

## TECHNICAL GUIDE

# HOW TO SOLVE YOUR HIGH ROTATIONAL CAPACITY APPLICATION CHALLENGES

SMALLEYS RETAINING RING SOLUTIONS



Smalley offers a variety of retaining ring solutions engineered with your high rotational capacity applications in mind.

[smalley.com/RPM](http://smalley.com/RPM)



**SMALLEY**

THE ENGINEER'S CHOICE™

# TABLE OF CONTENTS

## Overview

Fastening Options for High Rotational Capacity Applications .....	3
---	---

## Background and Applications

Background .....	4
Common High Rotational Capacity Applications .....	4

## Self-Locking Retaining Ring Solutions

Retaining Ring Solutions for High RPM .....	5
---	---

## Spirolox® Retaining Rings

Standard Solution for Low RPM .....	6
-------------------------------------	---

## Custom Spirolox® Retaining Rings

Custom Solution for Moderate RPM .....	7
--	---

## 'Tab and Slot' Self-Locking Ring

'Tab and Slot' Design .....	8
Advantages .....	9

## 'Dimple and Slot' Revolox™ Self-Locking Ring

'Dimple and Slot' Design .....	10
Advantages .....	11

## Development Process

Invention of the Revolox Self-Locking Ring .....	12
--	----

## Alternate Solutions

Application Issues with Other Options .....	13
---	----

## Future

High Rotational Capacity Applications .....	14
---	----

## Revolutionize My Design

Get Started .....	15
-------------------	----

# OVERVIEW

## Fastening Options for High Rotational Capacity Applications

### Safely and Easily Secure Your High-Speed Rotational Needs

Rotational capacity requirements for modern applications such as electric motors are higher than ever.

As the market leader for innovative retaining ring solutions, Smalley has been continually investing in ongoing research and development to meet the demand for high RPM requirements.

Over six decades ago, Spirolox®, a division of Smalley, invented the first self-locking ring. A self-locking ring is a custom retaining ring engineered to operate in high RPM applications.

Since then, Smalley has been paving the way for innovative high RPM retaining ring solutions.

### High RPM Fastening Options

We offer a few different types of high RPM retaining ring solutions.

This Technical Guide will discuss the pros and cons of each available option, including alternative solutions to retaining rings that our customers have tried prior to using our high RPM solutions.

If a standard catalog part does not meet your needs, then below are the three most common options:



Design a custom retaining ring



Add a self-locking feature to a standard or custom retaining ring



Review non-retaining ring alternate solutions  
(often requires additional components, increased assembly time, and higher overall cost)

# BACKGROUND AND APPLICATIONS

## Background

### Retaining Ring RPM Limitations

With rotational capacity requirements of modern applications higher than ever, many engineers struggle to find retaining rings that can withstand high speeds. If an engineer settles for a non-retaining ring alternate design, it often results in more assembly time and costs more money, or even worse, fails in the application.

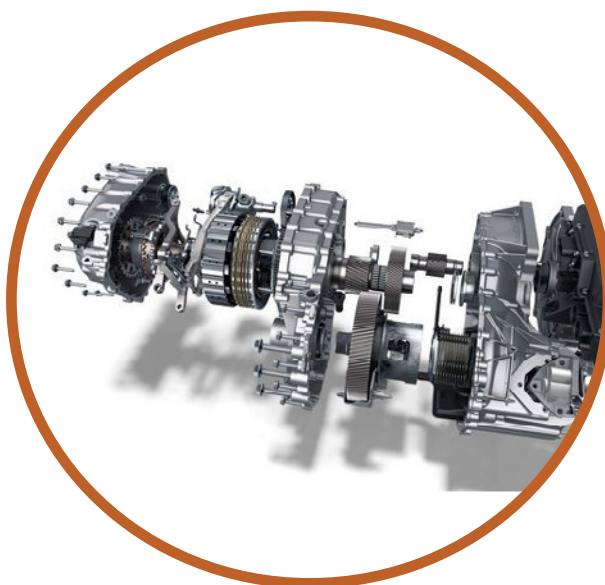
Centrifugal forces limit all retaining rings operating on a rotating shaft. If the centrifugal forces are great enough to expand and lift the retaining ring from the groove, failure usually occurs.

## Common High Rotational Capacity Applications

### Where are some common high rotational capacity applications?

Rotational-dependent applications can be found in nearly all industries, but are especially critical for the automotive, industrial, and aerospace industries. For example, shafts in automotive applications can reach 15,000 RPM or more.

A retaining ring designed for high RPM is critical in applications such as electric motors, automotive transmissions, gearboxes, and high-speed spindles.



*Fig 1. Electric vehicle transmissions require a fastening solution that can withstand high RPM.*

# SELF-LOCKING RETAINING RING SOLUTIONS

## Retaining Ring Solutions for High RPM

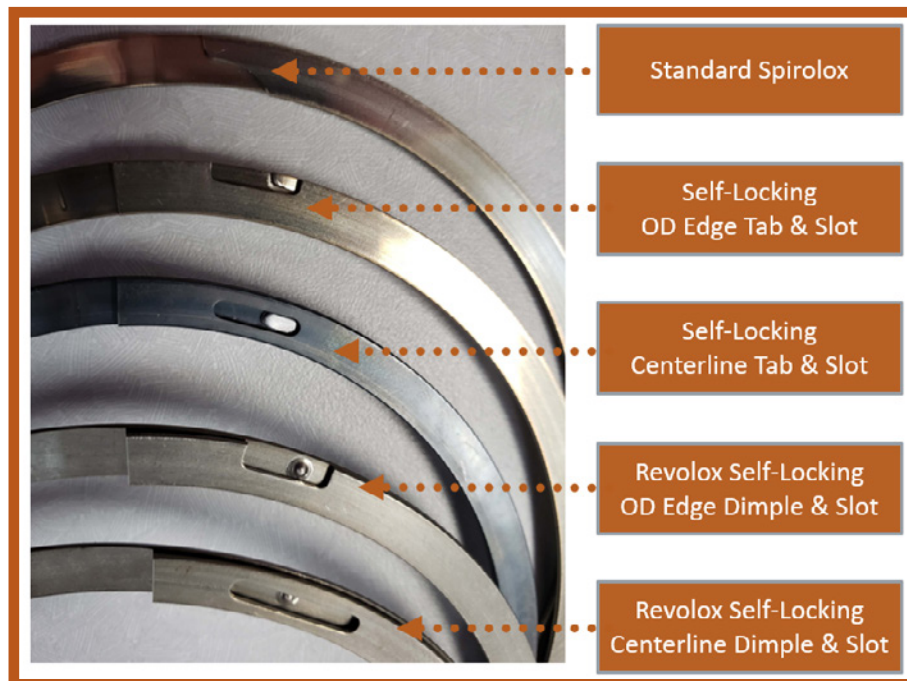
### What option is right for me?

Smalley has been leading innovation for retaining rings for over a century.

In Fig 2 below, Smalley's retaining ring options are shown. First is the Spirolox Spiral Retaining Ring that is not specifically designed to withstand high RPM. It has a removal notch to aid with removal. Rotational capacity can be increased with a custom design.

Next, the self-locking ring (designed for highest RPM) is pictured in the 'tab and slot' configuration on the outer ring and centerline ring diameters.

Then, the Revolox Self-Locking Ring (designed for high RPM) is pictured in the 'dimple and slot' configuration on the outside edge (preferred placement) and centerline of the ring. The placement of the self-locking feature depends on the application.



*Fig 2. Smalley's high RPM retaining ring solutions.  
OD represents outer diameter.*

# SPIROLOX® RETAINING RINGS

## Standard Solution for Low RPM

Should I use a Spirolox Retaining Ring, Constant Section Ring, or Tapered Section Retaining Ring (Circlip)?

For low to moderate rotational capacity requirements, a standard Spirolox Retaining Ring may work.

Advantages of a [Spirolox Retaining Ring](#):

- **Easiest, fastest option compared to a custom design**  
Over 6,000 standard sizes in stock to choose from
- **Better balanced compared to Tapered Section Retaining Ring**  
Tapered Section Retaining Rings have lugs that contribute to imbalance and excess vibration during high speeds.
- **No yielding during installation or rotation**  
Spirolox Retaining Rings can be installed by hand, requiring no special tools. Snap rings are installed with pliers and may yield during installation due to the ring's heavy cross-section. Snap rings may also yield from high-speed rotation. Yielding can be seen in Fig 4.

You may want to consider other options if:

- **Your application's rotational requirements exceed a standard Spirolox Retaining Ring's max RPM capabilities**  
We offer free samples if you would like to test Spirolox RPM performance for yourself.
- **Your application dimensions don't match a standard Spirolox Retaining Ring**  
Rings can easily be customized by making changes to thickness, radial wall, and diameter.
- **Installation ease/rotating mass is important to you**  
Spirolox Retaining Rings with a heavy cross-section can be more difficult to install, cost more, and increase the total application weight. Other options have a cross-section optimized for installation, cost, and efficiency.



*Fig 3. Standard External Spirolox Retaining Ring.*



*Fig 4. Yielding (deformation) on a Tapered Section Retaining Ring from rotation.*

# CUSTOM SPIROLOX RETAINING RINGS

## Custom Solution for Moderate RPM

### Does a custom Spirolox Retaining Ring make sense for my application?

If your rotational capacity requirements exceed a standard Spirolox Retaining Ring's capabilities or your application dimensions don't quite match a standard size, then a [custom](#) Spirolox Retaining Ring may work for you.

Why is that? The rotational capacity of a retaining ring is a function of several design parameters, including thickness, radial wall, cling (interference fit of the ring in the groove), diameter, etc. The design parameters are labeled below in Fig 5. for your reference.

Through a custom design, the rotational capacity of the ring may be improved by increasing the radial wall and/or increasing the amount of cling in the groove by decreasing the free inside diameter of the ring.

#### Nomenclature:

- Ds: Shaft Diameter (in)
- Dg: Groove Diameter (in)
- w: Groove Width (in)
- Di: Free Inside Diameter (in)
- t: Ring Thickness (in)
- b: Ring Radial Wall (in)

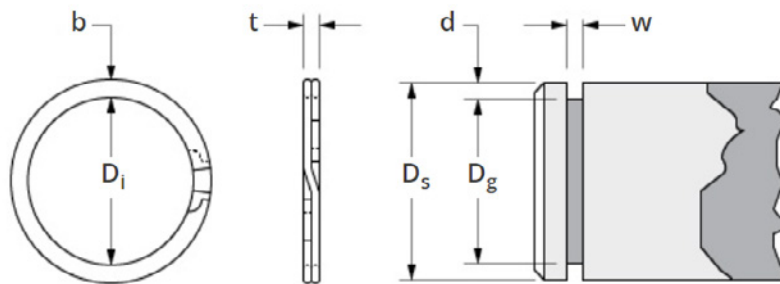


Fig 5. Retaining ring parameter dimensions.

Advantages of a Custom Spirolox Retaining Ring:

- **Higher RPM capacity than a standard Spirolox Retaining Ring**
- **Most economical of the custom retaining ring options for low to moderate RPM**

You may want to consider other options if:

- **Your application's required rotational capacity cannot be met by the methods outlined above**  
A custom self-locking feature can be added to the ring, as explained later on in the E-Book.

*Note: Since the self-locking feature significantly increases the rotational capacity of the ring, the design can then be optimized to minimize rotating mass and assembly time.*



# 'TAB AND SLOT' SELF-LOCKING RINGS

## 'Tab and Slot' Design

### What is a Self-Locking Ring?

Spirolox®, a division of Smalley, invented the 'Tab and Slot' [Self-Locking Ring](#) back in 1958. The innovative design has been proven in thousands of high-speed applications.

So, what is a self-locking ring?

A self-locking ring is a custom retaining ring feature that increases a ring's rotational capacity.

This self-locking feature consists of a 'tab and slot' design that interlocks to prevent the ring from expanding due to centrifugal forces. The tab lines up with a slot on the mating turn such that when the ring is installed into the groove, the tab locates inside the slot securing the ring from expansion.



*Fig 6. The 'Tab and Slot' Self-Locking Ring in the outer diameter (OD) configuration.*



# 'TAB AND SLOT' SELF-LOCKING RINGS

## Advantages

### What are the benefits of the 'tab and slot' design?

The 'tab and slot' design allows the ring to function properly at speeds far exceeding the rotational capacity of a standard retaining ring.

The self-locking tabs can be designed on the outside diameter (for external retaining rings) or on the centerline of the ring.



*Fig 7. 'Tab and Slot' Self-Locking Ring in the outer and centerline diameter 'tab and slot' configurations.*

Installation of the self-locking ring follows the same process as installing a standard Spirolox® retaining ring. Both tabs must be fully secured in their respective slots on the mating turn. Proper installation can be visually inspected.

### Advantages of a 'Tab and Slot' Self-Locking Ring

- **Can withstand vibration, function under rapid acceleration, and absorb a degree of impact loading**
- **Most secure and highest RPM capabilities**  
'Tab and slot' design allows for the highest RPM capacity of all retaining ring options.

You may want to consider other options if:

- **High volume automated installation capabilities are important to you**  
No semi or fully-automated installation is currently available for 'Tab and Slot' Self-Locking Ring.
- **Ease of installation is important to you**  
Improper installation can cause tab misalignment and damage. This may result in premature ring failure.

Additionally, rings with heavier cross sections are generally more difficult to install. Heavier cross sections require more material and are therefore more costly.

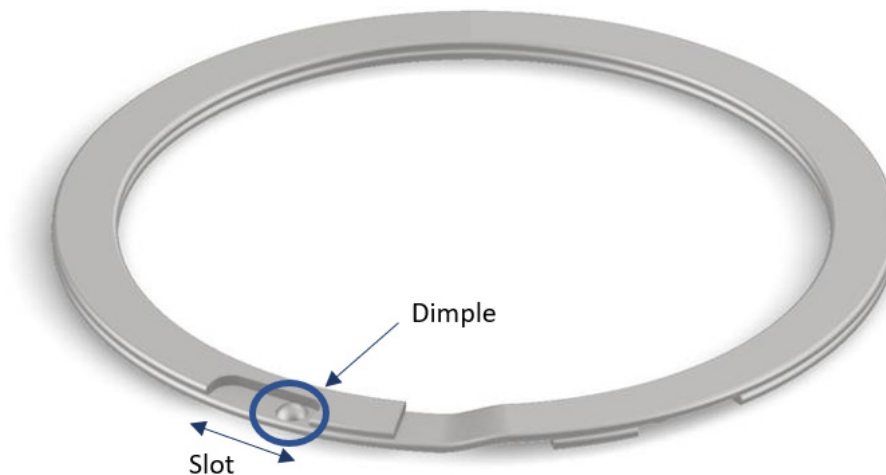
# 'DIMPLE AND SLOT' REVOLOX™ SELF-LOCKING RING

## 'Dimple and Slot' Design

What is the Revolox Self-Locking Ring and how does it work?

Smalley's latest innovation is the 'Dimple and Slot' [Revolox Self-Locking Ring](#).

The 'dimple and slot' design prevents ring expansion at high speeds.



*Fig 8. Revolox Self-Locking Ring with dimple and slot labeled.*

So what is a 'dimple and slot' design, and how does it work?

The dimple feature is punched into the underside of the ring, resulting in a dimple shape on the opposing side of the ring. It's integral that the dome shape protrudes above the surface of the ring, but with no shearing. The slot portion is created by cutting into the mating turn.

The dimple and slot are located such that the dimple is trapped within the slot once installed in a groove, thus locking into place.

As the ring rotates it expands, engaging the dimple and the slot and preventing any further expansion.

# REVOLOX SELF-LOCKING RING

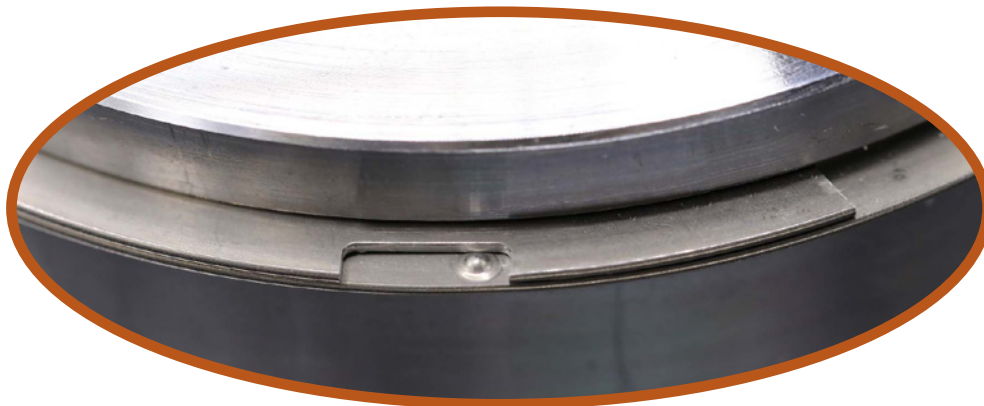
## Advantages

### What are the advantages of a Revolox Self-Locking Ring?

Revolox Self-Locking Rings have the same benefits as 'Tab and Slot' Self-Locking Rings, with the following additional advantages.

#### 1. Significantly higher RPM capacity over an equivalent non-locking retaining ring

Revolox Self-Locking Rings were tested and optimized for high RPM performance. Contact Smalley Engineers to discuss RPM capabilities in your application.



*Fig 9. The 'dimple and slot' design prevents ring expansion.*

#### 2. Ease of installation

The sturdy 'dimple and slot' design is not easily damaged during installation.

#### 3. Lightweight

With a part weight approximately half the weight of a typical retaining ring, the lower part weight reduces rotating mass and therefore increases efficiency in the application.

#### 4. Automated installation capabilities

Automated installation capabilities make Revolox Self-Locking Rings an ideal solution for high production volumes.

#### 5. Inherently better-balanced than Tapered Section Retaining Rings

Revolox Self-Locking Rings have an inherently better-balanced design that helps decrease vibration.

# DEVELOPMENT PROCESS

## Invention of the Revolox Self-Locking Ring

### How was the Revolox Self-Locking Ring developed?

The goal of the Revolox Self-Locking Ring was to develop a retaining ring optimized for high RPM (low cost and efficient) that could be installed in a semi or fully automated assembly line.

During the early stages of development, years of data and application experience were taken into account. After proof of concept was confirmed, the next step was to develop the machinery to produce the part. Smalley designed and created all of its tooling and machinery in-house. Specialized tooling was developed to create the dimple feature on the ring.

Once the initial prototype was developed, the next step was test the ring for design validation on our in-house RPM tester. Since typical automotive applications are around 15,000 – 16,000 RPM, our testing capabilities were designed to far surpass this range.

The RPM tester confirmed high RPM performance and what design parameters affected the performance of the ring. Optimal design parameters were determined using this data.

After evaluating and confirming manufacturability, prototypes were sent out to automotive customers for testing. The Revolox Self-Locking Rings have proven successful in production applications.

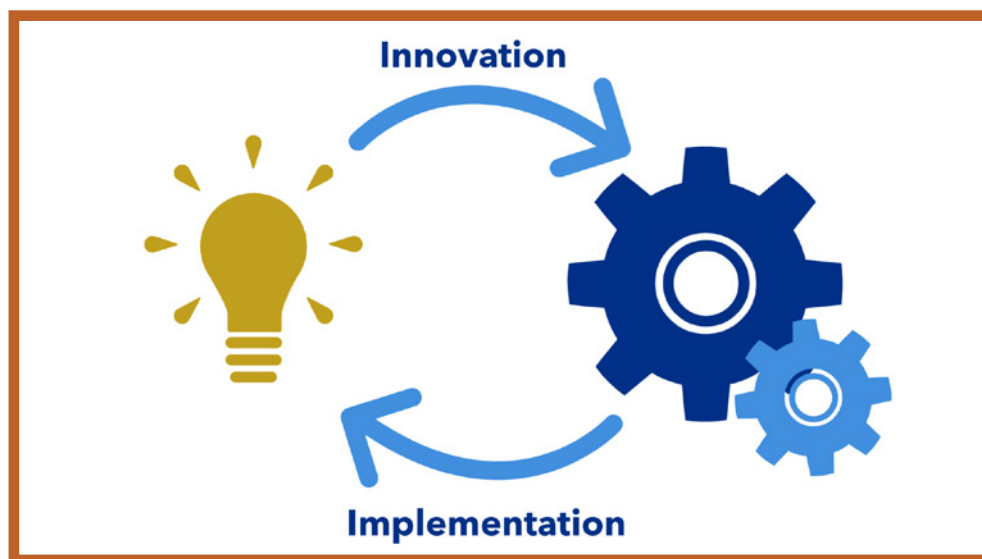


Fig 10. Process Development.

# ALTERNATE SOLUTIONS

## Application Issues with Other Options

### Are there other retaining rings designed to tolerate high RPM?

Until Smalley released its initial self-locking ring, there were no other retaining rings specifically engineered to securely withstand high RPM.

Before hearing about Smalley's high RPM solutions, engineers who have tried to use standard Tapered Section Retaining Rings in their designs state that they have experienced:

- Problems with yielding during installation due to the snap ring's heavy cross-section
- Excess vibration due to imbalance of the snap ring
- Yielding and failure at high speeds



*Fig 11. Yielding (deformation) on a snap ring after use at high RPM.*

Other alternate industry designs include:

- Adding multiple components to trap the ring, preventing the ring from expanding
- Welding the ends of the installed ring in place to prevent expansion
- Application redesign to avoid rings

In general, most of the alternate designs result in increased development and assembly time, weight, cost, and often new problems.

# FUTURE

## High Rotational Capacity Applications

### What does the future of high rotational capacity applications hold?

The demand for a secure and efficient high RPM fastening solution is critical as more and more applications require high rotational capabilities.

Smalley was the first to create a new fastening product category of self-locking rings. Whether your application has low to high RPM, Smalley has a variety of solutions to solve your rotational application challenges.

Smalley's latest innovation, the revolutionary Revolox Self-Locking Ring, enables engineers to design around higher rotational capacity requirements safely, efficiently, and with ease of assembly for high volume applications.

[Work with a Smalley Engineer](#) to explore what high RPM fastening solution is right for your application.



*Fig 12. The demand for electric vehicles is increasing and the RPM requirements are higher than ever.*

# Revolutionize Your High RPM Design

As the inventor of the edgewound wave spring and with over 100 years of manufacturing excellence, Smalley is the Engineer's Choice® in providing wave springs, retaining rings, and constant section rings for all of your application needs.

We work with nearly every industry from aerospace, oil & gas, automotive, medical, off-highway to industrial.

While all of our manufacturing is made in our U.S. based 300,000 ft<sup>2</sup> facility, our global network of offices, engineers, and distribution partners allows you to quickly receive parts and support from anywhere in the world.



## Ready to get started?

We would love to hear from you.





# TECHNICAL GUIDE



[info@smalley.com](mailto:info@smalley.com)