springs, particularly in cases where a high but accurate force is needed.

WAVO®

Wavo Springs are produced from round-section wire to provide higher loads while maintaining the accurate loading found in wave springs. As an alternative to Belleville Springs, the Wavo provides similar loads but with an accurate, predictable spring rate.



Linear Springs

Linear springs are a continuous wave formed (marcelled) wire length produce from spring tempered materials. They act as a load bearing device having approximately the same load/deflection characteristics as a wave spring.

Forces act axially or radially depending on the installed position. Axial pressure is obtained by laying the spring flat in a straight line. Circular wrapping the spring produces a radial force or outward pressure. Linear springs are available cut to length or as a continuous coil, for the user to cut as needed.

Smalley® Steel Ring Company

Wave Spring Applications

A. Pressure Relief Valve

B. Face Seal

C. Clutch Drive

D. Bayonet Connector

E. Multi-Tooth Cutter

A. Pressure Relief Valve

An exact load applied to the top sealing plate was accomplished using a flat wire wave spring. Air pressure entering the top slots forces the plate away from the sealing surface providing the pressure relief mechanism.

B. Face Seal

Wave Spring applies pressure, to precisely load the carbon face against a mating surface, to properly seal fluids. The spring operates over a fixed working range and provides an exact force, unlike the stamped wavy washer it replaced which could not maintain the necessary spring rate.

C. Clutch Drive

Pressure on the round belt is produced by compressing the Wavo Spring through the sheave halves. The top threaded cap rotates to adjust the Wavo compression. The Wavo can produce a high force in a tight radial cavity.

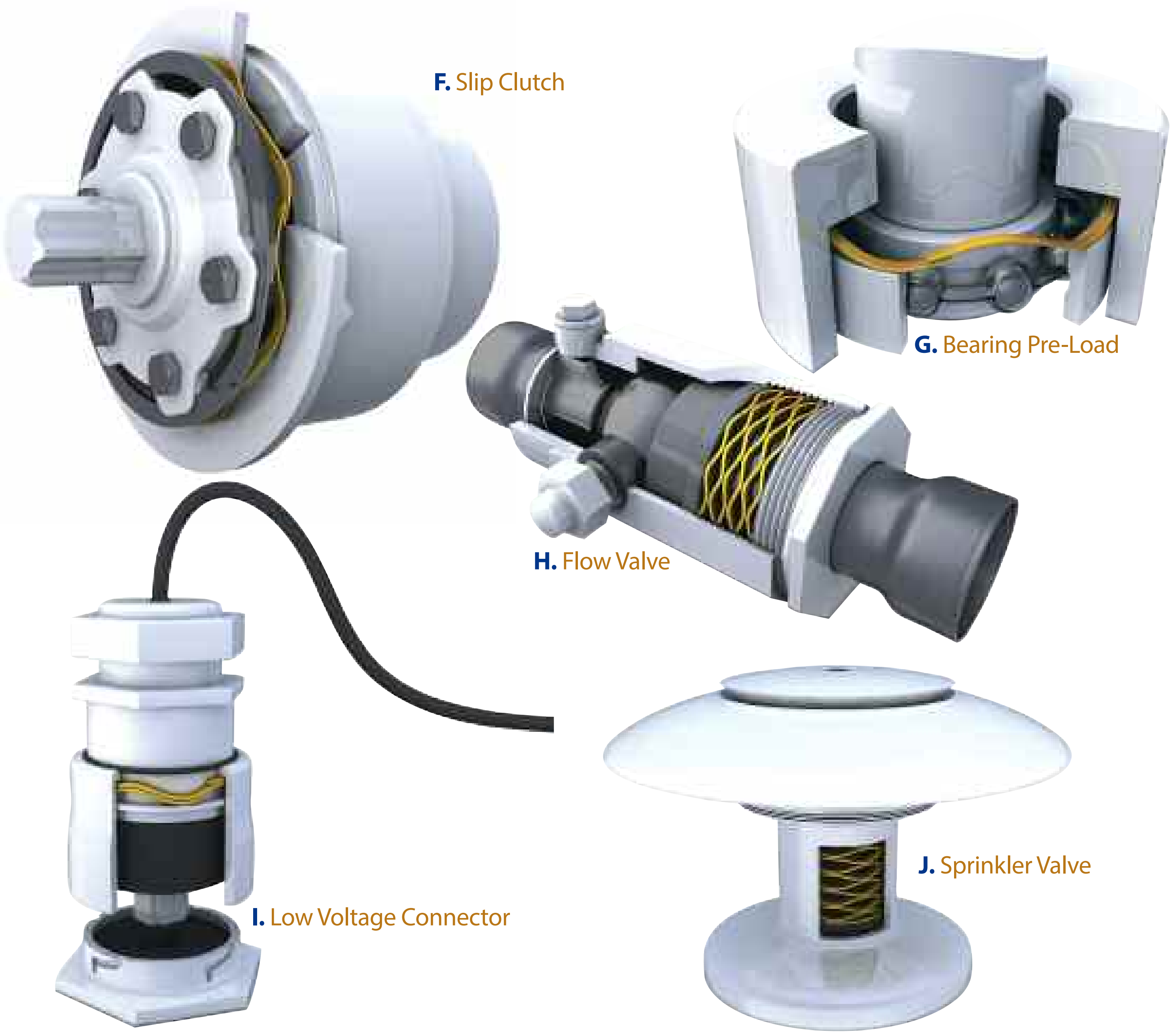
D. Bayonet Connector

Overlap Type Wave Spring installed in an electronic connector assembly. As male and female components are rotated together into final assembly, the wave spring is compressed to its working height. In this position it exerts a constant force that locks both components together.

E. Multi-Tooth Cutter

A custom designed wave spring with locating tabs is contained in the housing. The spring applies a precise force to the two cutter halves, allowing them to oscillate but not rattle.

Wave Spring Applications



F. Slip Clutch
Clutch drives when the “V"-detents are in the “V”-slots. A Smalley Wave Spring maintains pressure to hold this position. As torque is increased, the “V”-detents will ride up and out the “V”-slots, depressing the wave spring and developing the slip mechanism. When torque is decreased, the wave spring forces the “V”-detents firmly into the “V”-slots to drive again.

G. Bearing Pre-Load
One of the most common wave spring applications world-wide is a bearing preload arrangement as illustrated. Having the proper load will often extend bearing life by lowering operating temperatures, reducing vibration, minimizing wear and providing for quieter and smoother performance.

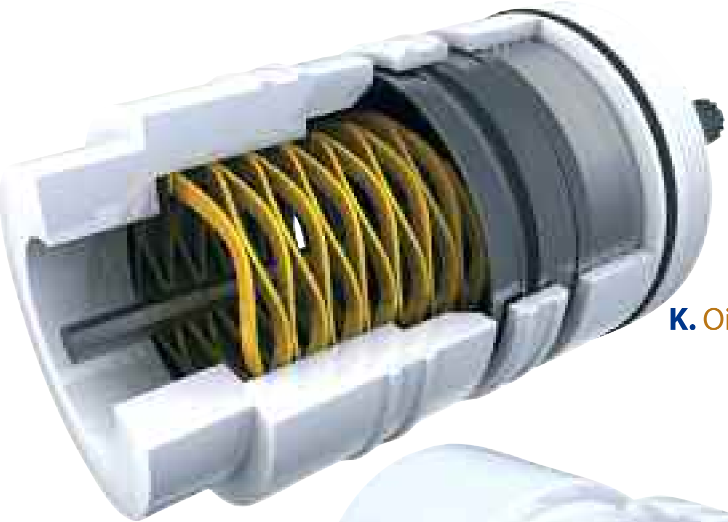
H. Flow Valve
As fluid pressure increases the Crest-to-Crest Wave Spring precisely controls the linear displacement of the piston, which positions the orifice for proper fluid flow. Because of the space savings of the Crest-to-Crest design, the valve can be made smaller.

I. Low Voltage Connector
A Bayonet Connector couples as the male end rotates and follows the groove contour in the female end. A 2-Turn Nested Spirawave Wave Spring provides the pre-load between the two halves. A 2-Turn Nested Spring was necessary to develop a higher load in very tight radial and axial space.

J. Sprinkler Valve
With height restrictions accounted for, the Smalley Crest-to-Crest Wave Spring maintains constant pressure on the pop-up head, holding it firmly closed. In operation, water pressure releases the head by overcoming the spring’s force.

Smalley Steel Ring Company

Wave Spring Applications

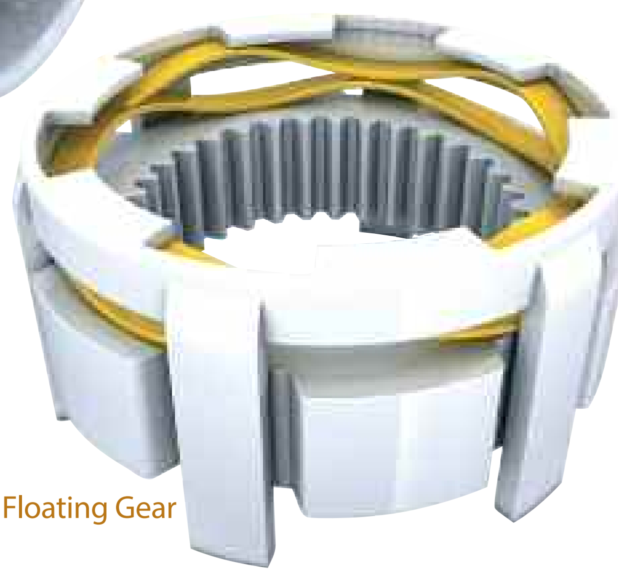


K. Oil Valve

L. Ball Valve

M. Quick Disconnect

N. Vibration Isolator



O. Floating Gear

K. Oil Valve

The force provided by the Crest-to-Crest Wave Spring in this oil valve application precisely regulates the amount of oil that is released. The Crest-to-Crest spring provides accurate resistance in a small space, allowing the overall size of the valve to be greatly reduced.

L. Ball Valve

A Smalley Crest-to-Crest Wave Spring is used to reduce the overall spring height in this application. The wave spring allows the seat to oscillate on the ball, keeping a tight seal in the operating position. The reduction in spring height and resulting smaller spring cavity also reduce the weight of the valve.

M. Quick Disconnect

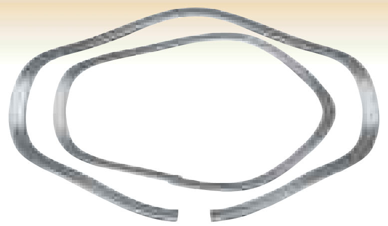
The sliding member of the disconnect is held in its forward/locked position against the retaining ring, by the Crest-to-Crest Spring. As the user slides the member in the opposite direction compressing the spring, the detent balls align with a groove and release.

N. Vibration Isolator

Wavo Springs provide high force and a relatively large axial displacement, in limited space. The springs are arranged in series for additional travel.

O. Floating Gear

Functioning in a contained bracket, a Crest-to-Crest Wave Spring loads a gear with light force allowing axial movement. The gear shown self-aligns with its mating gear during operation.



Stock Items in carbon steel and 17-7 PH stainless steel. Springs listed below are 3 wave, **Overlap Type.**

Smalley Part Number [1,4]	Operates in Bore Diameter	Clears Shaft Diameter	Load (lb)	Work Height	Free Height [2]	Number of Waves	Thickness	Radial Wall	Spring Rate [3]
SSR-0050	.500	.390	7	.050	.085	3	.008	.040	200
SSR-0062	.625	.480	10	.050	.095	3	.010	.058	222
SSR-0075	.750	.500	14	.062	.160	3	.010	.078	143
SSR-0087	.875	.620	16	.062	.130	3	.012	.094	235
SSR-0100	1.000	.780	18	.062	.160	3	.012	.094	184
SSR-0112	1.125	.840	20	.078	.130	3	.016	.133	385
SSR-0125	1.250	.960	22	.078	.150	3	.016	.133	306
SSR-0137	1.375	1.090	24	.078	.190	3	.016	.133	214
SSR-0150	1.500	1.170	26	.078	.170	3	.018	.143	283
SSR-0162	1.625	1.310	28	.078	.200	3	.018	.143	230

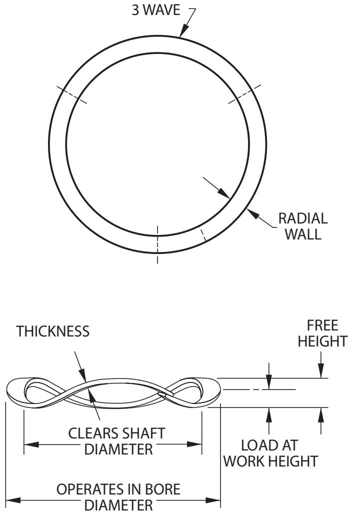
[1] Add suffix "-S17" for 17-7 stainless steel.
[2] Reference dimension.
[3] Theoretical dimension; measured in lb/in.
[4] See pages 134-135 for How to Order.

OVERLAP TYPE

SSR-0050 to SSR-0162

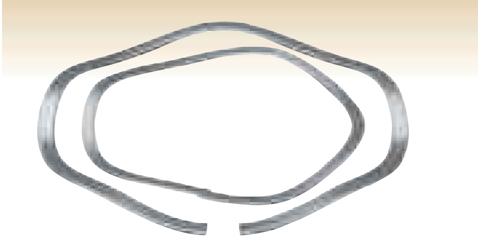
Product Dimensions

All dimensions in inches unless otherwise specified.



Bayonet Connector

Stock Items in carbon steel and 17-7 PH stainless steel. Springs listed below are 4 waves and up, **Gap Type.**



Smalley Part Number [1,4]	Operates in Bore Diameter	Clears Shaft Diameter	Load (lb)	Work Height	Free Height [2]	Number of Waves	Thickness	Radial Wall	Spring Rate [3]
SSR-0175	1.750	1.440	30	.078	.140	4	.018	.143	484
SSR-0187	1.875	1.560	32	.078	.150	4	.018	.143	444
SSR-0200	2.000	1.680	34	.093	.140	4	.024	.150	723
SSR-0212	2.125	1.800	36	.093	.150	4	.024	.150	632
SSR-0225	2.250	1.930	38	.093	.170	4	.024	.150	494
SSR-0237	2.375	1.990	40	.093	.160	4	.024	.178	597
SSR-0250	2.500	2.120	42	.093	.170	4	.024	.178	545
SSR-0262	2.625	2.240	44	.093	.190	4	.024	.178	454
SSR-0275	2.750	2.340	46	.109	.170	4	.030	.188	754
SSR-0287	2.875	2.470	48	.109	.180	4	.030	.188	676
SSR-0300	3.000	2.590	50	.109	.190	4	.030	.188	617
SSR-0312	3.125	2.710	52	.109	.210	4	.030	.188	515
SSR-0325	3.250	2.750	54	.109	.200	4	.030	.233	593
SSR-0337	3.375	2.840	56	.109	.220	4	.030	.233	505
SSR-0350	3.500	3.000	58	.109	.230	4	.030	.233	479
SSR-0362	3.625	3.120	60	.109	.240	4	.030	.233	458
SSR-0375	3.750	3.250	62	.109	.260	4	.030	.233	411
SSR-0387	3.875	3.370	64	.109	.300	4	.030	.233	335
SSR-0400	4.000	3.500	66	.109	.190	5	.030	.233	815
SSR-0412	4.125	3.620	67	.109	.200	5	.030	.233	736
SSR-0425	4.250	3.740	69	.109	.210	5	.030	.233	683
SSR-0437	4.375	3.860	70	.109	.210	5	.030	.233	693
SSR-0450	4.500	3.990	72	.109	.230	5	.030	.233	595
SSR-0462	4.625	4.110	73	.125	.270	5	.030	.233	503
SSR-0475	4.750	4.240	75	.125	.310	5	.030	.233	405
SSR-0487	4.875	4.370	76	.125	.290	5	.030	.233	461
SSR-0500	5.000	4.490	78	.125	.310	5	.030	.233	422
SSR-0512	5.125	4.610	80	.125	.340	5	.030	.233	372
SSR-0525	5.250	4.740	82	.125	.370	5	.030	.233	335
SSR-0537	5.375	4.860	84	.125	.380	5	.030	.233	329
SSR-0550	5.500	4.990	86	.125	.250	6	.030	.233	688
SSR-0562	5.625	5.110	88	.125	.270	6	.030	.233	607
SSR-0575	5.750	5.240	90	.125	.280	6	.030	.233	581
SSR-0587	5.875	5.360	92	.125	.300	6	.030	.233	526
SSR-0600	6.000	5.490	94	.125	.300	6	.030	.233	537
SSR-0612	6.125	5.610	96	.125	.310	6	.030	.233	519
SSR-0625	6.250	5.730	98	.125	.340	6	.030	.233	456
SSR-0637	6.375	5.860	100	.125	.350	6	.030	.233	444
SSR-0650	6.500	5.980	102	.125	.390	6	.030	.233	385
SSR-0675	6.750	6.230	104	.125	.420	6	.030	.233	353
SSR-0700	7.000	6.160	106	.156	.320	6	.032	.375	646
SSR-0725	7.250	6.440	108	.156	.350	6	.032	.375	557
SSR-0750	7.500	6.690	110	.156	.360	6	.032	.375	539
SSR-0775	7.750	6.940	114	.156	.380	6	.032	.375	509
SSR-0800	8.000	7.190	118	.156	.390	6	.032	.375	504
SSR-0825	8.250	7.440	122	.156	.430	6	.032	.375	445
SSR-0850	8.500	7.680	126	.156	.340	7	.032	.375	685
SSR-0875	8.750	7.930	130	.156	.340	7	.032	.375	707
SSR-0900	9.000	8.180	134	.156	.290	8	.032	.375	1,000
SSR-0950	9.500	8.680	142	.156	.240	9	.032	.375	1,690
SSR-1000	10.000	9.170	150	.156	.290	9	.032	.375	1,119
SSR-1050	10.500	9.670	158	.156	.310	9	.032	.375	1,026
SSR-1100	11.000	10.170	166	.156	.350	9	.032	.375	856
SSR-1150	11.500	10.660	174	.156	.360	9	.032	.375	853
SSR-1200	12.000	11.160	182	.156	.440	9	.032	.375	641
SSR-1250	12.500	11.660	190	.156	.350	10	.032	.375	979
SSR-1300	13.000	12.160	198	.156	.410	10	.032	.375	780
SSR-1350	13.500	12.650	206	.156	.430	10	.032	.375	752
SSR-1400	14.000	13.150	214	.156	.300	12	.032	.375	1,486
SSR-1450	14.500	13.650	221	.156	.320	12	.032	.375	1,348
SSR-1500	15.000	14.130	230	.156	.350	12	.032	.375	1,186
SSR-1550	15.500	14.640	239	.156	.310	13	.032	.375	1,552
SSR-1600	16.000	15.140	248	.156	.340	13	.032	.375	1,348

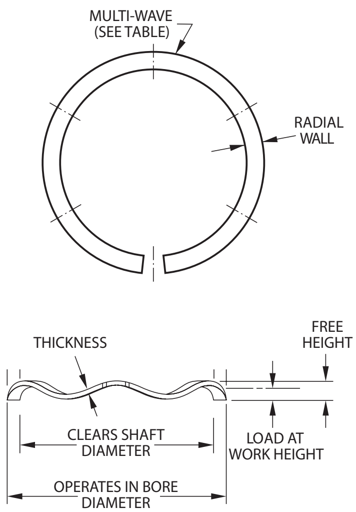
[1] Add suffix "-S17" for 17-7 stainless steel.
[2] Reference dimension.
[3] Theoretical dimension; measured in lb/in.
[4] See pages 134-135 for How to Order.

GAP TYPE

SSR-0175 to SSR-1600

Product Dimensions

All dimensions in inches unless otherwise specified.



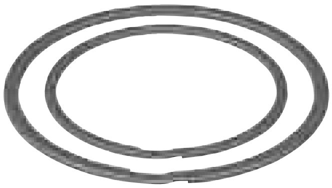
Advantages of Spirolox® Retaining Rings

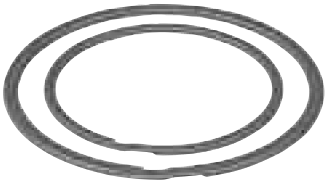
Spirolox Retaining Rings have No Ears to Interfere in your assembly! Spirolox Rings are manufactured by coiling the ring from flat wire. This unique process produces a retaining ring that has no protruding ears or burrs to interfere with your assembly. Because coiling produces a retaining ring with no scrap, the Spirolox Ring can be economically produced in carbon steel, stainless steel, coppers, and many other alloys.

Smalley offers over 6,000 standard parts, which are readily available in both carbon and stainless steel. If you require special designs, take advantage of Smalley's No-Tooling-Cost process; a process perfect for large runs, prototypes and midstream design changes. Whatever your application, Smalley has the cost-effective and innovative design solution.

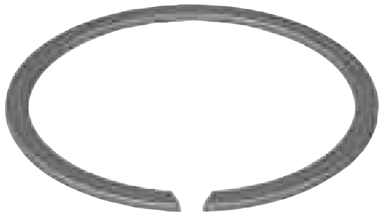
Spirolox Retaining Rings offer many advantages over stamped retaining rings

- No gap - 360˚ retaining surface
- No protruding ears to interfere with mating components (uniform cross-section)
- Economically produced in stainless steel because the coiling process produces no scrap
- **No-Tooling-Charge** on special designs
- Easy installation and removal





Other Ring Types & Special Designs

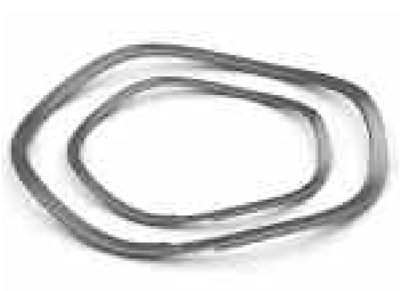


Constant Section Rings

Another popular choice of retaining ring configurations is the well known Constant Section Ring. Produced by edgewinding with no special tooling charges, Constant Section Rings have been specified for many years in the automotive and heavy equipment industries as a standard choice of engineers.

Smalley has hundreds of standard Constant Section Rings in stock, in carbon steel and stainless steel and in both inch and metric sizes. Special or custom designs can be produced quickly and economically utilizing Smalley's precision No-Tooling-Cost manufacturing process.

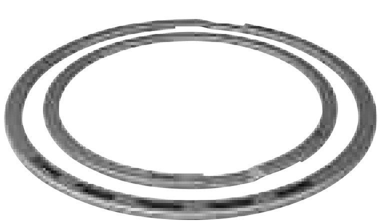
Constant Section Rings can withstand high forces and impact loads and are easily installed and removed from their internal or external groove for field servicing your product.



WAVERING®

The WaveRing is a spiral retaining ring with an axial wave form. It acts like a standard retaining ring with the additional feature of compressibility. It compensates for the overall length tolerance of stacked components, while still acting as a retaining ring. Once assembled the WaveRing will reduce looseness and vibration in the assembly.

Designed to fit into a groove, the WaveRing applies pressure in two directions: against the groove wall and against the assembly components. Single, double or multiple turns in the WaveRing are possible as well as a choice of materials, including our standard 17-7 PH stainless and carbon steel.



Special Rings

A major segment of Smalley manufacturing is in "special" or prototype retaining rings. Common Smalley specials include balanced, multi-turn (4,5,6 turns and more) and special ends in diameters from .200 in – 120 in (5 mm – 3,000 mm) and larger. Smalley engineers are on hand to help you design a ring specific to your application. Because there are no tooling costs, no job is too big or too little. Prototypes can be quickly and economically produced to test a design; in days, not weeks.

Retaining Ring Selection Guide

1

STEP 1: Do you need to meet any specifications?

YES | **NO**

Specification	Smalley Series
Military MIL- DTL-27426/3	WH
Military MIL- DTL-27426/1	WS
Military MIL- DTL-27426/4	WHM
Military MIL- DTL-27426/2	WSM
Aerospace AS4299, AS3217, AS3219	WH
Aerospace AS4299, AS3218, AS3219	WS
Aerospace AS4299, AS3215, AS3219	WHM
Aerospace AS4299, AS3216, AS3219	WSM
Metric Aerospace MA 4017	EH
Metric Aerospace MA 4016	ES

2

STEP 2: Do you need to match an alternative ring groove?

YES | **NO**

Manufacturer	Smalley Series
Truarc N5000 & 5008	WHM
Truarc 5100 & 5108	WSM
Eaton NAN	WHT
Eaton XAN	WST
Eaton I-N	WHM
Eaton E-N	WSM
Industrial RR 3000 & 4000	WHM
Industrial RR 3100 & 4100	WSM
Anderton N1300	WHM
Anderton N1400	WSM
Anderton D1300	DNH
Anderton D1400	DNS
European Specification DIN 472	DNH
European Specification DIN 471	DNS

3

STEP 3A: Choose by the Thrust Capacity needed OR see step 3B

Standard Units (inches)

Series	Load [1]	Housing	Shaft
Light Duty	4100	VH	VS
Medium Duty	4950	WH	WS
Medium Heavy Duty	7070	WHT	WST
Heavy Duty	8340	WHM	WSM
Constant Section Rings	8341	FHE	FSE
WaveRing	—	WHW	WSW

[1] Representative example shows the load capacity (lb) for a 2" ring.

Metric Units (mm)

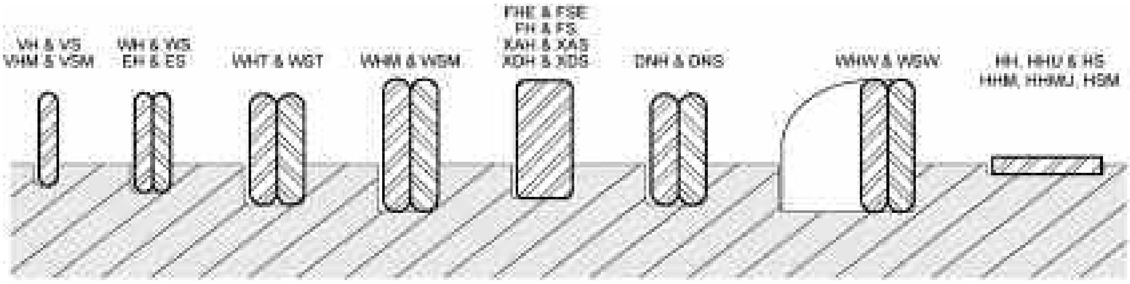
Series	Load [1]	Housing	Shaft
Light Duty	18.03	VHM	VSM
DIN Series [2]	36.55	DNH	DNS
Aerospace Series	38.96	EH	ES
Constant Section Rings	36.53	FH	FS

[1] Representative example shows the load capacity (kN) for a 50 mm ring.
[2] Manufactured to DIN groove specifications.

STEP 3B: Still not sure?
Use Smalley's most popular series, Medium Duty WH (internal) or WS (external).
Ask for a free sample.

Relative proportions of rings in grooves

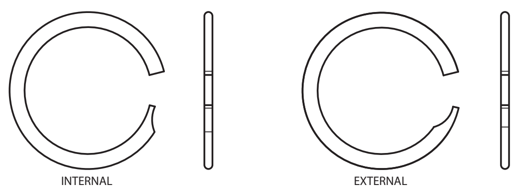
A cross-section of each Spirolox Retaining Ring configuration is illustrated, comparing groove and ring sections in the same diameter bore or shaft. The heavier retaining ring cross-sections are in deeper and wider grooves, to provide significantly greater thrust capacity.



Ring Types

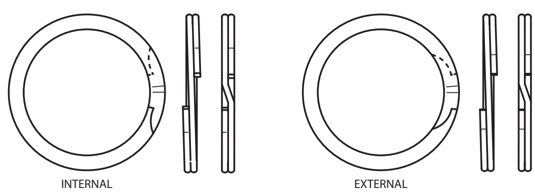
Spirolox Retaining Rings—Single Turn (1-Turn)

VH & VS — Light Duty, inch
VHM & VSM — Light Duty, metric



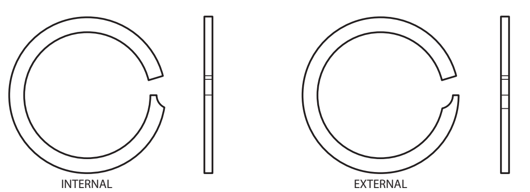
Spirolox Retaining Rings—2-Turn

WH & WS — Medium Duty, inch
WHT & WST — Medium Heavy Duty, inch
WHM & WSM — Heavy Duty, inch
EH & ES — Medium Duty, Metric Aerospace
DNH & DNS — Heavy Duty DIN, metric



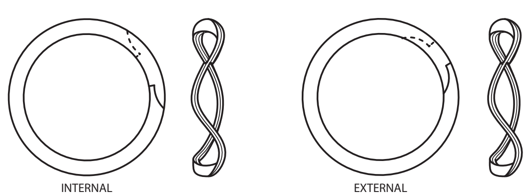
Constant Section Rings

FHE & FSE — Heavy Duty, inch
FH & FS — Heavy Duty, metric
*XAH & XAS — Eaton Style, inch
*XDH & XDS — Eaton Style, inch



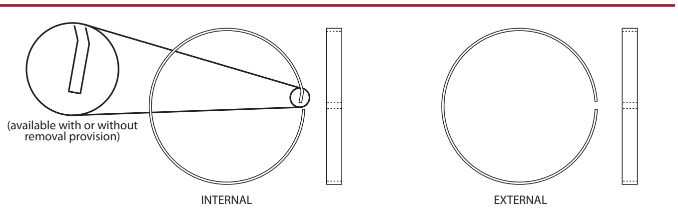
WaveRings

WHW & WSW — inch



Hoopster Rings

HH, HHU & HS — inch
HHM, HHMU & HSM — metric



*End configurations vary by size; see page 128 for Constant Section Ring end configurations.

Interchange Listing

Smalley Retaining Rings are interchangeable with both inch and metric retaining ring grooves. Smalley offers free samples of all stock retaining rings to test in your application.

Cross reference a standard stamped ring or snap ring to find the appropriate Smalley Retaining Ring to fit your application.

SMALLEY®	SPIROLOX® SERIES	MILITARY MIL-DTL-27426	AEROSPACE AS3219	METRIC AEROSPACE MA 4035	EUROPEAN SPECIFICATION DIN	WALDES TRUARC	EATON	INDUSTRIAL RETAINING RING	OTHER RINGS	ANDERTON
VH	UR	---	---	---						
VS	US	---	---	---						
WH	RR	/3	AS4299 AS3217	---						
WS	RS	/1	AS4299 AS3218	---						
WHT	RRT	---	---	---	---	---	NAN	---	UHB	---
WST	RST	---	---	---	---	---	XAN	---	USC	---
WHM	RRN	/4	AS4299 AS3215	---	---	N5000 5008	IN	3000 4000	HO HOI UHO	N1300
WSM	RSN	/2	AS4299 AS3216	---	---	5100 5108	EN	3100 4100	SH SHI USH	N1400
DNH	---	---	---	---	DIN 472	---	---	---	DHO	D1300
DNS	---	---	---	---	DIN 471	---	---	---	DSH	D1400
EH	---	---	---	MA 4017	---	---	---	---	---	---
ES	---	---	---	MA 4016	---	---	---	---	---	---
FH	---	---	---	---	DIN 472	---	---	---	DHO	D1300
FS	---	---	---	---	DIN 471	---	---	---	DSH	D1400
XAH	---	---	---	---	---	---	NAN	---	UHB	---
XAS	---	---	---	---	---	---	XAN	---	USC	---
XDH	---	---	---	---	---	---	ND	---	HN	---
XDS	---	---	---	---	---	---	XD	---	SNL	---
XNH	---	---	---	---	---	---	IN	---	UHO	---
XNS	---	---	---	---	---	---	EN	---	USH	---

Groove Interchange Only
Use a Smalley Retaining Ring to fit into the same groove of these stamped Retaining Rings (circlips).

Smalley® Steel Ring Company

Ring Applications

A. Rubber Boot

A 2-Turn Spirolox Retaining Ring clamps the rubber boot onto the groove making for a nearly perfect seal when the boot is filled with grease. The ring has been deburred so it will not tear into the rubber.

B. Pneumatic Fitting

An economical (without removal notches or off-set) 2-Turn Spirolox Retaining Ring creates an ID/OD lock, permitting the 360º rotation of the nut. This permanent assembly is commonly used to hold two components together.

C. Conduit Connector

In this unique application, a Dished Retaining Ring was designed with sharp edges, to bite into the conduit it holds in place. The clamping force of the ring to the conduit (not shown) is achieved by screwing the nut. This decreases the ring's diameter as it advances in a tapered bore.

D. Gear Bracket

The worm gear shaft is held in place and pre-loaded using a 2-Turn Smalley WaveRing. The WaveRing fits an internal groove and the waveform in the ring allows the gear/shaft to float axially as the gear rotates.

E. Ratchet Wrench

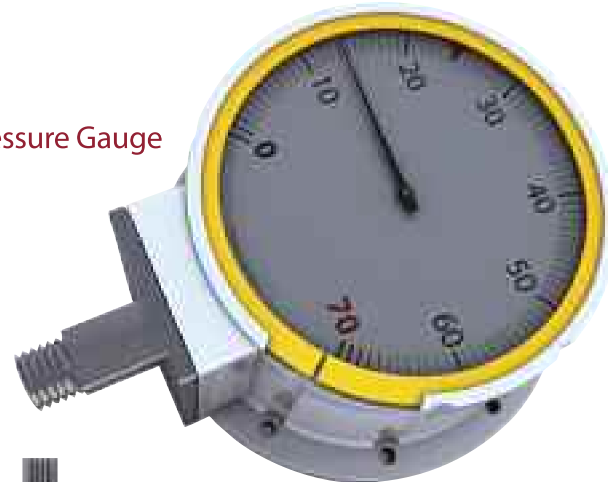
This Single-Turn (it is actually 1½ turns) External Retaining Ring retains the internal mechanical components of the ratchet wrench. The additional ½ turn provides that little extra strength needed to prevent the ring from dislodging when the wrench is dropped.

F. Cylinder Housing

The Hoopster Retaining Ring in this application allows for a shallow groove in the cylinder housing without compromising the ability to have high forces applied to the Hoopster. Because the cylinder is thin, a normal retaining ring groove could not be used.

Ring Applications

G. Bike Lock



H. Pressure Gauge

I. Gear Assembly

J. Actuator Valve

K. Pneumatic Clutch

L. Hose Fitting

G. Bike Lock

Tamper-proof ring holds the lock assembly within its housing. The ring is considered tamper-proof because of reversed removal notches. Also, having a heavy cross-section makes the ring nearly impossible to remove.

H. Pressure Gauge

A retaining ring designed in a shallow groove exerts very light pressure on the glass lens in this pressure gauge. This single-turn retaining ring design provides the optimum load without breaking the glass.

I. Gear Assembly

External 2-Turn retaining ring prevents the pinion shafts from spinning when the gears are rotating. The Spirolox ring snaps securely on the groove and the ring's radial wall is designed to extend radially outward, clearing the four flat pinion shaft pins by .020".

J. Actuator Valve

High thrust capacity was needed and a constant section ring was selected to absorb the occasional shock loading of the pistons.

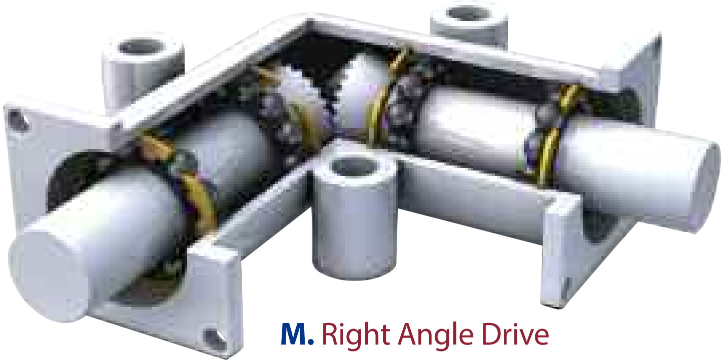
K. Pneumatic Clutch

The internal components of this clutch are held in the housing using a heavy-duty constant section ring ring. Field servicing was often necessary and the snap ring was the ideal solution to the design requirement.

L. Hose Fitting

To keep the cap on the fitting, a single-turn retaining ring is located in a shallow internal groove. The wall thickness of the cap is small, so the ring was designed with square corners to operate in a very shallow groove.

Ring Applications



M. Right Angle Drive

N. Air Vent

O. Pulley

P. Belt Pulley

Q. ID/OD Lock

R. Hip Replacement

M. Right Angle Drive

Constant section rings secure the bearing assembly by providing removable shoulders in the bore. This simplifies the design of the gear box and replaces costly flanged end plates.

N. Air Vent

Single-turn, light-duty retaining ring fits tightly in the internal groove of a plastic air vent. Ring ends are dimensioned close together, providing nearly complete 360° ring support.

O. Pulley

2-Turn retaining rings provide 360° side walls as sides of the timing belt pulley. Design eliminates costly pressed-on stamped side walls. For belt replacement one ring can be easily removed.

P. Belt Pulley

Three hold down screws and a 2-Turn Spirolox Ring form a bi-directional shoulder. The shaft is inserted through the pulley and the retaining ring rests on the pulley face securing the shaft in one direction. Movement is prevented in the other direction with the three screws clamping down on the ring.

Q. ID/OD Lock

Single-turn retaining ring operates in an internal and external groove at the same time, commonly referred to as an ID/OD Lock. In this application, the ring fits tight on the body (shaft) groove and extends radially into the nut (housing). This allows the nut to spin freely but not come off the body.

R. Hip Replacement

A titanium Spirolox Retaining Ring is used in this hip replacement application to secure the shell and the liner together to form the socket of the new hip. Smalley's manufacturing process allows for the economical production of special alloy products.

Manual Installation

Manual installation on an individual or low production basis is accomplished as follows:

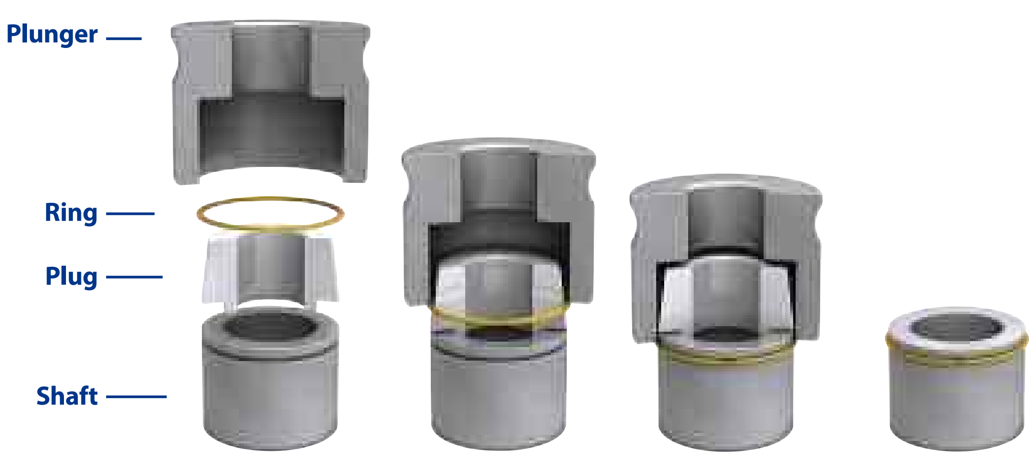
- Separate the ring coils and insert one end of the ring into the groove.
- Wind the ring by pressing down around the circumference until the entire ring is inserted into the groove.

Housing:

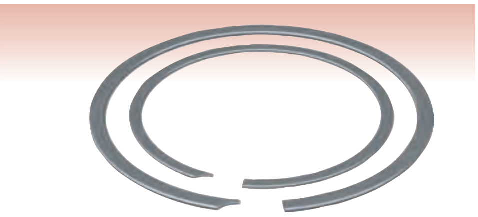
Shaft:

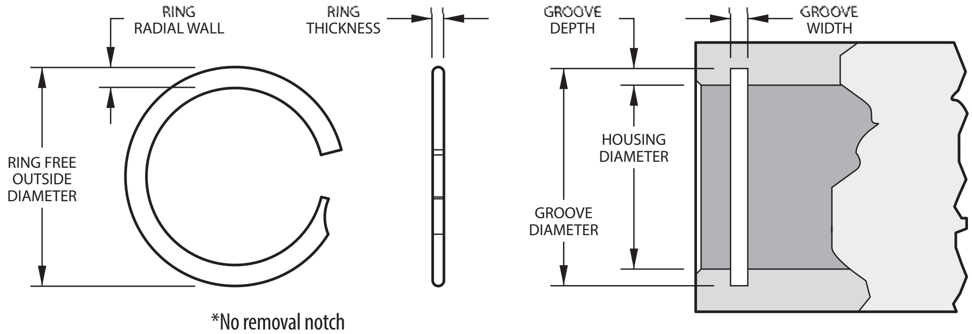
Semi–Automated and Automated Installation

For higher speed and automated assembly operations, simple tooling or assembly fixtures can be designed. External installation on a shaft can be accomplished with a plunger and tapered plug. The plug, angled at approximately 6 degrees, is centered over the shaft end. A loose fitting plunger pushes the ring into position over the tapered plug. An arbor press or air cylinder is commonly used to automate this assembly operation.



Stock Items available in carbon steel and 302 and 316 stainless steel.





*No removal notch

Product Dimensions All dimensions in inches unless otherwise specified.

Smalley Part Number [1, 4]	Housing Diameter	Ring						Groove				Thrust Capacity	
		Outside Diameter		Radial Wall		Thickness		Diameter		Width		Groove Yield (lb)[2]	Ring Shear (lb)[3]
VH-25*	.250	.264		.020		.012		.262		.015		106	481
VH-31*	.312	.329	+.010/-.000	.025		.015		.326		.018		154	750
VH-37*	.375	.398		.030		.015		.395		.018		265	901
VH-43	.437	.466	+.012/-.000	.030		.015		.463		.018		402	1,050
VH-50	.500	.531		.045		.018		.528	±.002	.022		500	1,300
VH-56	.562	.593		.045		.018		.590		.022		560	1,460
VH-62	.625	.656		.045		.018		.653		.022		620	1,630
VH-68	.687	.719		.045		.018		.715		.022		680	1,790
VH-75	.750	.783	+.013/-.000	.045		.018		.779		.022		800	1,950
VH-81	.812	.862		.065		.021		.854		.026		1,210	2,460
VH-87	.875	.926		.065		.021	±.0015	.917		.026		1,300	2,660
VH-93	.937	.989		.065		.021		.979	±.003	.026	+.002/-.000	1,390	2,840
VH-100	1.000	1.052		.065		.021		1.042		.026		1,480	3,040
VH-106	1.062	1.117		.088		.025		1.106		.031		1,650	3,500
VH-112	1.125	1.180		.088		.025		1.169		.031		1,750	3,710
VH-118	1.187	1.242		.088		.025		1.231		.031		1,850	3,920
VH-125	1.250	1.307	+.015/-.000	.088		.025		1.294	±.004	.031		1,940	4,120
VH-131	1.312	1.369		.088		.025		1.356		.031		2,040	4,330
VH-137	1.375	1.433		.088		.025		1.419		.031		2,140	4,540
VH-143	1.437	1.496		.088		.025		1.481		.031		2,240	4,740
VH-150	1.500	1.559		.088		.025		1.544		.031		2,330	4,950
VH-156	1.562	1.637		.118		.031		1.619		.039		3,200	6,390
VH-162	1.625	1.701		.118	±.004	.031		1.682		.039		3,330	6,650
VH-168	1.687	1.763		.118		.031		1.744		.039		3,460	6,900
VH-175	1.750	1.827		.118		.031		1.807		.039		3,590	7,160
VH-181	1.812	1.890	+.020/-.000	.118		.031		1.869	±.005	.039		3,710	7,410
VH-187	1.875	1.953		.118		.031		1.932		.039		3,840	7,670
VH-193	1.937	2.016		.118		.031		1.994		.039		3,970	7,920
VH-200	2.000	2.079		.118		.031		2.057		.039		4,100	8,180
VH-206	2.062	2.162		.158		.031		2.138		.039		5,540	8,430
VH-212	2.125	2.226		.158		.031		2.201		.039		5,710	8,690
VH-218	2.187	2.289		.158		.031		2.263		.039		5,870	8,950
VH-225	2.250	2.352		.158		.031		2.326		.039		6,040	9,200
VH-231	2.312	2.415		.158		.031	±.002	2.388		.039		6,210	9,460
VH-237	2.375	2.478		.158		.031		2.451		.039	+.003/-.000	6,380	9,720
VH-243	2.437	2.541		.158		.031		2.513		.039		6,550	9,970
VH-250	2.500	2.605	+.025/-.000	.158		.031		2.576		.039		6,720	10,230
VH-256	2.562	2.667		.158		.031		2.638		.039		6,880	10,480
VH-262	2.625	2.731		.158		.031		2.701		.039		7,050	10,740
VH-268	2.687	2.794		.158		.031		2.763		.039		7,220	10,990
VH-275	2.750	2.857		.158		.031		2.826	±.006	.039		7,390	11,250
VH-281	2.812	2.920		.158		.031		2.888		.039		7,550	11,500
VH-287	2.875	2.983		.158		.031		2.951		.039		7,720	11,760
VH-293	2.937	3.046		.158		.031		3.013		.039		7,890	12,010
VH-300	3.000	3.110		.158		.031		3.076		.039		8,060	12,270

[1] Add suffix "-S02" for 302 stainless steel, "-S16" for 316 stainless steel.
[2] Based on a groove material yield strength of 45,000 psi and a safety factor of 2.
[3] Based on a safety factor of 3.
[4] See pages 134-135 for How to Order.

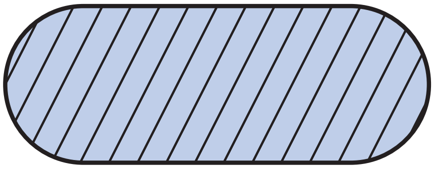
Smalley Part Number [1,4]	Housing Diameter	Ring						Groove				Thrust Capacity	
		Outside Diameter	Tol.	Radial Wall	Tol.	Thickness	Tol.	Diameter	Tol.	Width	Tol.	Groove Yield (lb)[2]	Ring Shear (lb)[3]
VH-306	3.062	3.188	+.030/-.000	.188	±.005	.039	±.002	3.154	±.006	.044	+.003/-.000	9,960	15,760
VH-312	3.125	3.251		.188		.039		3.217		.044		10,160	16,080
VH-318	3.187	3.314		.188		.039		3.279		.044		10,360	16,400
VH-325	3.250	3.377		.188		.039		3.342		.044		10,570	16,720
VH-331	3.312	3.440		.188		.039		3.404		.044		10,770	17,040
VH-337	3.375	3.504		.188		.039		3.467		.044		10,970	17,370
VH-343	3.437	3.566		.188		.039		3.529		.044		11,180	17,690
VH-350	3.500	3.630		.188		.039		3.592		.044		11,380	18,010
VH-356	3.562	3.692		.188		.039		3.654		.044		11,580	18,330
VH-362	3.625	3.756		.188		.039		3.717		.044		11,790	18,650
VH-368	3.687	3.819		.188		.039		3.779		.044		11,990	18,970
VH-375	3.750	3.882		.188		.039		3.842		.044		12,190	19,300
VH-381	3.812	3.945		.188		.039		3.904		.044		12,400	19,620
VH-387	3.875	4.009		.188		.039		3.967		.044		12,600	19,940
VH-393	3.937	4.071		.188		.039		4.029		.044		12,800	20,260
VH-400	4.000	4.135		.188		.039		4.092		.044		13,010	20,580
VH-412	4.125	4.279	+.035/-.000	.225		.046		4.235		.052	+.004/-.000	16,040	23,850
VH-425	4.250	4.405		.225		.046		4.360		.052		16,520	24,570
VH-437	4.375	4.531		.225		.046		4.485		.052		17,010	25,290
VH-450	4.500	4.658		.225		.046		4.610		.052		17,500	26,010
VH-462	4.625	4.784		.225		.046		4.735		.052		17,980	26,740
VH-475	4.750	4.910		.225		.046		4.860		.052		18,470	27,460
VH-487	4.875	5.036		.225		.046		4.985		.052		18,950	28,180
VH-500	5.000	5.163		.225		.046		5.110	±.007	.052		19,440	28,900
VH-525	5.250	5.435	+.045/-.000	.225		.061		5.381		.067		24,490	40,240
VH-550	5.500	5.694		.225		.061		5.638		.067		26,830	42,160
VH-575	5.750	5.953		.225		.061		5.894		.067		29,260	44,080
VH-600	6.000	6.212		.265		.061		6.150		.067		31,810	45,990
VH-625	6.250	6.470		.265		.061		6.406	±.008	.067		34,460	47,910
VH-650	6.500	6.730		.265		.061		6.663		.067		37,680	49,830
VH-675	6.750	6.988		.265		.061		6.919		.067		40,560	51,740
VH-700	7.000	7.247		.265		.061		7.175		.067		43,540	53,660
VH-725	7.250	7.505	+.060/-.000	.265		.061		7.431		.067		46,640	55,580
VH-750	7.500	7.765		.265		.061		7.688		.067		49,830	57,490
VH-775	7.750	8.023		.300	+.004/-.008	.061		7.944		.067		53,140	59,410
VH-800	8.000	8.282		.300		.061		8.200		.067		56,550	61,320
VH-825	8.250	8.541		.300		.061		8.456		.067		60,070	63,240
VH-850	8.500	8.800		.300		.061		8.713		.067		64,290	65,160
VH-875	8.750	9.059	+.070/-.000	.345		.076		8.969		.082	+.005/-.000	68,040	83,570
VH-900	9.000	9.317		.345		.076		9.225		.082		71,890	85,950
VH-925	9.250	9.576		.345		.076		9.481		.082		75,850	88,340
VH-950	9.500	9.835		.345		.076		9.738		.082		79,910	90,730
VH-975	9.750	10.094		.345		.076		9.994		.082		84,080	93,120
VH-1000	10.000	10.353		.345		.076		10.250		.082		88,360	95,500

[1] Add suffix "-S02" for 302 stainless steel, "-S16" for 316 stainless steel.
[2] Based on a groove material yield strength of 45,000 psi and a safety factor of 2.
[3] Based on a safety factor of 3.
[4] See pages 134-135 for How to Order.

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.

A

B  B

A

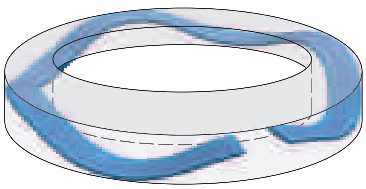
Ultimate Tensile Strength

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 cross-section, not a single point as in a hardness test.

Spring Design

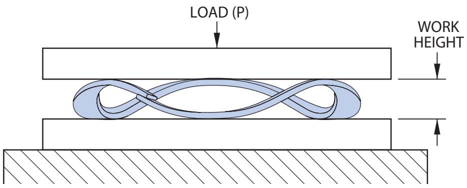
Defining the Spring Requirements

Although wave spring applications are extremely diverse, there is a consistently basic set of rules for defining spring requirements. Those requirements are used to select a stock/standard spring or design a special spring to meet the specifications.



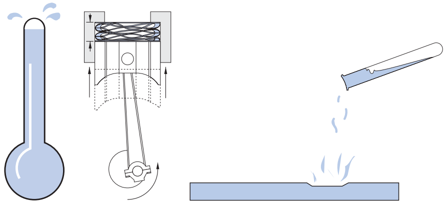
Working Cavity

The working cavity usually consists of a bore the spring operates in and/or a shaft the spring clears. The spring stays positioned by piloting in the bore or on the shaft. The distance between the loading surfaces defines the axial working cavity or work height of the spring.



Load Requirement

The load requirement is defined by the amount of axial force the spring must produce when installed at its work height. Some applications require multiple working heights, where loads at 2 or more operating heights are critical and must be considered in the design. Often minimum and/or maximum loads are satisfactory solutions, particularly where tolerance stack-ups are inherent in the application.



Operating Environment

High temperature, dynamic loading (fatigue), a corrosive media or other unusual operating conditions must be considered in spring applications. Solutions to various environmental conditions typically require selection of the optimal raw material and operating stress.

Standard Springs vs. Special Springs

Finding the right spring can be as easy as selecting a standard catalog item. A Smalley engineer can help you choose from over 4,000 standard parts available from stock in carbon and stainless steel. Smalley's "no-tooling" method of manufacturing provides the utmost in flexibility and quality. Whether the requirement is for 1 spring or 1,000,000 consider Smalley for your special spring requirements.

Let Smalley Design Your Spring

Over 50% of Smalley's business is in the design and manufacturing of special springs to suit individual applications. Whether it's a technical question, or the most complex spring design, Smalley engineers are always available and welcome the opportunity to assist you. Utilize the Application Checklist found in this catalog. Or at **www.smalley.com** we provide a simple procedure to e-mail us your known design parameters. An engineer will recommend a standard catalog item or provide you with design options for a special spring.

Spring Design

Nomenclature

b	Radial Width of Material, in [(O.D. - I.D.)÷2]
D_m	Mean Diameter, in [(O.D. + I.D.)÷2]
E	Modulus of Elasticity, psi
f	Deflection, in
H	Free height, in
I.D.	Inside Diameter, in
K	Multiple Wave Factor, see Table 1
L	Length, Overall Linear, in
N	Number of Waves (per turn)
O.D.	Outside Diameter, in
P	Load, lb
S	Operating Stress, psi
t	Thickness of Material, in
WH	Work Height, in (H-f)
Z	Number of Turns

Multiple Wave Factor (K)

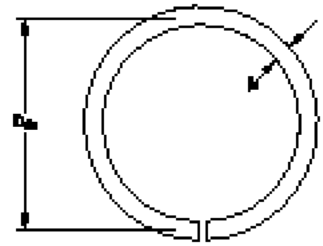
N	2.0-4.0	4.5-6.5	7.0-9.5	10.0 & Over
K	3.88	2.90	2.30	2.13

Table 1

Single Turn Gap or Overlap Type

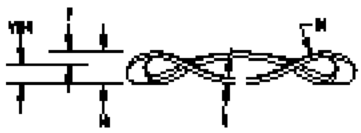
Applications

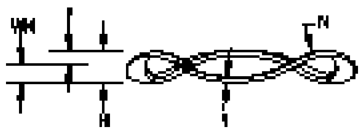
1. Low-Medium Force
2. Low-Medium Spring Rate
3. Short Deflection
4. Precise Load/Deflection Characteristics



Single turn wave springs are the basic and most common wave spring product. They are used in the widest variety of spring applications due to their lower cost and simplified design configuration.

Single turn wave springs provide the most flexibility to designers. There are few restrictions in their design. They are specified in the majority of small axial and radial space constraint applications.





Formulas:

$$\text{Deflection} = f = \frac{P K D_m^3}{E b t^3 N^4} \times \frac{I.D.}{O.D.}$$

$$\text{Operating Stress} = S = \frac{3 \pi P D_m}{4 b t^2 N^2}$$

Example: Smalley Part Number SSR-0200

Calculate free height and operating stress for Smalley part number SSR-0200 (Gap Type, Single Turn, Carbon Spring Temper Steel).

Where:

P = 34 lb
t = .024 in
b = .150 in
O.D = 1.985 in
I.D. = 1.685 in
Dm = 1.835 in
N = 4
E = 30x10⁶ psi
K = 3.88
WH = .093 in

$$\text{Deflection} = f = \frac{(34)(3.88)(1.835)^3}{(30x10^6)(.150)(.024)^3(4)^4} \times \frac{1.685}{1.985} = .043 \text{ in}$$

*Free Height = H = (W.H. + f) = .093 + .043 = .136 in

$$\text{Operating Stress} = S = \frac{(3)(\pi)(34)(1.835)}{(4)(.150)(.024)^2(4)^2} = 106{,}399 \text{ psi}$$

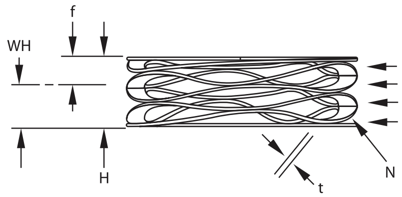
*Calculated free height may not be the same as the actual springs measure due to variations in raw material and manufacturing process.

Crest–to–Crest (Series Stacked)

Applications

1. Low-Medium Force
2. Low-Medium Spring Rate
3. Long Deflection
4. Precise Load/Deflection Characteristics

Crest-to-Crest flat wire compression springs are pre-stacked in series, decreasing the spring rate by a factor related to the number of turns.

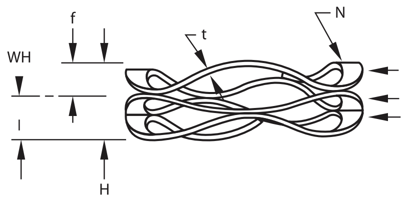


Formulas:

$$\text{Deflection} = f = \frac{P K D_m^3 Z}{E b t^3 N^4} * \frac{I.D.}{O.D.}$$

$$\text{Operating Stress} = S = \frac{3 \pi P D_m}{4 b t^2 N^2}$$

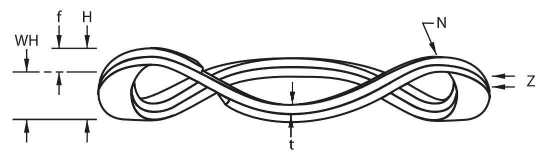
Note:
N must be in ½ wave increments
Z = Number of active turns



Nested Spirawave® (Parallel Stacked)

1. Higher Force
2. Higher Spring Rate
3. Short Deflection
4. Precise Load/Deflection Characteristics

Nested Spirawave Wave Springs are pre-stacked in parallel, increasing the spring rate by a factor related to the number of turns.



Formulas:

$$\text{Deflection} = f = \frac{P K D_m^3}{E b t^3 N^4 Z} * \frac{I.D.}{O.D.} \qquad \text{Operating Stress} = S = \frac{3 \pi P D_m}{4 b t^2 N^2 Z}$$

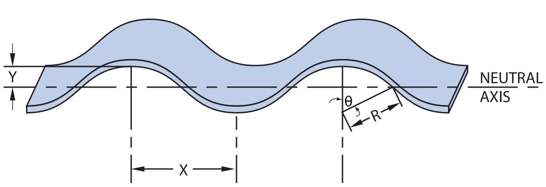
Diameter Expansion

Nested & Crest-to-Crest Spirawaves Only: Multiple turn Spirawaves expand in diameter when compressed. The formula shown below is used to predict the maximum fully compressed diameter.

Formula: Maximum outside diameter at 100% deflection (solid height) = $.02222 * R * N * \theta + b$

Where:

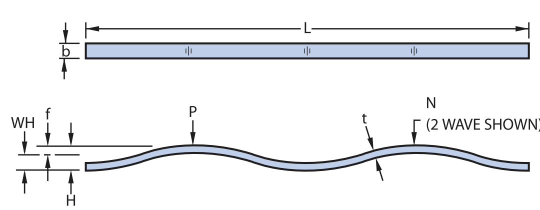
- R = Wave Radius = $(4Y^2 + X^2) \div 8Y$
- N = Number of Waves
- θ = Angle, degrees = ArcSin $(X \div 2R)$
- b = Radial Wall
- X = ½ Wave Frequency = $\pi D_m \div 2N$
- Y = ½ Mean Free Height = $(H\text{-}t) \div 2$
  Where H = Per Turn Free Height



Linear Springs

Linear Springs are a continuous wave formed (marcelled) wire length produced from spring temper materials. They act as a load bearing device having approximately the same load/deflection characteristics as a wave spring.

Forces act axially or radially depending on the installed position. Axial pressure is obtained by laying the spring flat in a straight line. Circular wrapping the spring (around a piston for example) produces a radial force or outward pressure.



Formula: ***Single*** **wave linear spring where N=1**

$$\text{Deflection} = f = \frac{P L^3}{4 E b t^3} \qquad \text{Operating Stress} = S = \frac{3 P L}{2 b t^2}$$

Formula: ***2 or more*** **wave linear springs where N>1**

$$\text{Deflection} = f = \frac{P L^3}{16 E b t^3 N^4} \qquad \text{Operating Stress} = S = \frac{3 P L}{4 b t^2 N^2}$$

Spring Design

Stress

Operating Stress

Compressing a wave spring creates bending stresses similar to a simple beam in bending. These compressive and tensile stresses limit the amount a spring can be compressed before it yields or "takes a set". Although spring set is sometimes not acceptable, load and deflection requirements will often drive the design to accept some set or "relaxation" over time.

Maximum Design Stress

Static Applications Smalley utilizes the Minimum Tensile Strength found in this catalog's Materials section to approximate yield strength due to the minimal elongation of the hardened flat wire used in Smalley products. When designing springs for static applications we recommend the calculated operating stress be no greater than 100% of the minimum tensile strength. However, depending on certain applications, operating stress can exceed the minimum tensile strength with allowances for yield strength. Typical factors to consider are permanent set, relaxation, loss of load and/or loss of free height.

Dynamic Applications When designing wave springs for dynamic applications, Smalley recommends that the calculation of operating stress not exceed 80% of the minimum tensile strength. Refer to the "Fatigue Stress Ratio" and Table 2 for further fatigue guidelines.

Residual Stress/Pre-Setting

Increasing the load capacity and/or fatigue life can be achieved by compressing a spring beyond its yield point or "presetting". Preset springs are manufactured to a higher than needed free height and load and then compressed solid. Both the free height and load are reduced and the material surfaces now exhibit residual stresses, which enhance spring performance.

Fatigue

Fatigue cycling is an important consideration in wave spring design and determining precisely how much the spring will deflect can greatly impact the price of the spring. An analysis should include whether the spring deflects full stroke or only a few thousandths each cycle or possibly a combination of both as parts wear or temperature changes.

The fatigue guidelines in Table 2 provide a conservative approach and allow for calculation of cycle life between 2 work heights. Although these methods of fatigue analysis have proven to be a good approximation, testing is recommended whenever cycle life is critical.

Formula:

$$\text{Fatigue Stress Ratio} = X = \frac{(\sigma - S_1)}{(\sigma - S_2)}$$

(refer to Table 2)

Where: σ = Material tensile strength

S_1 = Calculated operating stress at lower work height (must be less than σ)

S_2 = Calculated operating stress at upper work height

Fatigue Guidelines

X	Estimated Cycle Life
< .40	Under 30,000
.40 - .49	30,000 – 50,000
.50 - .55	50,000 – 75,000
.56 - .60	75,000 – 100,000
.61 - .67	100,000 – 200,000
.68 - .70	200,000 – 1,000,000
> .70	Over 1,000,000

Table 2

Load/Deflection

A comparison of the actual spring rate to the theoretical (calculated) spring rate provides practical limits for the working range of the spring. Spring rate (P/f) can be calculated by manipulating the deflection equations. See formulas in the Spring Design section.

Figure 1 shows a graph of theoretical and tested spring rate. Typically, theoretical rate is accurate until the spring starts to bottom out or reach its "solid height".

As a general rule, the calculated spring rate is linear through the first 80% of available deflection and for work heights down to 2 times the solid height. Although the spring can operate beyond this "linear" range, measured loads will be much higher than calculated.

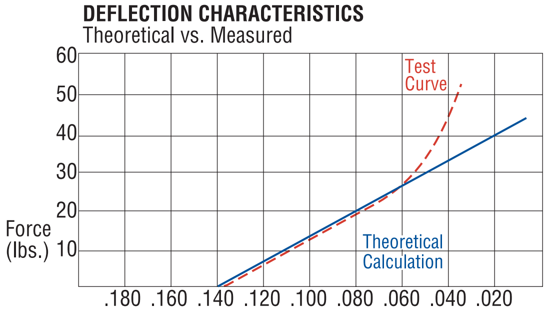


Figure 1

Hysteresis

Wave springs exert a greater force upon loading and lower force upon unloading. This effect is known as hysteresis. The shaded area shows a graphic representation between the curves in Figure 2.

In a single turn spring, friction due to circumferential and radial movements are the prime causes. Crest-to-Crest and Nested Springs also contribute to the frictional loss as adjacent layers rub against each other. Sufficient lubrication will minimize this effect.

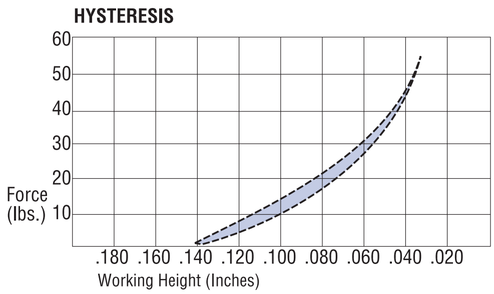


Figure 2

Design Guidelines

Material Cross-Section

Material cross-section plays an important role in wave spring design. The most economical materials are those used in manufacturing Smalley standard springs and retaining rings. In addition, many other material cross sections are commonly used in special spring manufacture designs. Smalley engineering can provide assistance in selecting an economical alloy and cross section.

As a basic guideline, use our standard 'SSR'-Wave Spring series for cross-section/diameter relationships. Lighter material sections are usually acceptable. Heavier sections for a given diameter may be incorporated using the following information:

Special wave spring design criteria for selecting material cross-sections:

Maximum material thickness = standard ('SSR-') thickness * 2
Maximum radial wall = material thickness (any value) * 10
Minimum radial wall = material thickness (any value) * 3

For Overlap Type Wave Springs and multiple turn Spirawaves, the radial wall must be sufficient to prevent misalignment between adjacent layers. For springs with a narrow radial wall, radial misalignment can occur during handling or during operation if the spring is not contained or closely piloted.

Solutions to this problem include dimensioning the spring to pilot closely on the I.D. and/or O.D. or designing the spring as a single turn Gap Type.

Diameters

Figure 3 illustrates two methods of specifying diameters. In either case, the spring diameter is developed to provide proper operation between the bore and the shaft.
Note: Smalley's manufacturing process of edgewinding controls either the O.D. or the I.D. The material radial wall is also tightly controlled. Therefore whenever possible, tolerance only one diameter and the radial wall instead of tolerancing both the O.D. and I.D.

Bore Pilot

For springs that pilot in the bore as shown in figure 3a, the bore and shaft diameters should be included in the spring specifications. Commonly used requirements would read:

"Spring must pilot and operate in a (minimum bore) bore diameter."

"Spring must clear a (maximum shaft) shaft diameter."

The actual spring diameter is then developed at time of manufacture to provide the best fit and prevent binding due to expansion.

For Gap Type and Overlap Type Springs, the outside diameter can be specified because binding is not a concern. The outside diameter can be toleranced to provide a minimum clearance in the bore or provide cling in the bore, as do the Smalley Bearing Preload Springs.

Shaft Pilot

For springs that pilot on a shaft as shown in Figure 3b, the inside diameter can be toleranced to provide a minimum clearance from the shaft. Since wave springs expand during compression, interference with the shaft is generally not a concern.

To insure proper operation, include shaft and bore diameters in the spring specifications. Commonly used requirements would read:

"Spring pilots over and clears a (maximum shaft) shaft diameter."

"Spring operates in a (minimum bore) bore diameter."

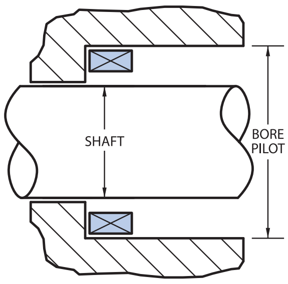


Figure 3a

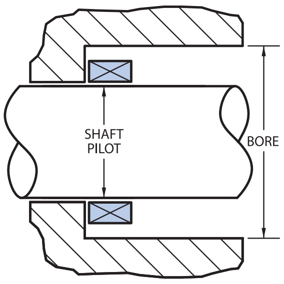


Figure 3b

Engineering Design

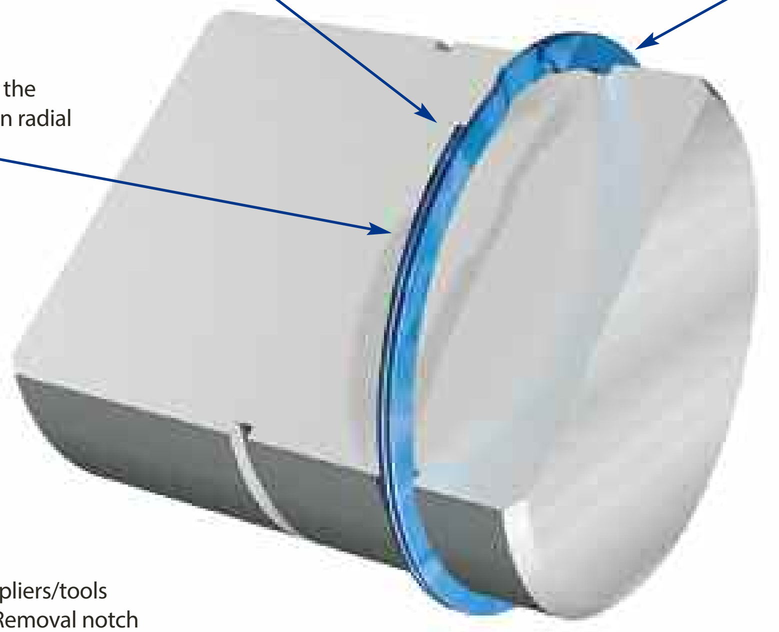
Spirolox Retaining Ring and Constant Section Ring applications, although diverse, can be analyzed with a straight forward set of design calculations. There are four main areas that should be considered in most applications.

1. Material Selection
2. Load Capacity
3. Rotational Capacity
4. Installation Stress

Smalley Application Engineers are available to provide immediate technical assistance.

The following pages of Spirolox Retaining Ring and Constant Section Ring engineering design have been developed from over 45 years of extensive testing and research into the various applications of retaining rings. The formulas are provided for the preliminary analysis of a ring application and the design of a Spirolox Retaining Ring.

Design engineers commonly associate the word "retaining ring" to a basic style or type of retaining device. In reality, retaining rings are nearly as diverse as their applications. Spirolox Retaining Rings offer a distinct alternative, and in many instances an advantage, over the more common retaining rings available on the market today. Some of the major distinctions are:



Spiral Wound in Multiple Turns

Increases load capacity yet allows easy assembly by hand or as an automated process.

360˚ Retaining Surface

No gap – no protruding ears.

Uniform Radial Section

Provides a pleasant appearance on the assembled product. Beneficial when radial clearance is limited.

Simplified Assembly

Wind into groove. No special pliers/tools needed to install or remove. Removal notch provided for easy removal using a screwdriver.

Design Flexibility

Ring thickness can be changed to accommodate most any application by either varying material thickness and/or number of turns. Standard rings meet military and aerospace specifications. Special designs are produced quickly and economically in many alloys.

Load Capacity

Understanding the load capacity of a Spirolox Retaining Ring assembly requires calculations for both ring shear and groove deformation, with the design limitation being the lesser of the two.

The load capacity formulas do not take into account any dynamic or eccentric loading. If this type of loading exists, the proper safety factor should be applied and product testing conducted. In addition, the groove geometry and edge margin (i.e.; the distance of the groove from the end of the shaft or housing) should be considered.

When abusive operating conditions exist, true ring performance is best determined thorough actual testing.

Ring Shear

Although not commonly associated as a typical failure of Spirolox Retaining Rings, ring shear can be a design limitation when hardened steel is used as a groove material. Ring thrust load capacities based on ring shear are provided within this catalog's tables of standard rings. These values are based on a shear strength of carbon steel with the recommended safety factor of 3.

Formula:

$$P_R = \frac{D\,T\,S_S\,\pi}{K}$$

Where:

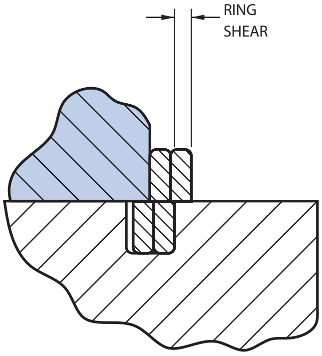
- P_R = Allowable thrust load based on ring shear (lb)
- D = Shaft or housing diameter (in)
- T = Ring thickness (in)
- S_S = Shear strength of ring material (psi)
- K = Safety factor (3 recommended)

Example:

1. WH-550-S16
2. Safety factor = 3

$$P_R = \frac{5.500\,(.072)\,108{,}000\,(\pi)}{3}$$

$$P_R = 44{,}787 \text{ lb}$$



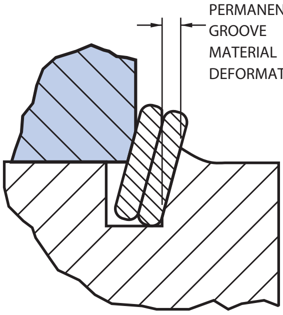
The thrust load based on ring shear above, must be compared to the thrust load based on groove deformation to determine which is the limiting factor in the design.

Groove Deformation (Yield)

Groove deformation is by far the most common design limitation of retaining rings. As permanent groove deformation occurs, the ring begins to twist. As the angle of twist increases, the ring begins to enlarge in diameter. Ultimately, the ring becomes dished and extrudes (rolls) out of the groove. As a conservative interpretation, the following equation calculates the point of initial groove deformation. This does not constitute failure which occurs at a much higher value. A safety factor of 2 is suggested. Ring thrust load capabilities based on groove deformation are provided within this catalog's tables of standard rings.

Formula:

$$P_G = \frac{D\,d\,S_y\,\pi}{K}$$



Where:

- P_G = Allowable thrust load based on groove deformation (lb)
- D = Shaft or housing diameter (in)
- d = Groove depth (in)
- S_y = Yield strength of groove material (psi), see Table 1
- K = Safety factor (2 recommended)

Example:

1. WH-550-S16
2. Groove material yield strength = 45,000 psi
3. Safety factor = 2

$$P_G = \frac{5.500\,(.074)\,45{,}000\,(\pi)}{2}$$

$$P_G = 28{,}769 \text{ lb}$$

Typical Groove material yield strengths	
Hardened Steel 8620	110,000 psi
Cold Drawn Steel 1018	70,000 psi
Hot Rolled Steel 1018	45,000 psi
Aluminum 2017	40,000 psi
Cast Iron	10-40,000 psi

Table 1

Since ring shear was calculated at 44,787 lb, the groove yields before the ring shears. Therefore 28,769 lb is the load capacity of the retaining ring.

Ring Design

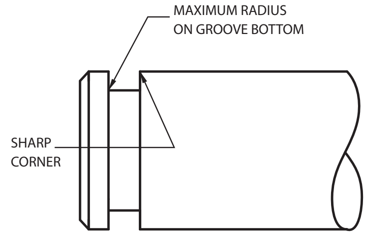
Groove Geometry

Groove Radius

To assure maximum load capacity it is essential to have square corners on the groove and retained components. Additionally, retained components must always be square to the ring groove in order to maintain a uniform concentric load against the retained part. The radius at the bottom of the groove should be no larger than Table 2 states.

Shaft or Housing Diameter	Maximum Radius on Groove Bottom
1 inch and under	.005 Max.
Over 1 inch	.010 Max.

Table 2



Retained Component

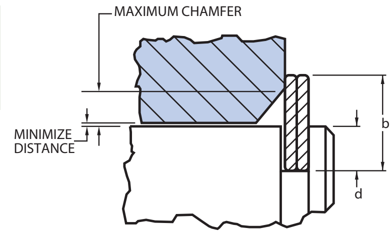
The retained part ideally has a square corner and contacts the ring as close as possible to the housing or shaft. The maximum recommended radius or chamfer allowable on the retained part can be calculated with the following formulas.

Where:
- b = Radial wall (in)
- d = Groove depth (in)

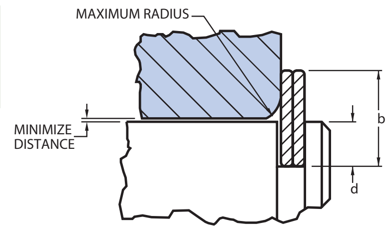
Example:
1. WH-100

Maximum Chamfer = .375(.075-.021) = .020 in
Maximum Radius = .5(.075-.021) = .027 in

Formula:
Maximum Chamfer = .375(b - d)
(on retained component)



Formula:
Maximum Radius = .5(b - d)
(on retained component)



Edge Margin

Ring grooves which are located near the end of a shaft or housing should have an adequate edge margin to maximize strength. Both shear and bending should be checked and the larger value selected for the edge margin. As a general rule, the minimum edge margin may be approximated by a value of 3 times the groove depth.

Formula:

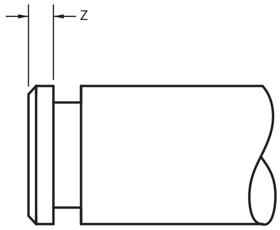
Shear

$$z = \frac{K\,3\,P}{S_Y\,D_G\,\pi}$$

Bending

$$z = \left[\frac{K\,6\,d\,P}{S_Y\,D_G\,\pi}\right]^{1/2}$$

Where:
- z = Edge margin (in)
- P = Load (lb)
- D_G = Groove diameter (in)
- S_Y = Yield strength of groove material (psi), Table 1
- d = Groove depth (in)
- K = Safety factor (3 recommended)



Example:
1. VS-125
2. Groove material yield strength = 40,000 psi
3. Safety factor = 3
4. Load = 1,000 lb

Shear

$$z = \frac{3\,(3)\,1000}{40{,}000\,(1.206)\,\pi}$$

z = .059 in

Bending

$$z = \left[\frac{3\,(6)\,.022\,(1000)}{40{,}000\,(1.206)\,\pi}\right]^{1/2}$$

z = .051 in

Therefore the minimum edge margin that should be used is .059 inv

Rotational Capacity

The maximum recommended RPM for all standard external Spirolox Retaining Rings are listed in the ring tables of this manual.

A Spirolox Retaining Ring, operating on a rotating shaft, can be limited by centrifugal forces. Failure may occur when these centrifugal forces are great enough to lift the ring from the groove. The formula below calculates the RPM at which the force holding the ring tight on the groove (cling) becomes zero.

Rapid acceleration of the assembly may cause failure of the retaining ring. If this is a potential problem, contact Smalley engineering for design assistance.

Maximum RPM

Formula:

$$N = \left[\frac{3600\, V\, E\, I\, g}{(4\pi^2)\, Y\, \gamma\, A\, R_M^5}\right]^{1/2}$$

n	1	2	3	4
Y	1.909	3.407	4.958	6.520

Table 3

Where: N = Maximum allowable rpm (rpm)
E = Modulus of elasticity (psi)
I = Moment of inertia = (t x b^3)÷12 (in^4)
g = Gravitational acceleration (in/sec^2), 386.4 in/sec^2
V = Cling÷2 = (D_G - D_I)÷2 (in)
D_G = Groove diameter (in)
D_I = Free inside diameter (in)
Y = Multiple turn factor, Table 3
n = Number of turns
γ = Material density (lb/in^3), (assume .283 lb/in^3)
A = Cross sectional area = (t x b) - (.12)t^2 (in^2)
t = Material thickness (in)
b = Radial wall (in)
R_M = Mean free radius = (D_I + b)÷2 (in)

Example:

1. WSM-150

$V = (D_G - D_I)÷2 = (1.406-1.390)÷2 = .008$ in
$I = (t \times b^3)÷12 = (.024 \times .118^3)÷12 = 3.29 \times 10^{-6}\ in^4$
$A = (t \times b)-(.12)t^2 = (.024 \times .118)-.12(.024)^2 = .00276\ in^2$
$R_M = (D_I + b)÷2 = (1.390+.118)÷2 = .754$ in

$$N = \left[\frac{3600\,(.008)\ 30{,}000{,}000\ (3.29 \times 10^{-6})\ 386.4}{(4\pi^2)\ 3.407\ (.283)\ .00276\ (.754)^5}\right]^{1/2}$$

N = 6,539 rpm

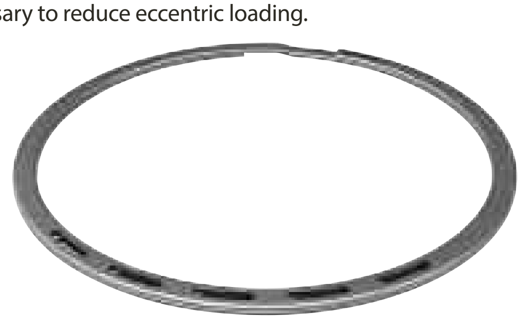
Self-Locking

This feature allows the ring to function properly at speeds that exceed the recommended rotational capacity. The self-locking option can be incorporated for both external and internal rings. The self-locking feature utilizes a small tab on the inside turn "locking" into a slot on the outside turn. Self-locking allows the ring to operate at high speeds, withstand vibration, function under rapid acceleration and absorb a degree of impact loading.

To learn more about self-locking rings and their installation and removal, please visit: www.smalley.com/LockingRings.

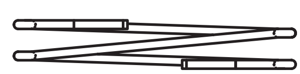
Balanced

Smalley's balanced feature statically balances the retaining ring. A series of slots, opposite the gap end, account for the missing material in the gap. This characteristic is very useful when the balance of the assembly is critical and it is necessary to reduce eccentric loading.

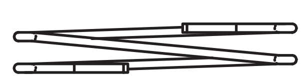


Left Hand Wound

Smalley retaining rings are wound standard in a clockwise direction. In special applications it is sometimes favorable to have the retaining ring reverse, left hand wound.



Right Hand (Standard Wound)



Left Hand (Reverse Wound)

Maximum Allowable RPM for Spirolox Retaining Rings — Imperial

Part NUMBER	VS	WS	WST	WSM	FSE
25	45,227	–	–	36,651	–
31	39,946	–	–	31,364	–
37	31,161	–	–	23,025	–
43	24,067	–	–	18,019	–
46	–	–	28,820	21,450	–
50	28,030	24,650	20,780	20,600	32,573
56	–	–	–	–	32,410
53	–	21,280	–	–	–
55	–	19,440	18,130	18,260	–
56	21,060	18,520	17,270	17,400	–
59	–	17,290	15,200	15,390	–
62	17,850	19,500	15,700	14,730	22,107
65	–	16,270	–	–	–
66	–	16,510	15,600	13,860	–
68	15,340	15,470	15,600	13,510	19,520
71	–	13,050	–	–	–
75	12,350	14,290	12,750	12,190	22,451
78	–	12,960	11,590	11,110	–
81	15,380	12,470	11,300	10,150	17,414
84	–	10,770	–	–	–
87	12,800	10,570	10,660	10,340	17,374
90	–	9,180	–	–	–
93	11,500	9,400	9,100	8,760	12,757
96	–	8,920	–	–	–
98	–	9,530	6,980	8,640	–
100	9,800	9,160	7,800	8,940	18,675
102	–	9,070	7,400	8,500	–
103	–	8,080	–	–	–
106	11,490	8,610	8,660	11,260	11,446
109	–	7,350	–	–	–
112	9,990	7,470	7,960	9,820	12,107
115	–	6,700	–	–	–
118	9,220	7,350	6,320	9,040	15,056
121	–	6,340	–	–	–
125	8,500	6,750	6,500	8,042	11,970
128	–	5,860	–	–	–
131	7,880	6,310	5,800	8,280	13,786
134	–	5,960	–	–	–
137	7,030	6,110	6,000	7,430	11,008
140	–	5,580	–	–	–
143	6,560	5,490	5,160	6,700	11,594

Part NUMBER	VS	WS	WST	WSM	FSE
146	–	5,020	–	–	–
150	5,900	4,940	4,670	6,540	12,178
156	7,720	5,343	5,160	6,110	9,004
157	–	5,240	–	–	–
162	7,220	4,880	4,690	5,750	9,118
168	6,590	4,930	4,110	5,260	8,595
175	6,200	4,510	3,930	4,970	8,101
177	–	4,410	3,960	4,990	–
181	5,700	4,290	4,170	4,720	8,470
187	5,380	4,240	3,850	4,540	6,440
193	5,100	4,020	–	–	8,047
196	–	3,860	3,320	4,730	–
200	4,720	3,740	3,410	4,560	7,650
206	5,970	3,550	3,340	3,810	7,103
212	5,550	3,400	3,120	3,560	6,603
215	–	3,490	3,120	3,450	–
216	–	3,370	–	–	–
218	5,290	3,290	–	–	6,316
225	5,050	3,220	2,820	3,240	6,040
231	4,720	3,020	2,730	3,040	5,786
236	–	2,870	–	–	–
237	4,520	2,890	2,560	3,380	6,343
243	4,240	2,920	2,480	3,180	5,089
250	4,063	2,750	3,040	3,090	4,994
255	–	2,600	3,430	2,920	–
256	3,900	2,600	–	–	5,118
262	3,680	2,500	2,780	2,750	4,073
268	3,540	2,470	2,630	2,680	4,797
275	3,400	2,340	2,560	2,790	3,981
281	3,220	2,380	–	–	4,074
287	3,100	2,260	2,260	2,590	3,927
293	2,940	2,140	2,200	2,460	3,727
295	–	2,160	–	–	–
300	2,840	2,080	2,150	2,410	3,537
306	3,670	2,020	2,090	2,290	3,245
312	3,030	1,980	1,990	2,240	3,853
314	–	1,980	–	–	–
315	–	–	1,990	2,190	–
318	2,930	1,930	–	–	3,731
325	2,790	1,870	1,900	2,100	3,557
331	2,700	1,840	–	–	3,595

Part NUMBER	VS	WS	WST	WSM	FSE
334	–	1,840	1,810	1,960	–
337	2,630	1,790	–	–	3,433
343	3,500	1,750	1,690	1,880	3,334
350	2,440	1,700	2,020	2,090	3,236
354	–	1,730	1,960	2,080	–
356	2,370	1,680	–	1,970	3,528
362	2,270	1,660	1,860	1,890	2,970
368	2,210	1,600	1,860	1,890	2,890
374	–	1,520	–	–	–
375	2,120	1,530	1,790	1,860	2,964
381	2,060	1,470	–	–	2,701
387	2,010	1,500	1,620	1,750	2,934
393	1,930	1,510	1,560	1,690	2,529
400	1,880	1,470	1,560	1,660	2,264
406	–	1,400	–	–	–
412	2,090	1,350	–	–	2,367
413	–	1,380	–	–	–
418	–	1,360	–	–	–
425	1,960	1,360	1,350	1,440	2,350
431	–	1,300	–	–	–
433	–	1,300	–	–	–
437	1,850	1,290	1,250	1,360	2,215
443	–	1,230	–	–	–
450	1,750	1,270	1,210	1,300	2,116
456	–	1,280	–	–	–
462	1,670	1,240	–	–	2,001
468	–	1,220	–	–	–
472	–	1,180	–	–	–
475	1,580	1,180	1,160	1,180	2,193
481	–	1,140	–	–	–
487	1,520	1,120	–	–	1,816
493	–	1,090	–	–	–
500	1,440	1,050	1,020	1,080	1,724
511	–	1,000	–	–	–
512	–	1,020	–	–	–
525	1,310	970	1,280	1,210	
537	–	900	–	–	–
550	1,190	890	1,170	1,120	
551	–	870	–	–	–
562	–	840	–	–	–
575	1,090	820	1,100	1,030	–

Maximum Allowable RPM for Spirolox Retaining Rings — Metric

Part NUMBER	VSM	ES	DNS	FS
6	51,561	-	-	-
7	39,742	-	-	-
8	40,518	-	-	-
9	35,627	-	-	-
10	31,833	-	-	-
11	25,202	-	-	-
12	30,875	22,153	-	-
13	26,805	20,094	22,915	31,185
14	22,359	18,471	19,967	21,602
15	19,625	14,543	17,836	24,273
16	17,364	14,149	18,132	29,110
17	14,958	15,923	15,677	19,841
18	13,439	12,233	16,195	22,605
19	12,140	11,685	14,221	20,417
20	11,066	10,810	12,948	18,532
21	15,326	9,641	12,475	16,896
22	13,341	10,397	11,421	13,523
23	-	9,652	10,495	14,213
24	11,035	8,479	10,825	19,083
25	10,214	8,524	10,020	11,982
26	12,483	8,642	9,301	12,494
27	-	11,357	8,721	14,320
28	10,648	10,259	8,609	15,229
29	9,973	9,765	8,060	18,016
30	9,534	9,149	7,562	12,189
31	-	8,495	-	-
32	8,437	7,778	8,686	14,215
33	-	-	8,205	9,511

Part NUMBER	VSM	ES	DNS	FS
34	7,398	7,982	7,763	10,847
35	7,004	7,485	7,628	11,685
36	6,641	6,903	8,474	11,640
37	-	7,227	-	-
38	5,994	7,174	7,556	10,520
40	7,573	6,172	7,181	10,841
42	6,888	5,715	6,546	8,972
45	6,021	5,158	5,740	7,861
46	-	4,909	5,505	7,006
47	-	5,570	5,283	7,232
48	5,309	5,744	5,075	7,881
50	4,901	4,084	5,651	7,885
52	6,057	3,616	5,251	7,318
53	-	3,450	-	-
54	-	3,295	4,842	6,811
55	5,380	3,360	4,680	6,576
56	5,238	3,215	4,525	6,354
58	4,890	3,111	4,359	5,942
59	-	2,982	-	-
60	4,575	2,862	4,050	4,793
61	-	2,683	-	-
62	4,323	2,884	3,738	5,490
63	4,220	2,773	3,691	5,071
64	-	2,780	-	-
65	3,967	2,577	3,430	4,806
66	-	2,526	-	-
67	-	2,275	3,239	4,463
68	3,602	2,486	3,201	3,945
69	-	2,438	-	

Part NUMBER	VSM	ES	DNS	FS
70	3,402	2,315	2,982	4,411
71	-	2,309	-	-
72	3,218	2,321	2,805	3,947
75	2,949	2,152	2,537	3,648
77	-	-	2,379	3,467
78	3,158	2,007	2,304	3,731
80	3,025	1,981	2,576	3,747
82	2,900	1,895	2,425	3,574
85	2,703	1,825	2,333	3,476
88	2,526	1,737	2,143	3,252
90	2,443	1,721	2,029	2,731
92	-	-	-	-
95	2,174	1,509	1,777	2,598
98	-	-	1,659	2,377
100	1,955	1,508	1,579	2,542
102			1,530	2,746
105	2,082	1,399	1,435	2,640
108			1,368	2,418
110	1,902	1,323	1,391	2,279
115	1,745	1,248	1,280	2,090
120	1,606	1,176	1,175	1,694
125	1,483	1,092	1,088	1,778
130	1,374	993	1,017	1,647
135	1,270	934	952	1,530
140	1,186	870	888	1,519
145		821	835	1,331
150	1,022	755	788	1,470
155	961	891	733	1,379
160	1,060	831	690	1,296

Part NUMBER	VSM	ES	DNS	FS
165	1,000	795	753	1,201
170	945	749	715	1,151
175	894	697	671	1,088
180	848	657	636	1,030
185	898	631	601	1,115
190	854	591	577	860
195	813	569	551	880
200	775	534	518	837
205			495	1,068
210	802	579	466	1,077
220	734	530	425	932
230	674	482	527	854
240	622	444	486	735
250	575	413	451	726
260	582	381	424	743
270	541	354	390	718
280	505	328	363	714
290	472	-	382	624
300	443	-	357	584
310	-	-	342	-
320	-	-	316	-
330	-	-	299	-
340	-	-	343	-
350	-	-	322	-
360	-	-	305	-
370	-	-	291	-
380	-	-	276	-
390	-	-	262	-
400	-	-	251	-

Installation Stress Analysis

The equations provided are used to check that the elastic stress limit of the ring material is not exceeded by stress due to installation. Standard parts that are assembled manually in the recommended shaft/bore and groove diameters do not require stress analysis. Special rings, or rings being assembled with special tooling, require stress analysis.

To select a safe stress value, it is necessary to estimate the elastic limit of the raw material. The minimum tensile strength, as shown in the materials table of the catalog, can be used as a suitable estimate. As with any theoretical calculation, a closer analysis of the actual application may reveal that these stress values can be exceeded. However, particular consideration must be made to functional characteristics such as installation method, the number of times the ring will be installed and removed, thrust load and/or centrifugal capacity.

After forming, the ring's natural tendency is to return to its original state. This places the inner edge of the radial wall in residual tension and the outer edge in residual compression. To account for the residual stress in the ring when expansion is taking place, only 80% of the minimum tensile strength should be used to compare to the installation stress; see Table 4.

In special designs, where the installation stress exceeds the material's elastic limit, rings can be produced to diameters which will yield a predetermined amount during assembly. Once installed, the ring will have the proper cling (grip) on the groove.

Installation Stress

Formula:

For external rings

$$S_E = \frac{E\,b\,(D_S - D_I)}{(D_I + b)(D_S + b)}$$

For internal rings

$$S_C = \frac{E\,b\,(D_O - D_H)}{(D_O - b)(D_H - b)}$$

Application	Percent of Minimum Tensile Strength
Shaft	80%
Housing	100%

Table 4

Where:

S_E = Stress due to expansion (psi)
S_C = Stress due to compression (psi)
E = Modulus of elasticity (psi)
b = Radial wall (in)
D_S = Shaft diameter (in)
D_H = Housing diameter (in)
D_I = Free inside diameter, minimum (in)
D_O = Free outside diameter, maximum (in)

Example: Compare theoretical installation stress to percent of minimum tensile strength.

1. WS-100-S02

$$S_E = \frac{28{,}000{,}000\ (.075)\ (1.000\text{-}.933)}{(.933 + .075)(1.000 + .075)}$$

$$S_E = 129{,}845 \text{ psi}$$

Minimum tensile strength of the ring material: 210,000 psi.
Using 80%, (Table 4), of 210,000 psi = 168,000 psi.

$$129{,}845 \text{ psi} < 168{,}000 \text{ psi}$$

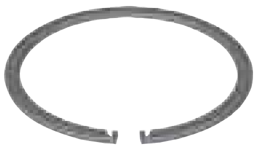
Since the installation stress is less than 80% of the minimum tensile strength, permanent set is not expected.

End Configurations

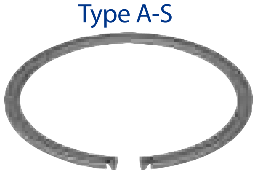
Smalley offers 4 series of Eaton style snap rings from stock. Additional end types can be manufactured to meet your snap ring requirements. Inquire about the following end types:

U-Notch

Type A-H

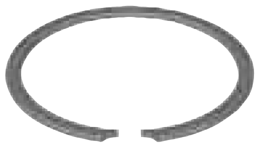


Type A-S

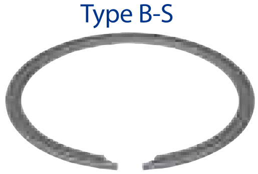


Double Scallop

Type B-H

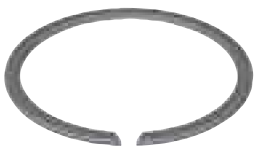


Type B-S

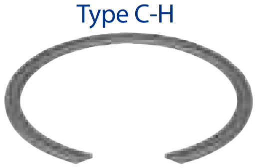


Double Angle

Type C-S



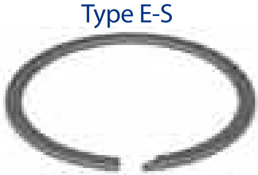
Type C-H



Single Scallop

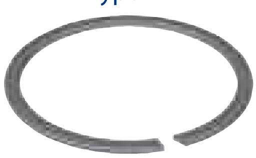
Type E-H

Type E-S



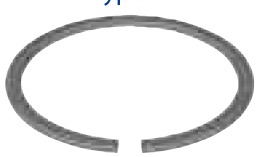
Single Angle

Type D



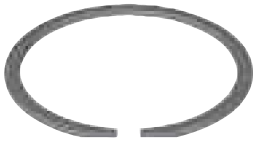
Pi-Cut

Type F



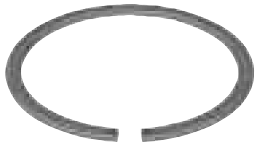
Flat Cut

Type G



Holes

Type H

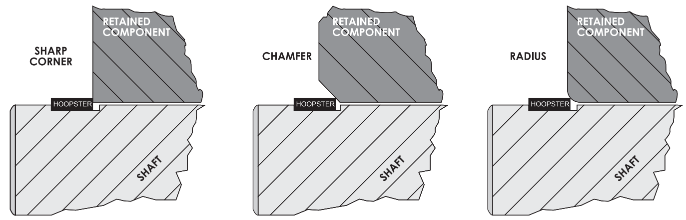


Material Hardness

Thickness (Inch)	Hardness (Rc) Min.
Up to .022	46.0
Over .022 to .050	44.0
Over .050 to .078	42.0
Over .078	40.0

Ring Abutment

Unlike a conventional Spiral Retaining Ring or Snap Ring, the retained component in a Hoopster® Retaining Ring* assembly may have a corner break. Thrust load is not sacrificed when the retained component has a broken corner because the moment arm is negligible in a Hoopster design.

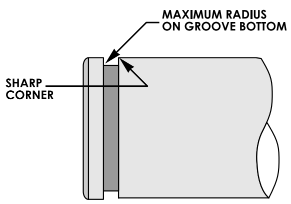


The 3 sketches above illustrate acceptable abutment practice.

Groove Design and Geometry

Groove deformation is by far the most common design limitation of most retaining rings. Unlike a conventional retaining ring or snap ring that fails by deforming and twisting, the Hoopster Retaining Ring shows superior strength from its low profile and mechanical advantage over traditional retaining rings under load. With a Hoopster, there is no moment arm that twists the ring causing premature failure as with a conventional retaining ring.

The shallow groove specification of a Hoopster makes the groove wall a critical specification, to ensure the function of the ring. To obtain maximum load capacity from a Hoopster Retaining Ring, it is essential to have sharp corners on the groove. The maximum radius on the groove bottom should be no greater than 10% of the ring's radial wall. Maintaining a sharp corner on the top of the groove is just as critical.



Formula: Maximum Radius on Groove Bottom = .10b

Where: b = Ring radial wall

Thrust Capacity

The shallow groove depth associated with a Hoopster, in combination with the groove material, are the controlling factors in determining thrust capacity. The Hoopster does not twist when loaded so pure thrust load based on the yield strength of the groove material maximizes the Hoopster's load carrying capacity.

Formula:

$$P_G = \frac{D\,d\,S_y\,\pi}{K}$$

Where:

- P_G = Allowable thrust load based on groove deformation (lb)
- D = Shaft or housing diameter (in)
- d = Groove depth (in)
- S_y = Yield strength of groove material (psi)
- K = Safety factor (2 recommended)

Typical Groove Material Yield Strengths	
Hardened Steel 8620	110,000 psi
Cold Drawn Steel 1018	70,000 psi
Hot Rolled Steel 1018	45,000 psi
Aluminum 2017	40,000 psi
Cast Iron	10-40,000 psi

Table 5

*PATENT PENDING