RENCOL®

Making small parts.
Making a big difference.

SMART DESIGN · PERFECT FIT · NOISE FREE · LONG LIFE

makingabigdifference.com

SAINT-GOBAIN • MOBILITY

SAINT-GOBAIN

Contents

What is a RENCOL® Tolerance Ring?

The RENCOL® Tolerance Ring has waves or other features that are compressed in the assembly, providing a retention force between two mating components.

Each wave acts as a spring, exerting a force relating to its compression characteristics. This force holds the components together while also satisfying other performance requirements.

Manufactured from high quality spring stainless steel, carbon steel and alloys, it is capable of mounting components, torque transfer, torque overload protection, positionable hinges and axial slip between mating components with designed forces.

Advantages at a glance

- Simple fixing
- Torque transfer or limitation
- Tolerance compensation
- Simplifying assemblies
- Resonance frequency control
- Consistent performance throughout lifetime
- Alignment compensation
- Compensation of differential thermal expansion

What does a RENCOL® Tolerance Ring do?

The RENCOL® Tolerance Ring allows a simple consistent joint between cylindrical parts without the complications and cost of adhesive, secondary machining operations or machined detail, such as splines or threads.

Engineered radial fastening

The tolerance ring is compressed between two components, resulting in an engineered fastening.

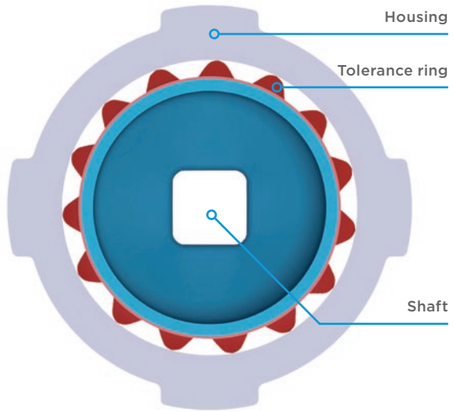
Static – holding the mating components together

- Bearing mount
- Stator mount
- Motor mount

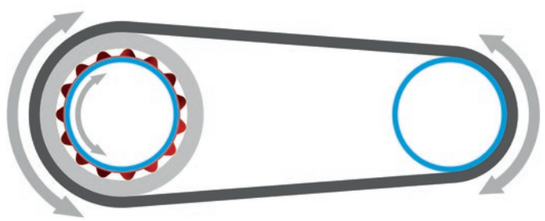
Torque drive

Transferring torque drive from one mating component to another

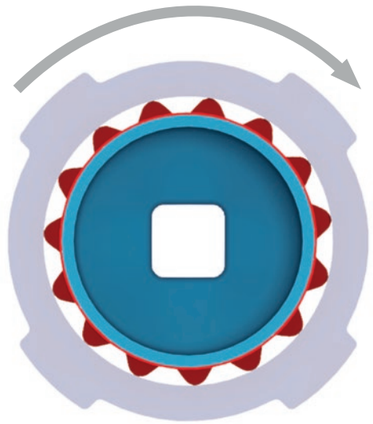
- Pulley mount
- Gear mount



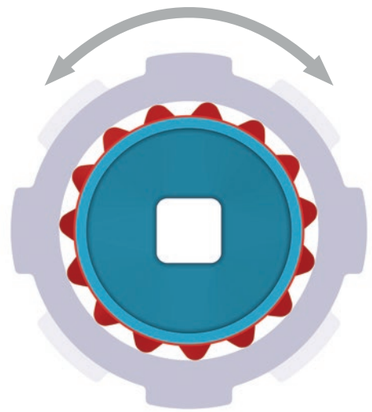
STATIC FASTENING



TORQUE DRIVE FASTENING



OVERLOAD PROTECTION



POSITION-ABILITY

Force slip – torque overload protection

In a torque overload application the RENCOL® Tolerance Ring sits between the driving component and the driven component. The system slips at a predetermined torque level controlled by the design characteristics of the tolerance ring and the mating components.

The Tolerance Ring acts as a cost-effective and space-saving slip clutch protecting expensive mechanisms such as gear boxes and motors from damaging torque overload situations.

Force slip – positionable systems

Dynamic - allowing mating components to move relative to each other at designed torque levels.

Another use of RENCOL® Tolerance Ring's force slip capability is pose-ability – the ability to set an object in a position which is then held. A tolerance ring allows smooth movement when the user moves the system and will maintain it's position when released.

How we make a big difference

A tolerance ring isn't just a stand-alone component; it is an integral part of a larger system that means a detailed, knowledge-based approach is needed for tolerance ring design.

That is why a RENCOL® Tolerance Ring is designed in collaboration with our customers, engineer to engineer. This process is made more powerful by using our FEA simulation capabilities along with in-house testing to analyse the system, with mating components included and under key conditions.

This means that we and our customers can have confidence in the solutions we provide.

Four Key Benefits

Our RENCOL® Tolerance Rings are designed to offer our customers four key benefits.

Exceeding our customers' expectations, by engineering weight, space and cost savings in their designs.

Making the assembly process truly efficient for our customers by using intelligent engineering to design solutions to suit our customer's system.

Minimising vibrations and reducing – or even eliminating – disturbing noise through our parts' unique geometries and structures.

Providing products that consistently perform over time, delivering controlled torque and retention forces.

Ease of assembly

PERFECT FIT

Process engineers are tasked with ensuring that the assembly line process is as efficient as possible.

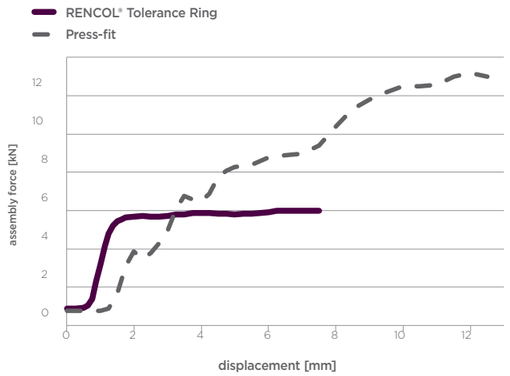
A RENCOL® Tolerance Ring can help the process engineer by reducing the forces required to assemble parts, keeping the assembly requirements to a minimum. Graph A shows that a RENCOL® Tolerance Ring reduces the assembly force significantly when compared to the press fit method. The spring properties of the tolerance ring also allow consistent assembly force throughout the tolerance range.

The press fit method is also limited to use with applications where both the mating components are made of similar materials. However, this isn't always possible. In cases where different materials are used – steel with aluminium for example – the differential thermal expansion can cause a significant drop in retention force. In this case, one can choose to assemble using heat-shrink press fit which increases the pressure holding the parts together or one can choose an adhesive fixing.

Both of these methods require either a heating and/or cooling process which can greatly increase the required factory floor space.

A RENCOL® Tolerance Ring can fix the parts together, compensate for component manufacturing tolerances and the tolerance ranges associated with differential thermal expansion coefficients. In addition, the assembly process is simple and induces less cost - as shown in Graph A on page 8.

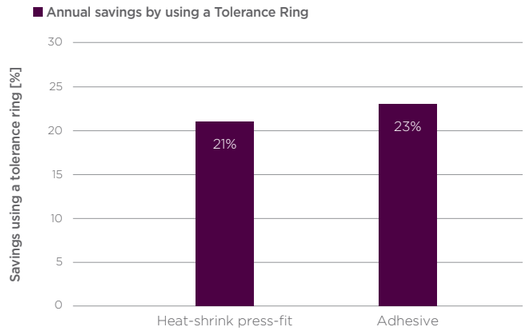
GRAPH A: ASSEMBLY FORCE OF A PRESS FIT AND A TOLERANCE RING FOR AN EXAMPLE BEARING MOUNT APPLICATION

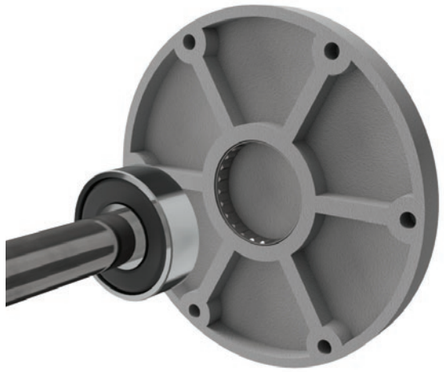


Reducing assembly costs

When fixing two components of different materials, a simple press fit can't always be used due to differential thermal expansion coefficients. In this case RENCOL® Tolerance Rings can offer a significant cost reduction vs heat-shrink press fit or adhesive.

GRAPH A: ANNUAL COSTS OF MOUNTING STATORS INTO ALUMINIUM HOUSINGS





Cost savings by reducing energy consumption and assembly time

Both of these techniques require temperature control in either heating or cooling down, which costs time and money. Graph A shows an example of the possible cost savings with RENCOL® Tolerance Rings based on an electric motor stator mounting solution with a 10 year project life and 1 million parts per year.

Cost savings by relaxing tolerances

Using a RENCOL® Tolerance Ring as a bearing mount solution allows the relaxation of tolerances and the precision requirements of the bearing housing due to the designed spring force characteristics. In an example case the tolerance on the housing was relaxed from IT6 to IT11. For a bearing housing with a 22mm diameter, this equates to going from a 13µm tolerance to 130µm.

By eliminating the precision turning process, a cost saving for the manufacturer for a batch size of 100,000, including the tolerance ring cost, is about 3% depending on the final design.

This study was calculated using a thermosetting plastic housing, the potential savings for metal housings will be greater.

Saving weight, without the problems

There are three major trends in the automotive industry, and other markets, that are strongly linked; reducing weight, reducing spatial footprint and reducing costs.

Reducing the space taken up by components means that the housing of the assembly can be smaller, usually resulting in reduced weight. In turn, if the overall weight is lower, the amount of CO_2 emissions are reduced, reducing the carbon tax on the car and the running costs.

Compensating for differential thermal expansion

Weight savings can also be achieved by changing the materials used in an assembly, such as changing from steel to a lighter material like aluminium. In some situations a simple switch can cause problems, due to the differential thermal expansion.

An aluminium housing will expand faster than a steel shaft when the temperature of the system increases. This means a simple press fit of the shaft into the housing will result in a reduction of retention force at elevated temperatures. Conversely, cooling the assembly can overload a bearing, leading to brinelling and torque shift. RENCOL® Tolerance Rings protect against this.

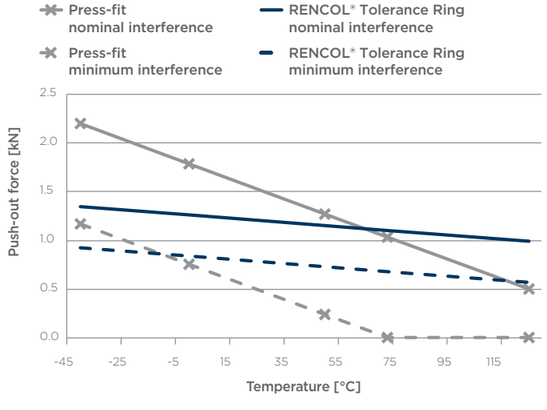
Using a RENCOL® Tolerance Ring to mount a stator or bearing into the housing results in more consistent retention forces due to the spring properties of the tolerance ring.

Consistent NVH properties throughout operating temperature ranges

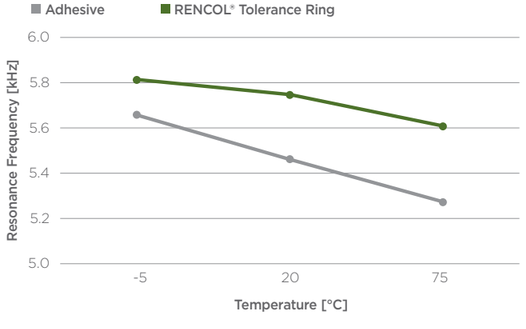
The use of aluminium housings, as a lightweight material, with steel shafts can also cause problems with vibration. For some electronics applications, elevated temperatures cause a decrease in dynamic stiffness of the joint, the result is a decrease in joint resonance frequency.

Graph B shows that more consistent resonance can be achieved throughout the temperature range using a RENCOL® Tolerance Ring that has been designed to have consistent static and dynamic stiffness across the temperature and tolerance ranges. A more consistent resonance frequency makes other aspects of the customer's design work, such as programming mechatronic systems, simpler.

GRAPH A: CALCULATED RETENTION FORCE THROUGHOUT A TYPICAL OPERATING TEMPERATURE RANGE



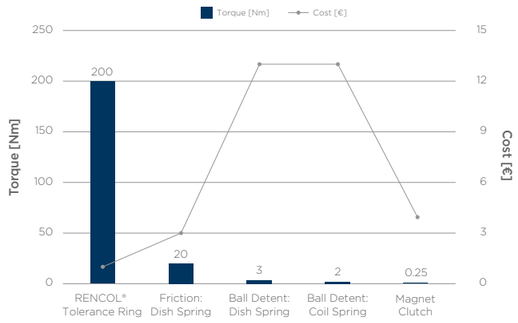
GRAPH B: RESONANCE FREQUENCY VERSUS TEMPERATURE



Savings in torque slip applications

Torque slip devices - or slip clutches - can be complicated systems with many components. A RENCOL® Tolerance Ring solution uses one component in-line with the mating components to reduce weight, space and overall cost.

GRAPH C: THE POSSIBLE TORQUE FOR A 35 MM DIAMETER X 35 MM WIDTH



Efficient solutions with RENCOL® Tolerance Rings

Torque slip devices come in many forms such as; magnetic clutch, friction slip devices and ball detent devices. Compared to a RENCOL® Tolerance Ring, all of these devices require more space to reach similar levels of torque

As shown in Graph C, for a given volume, the possible torque slip values are far greater for RENCOL® Tolerance Rings than for the alternative solutions. The other solutions would require larger housings to achieve similar torque levels.

The space saving for tolerance rings is enabled because tolerance rings work as an inline fixing between the driving and driven components. This means there is no need for an extra slip-clutch unit which takes up more space and weight.

Similarly, the torque generated when using a NORGLIDE® Bearing is also consistent with different sliding speeds. Graph C shows that a selection of NORGLIDE® Bearings have much more consistent torque performance between 45°/s and 135°/s than the PTFE/sintered bronze configurations.

Benefits

- The tolerance ring system uses a single component.
- Designs for 0.2Nm to 300Nm and beyond, depending on physical dimensions and the strength of the system for which the tolerance ring is designed.
- For human operated systems, tolerance rings offer a smooth feel, defining the perception of quality.
- The RENCOL® Tolerance Ring solution is custom designed to the optimal torque level rather than having to choose standard ranges with off-the-shelf products.

Notes

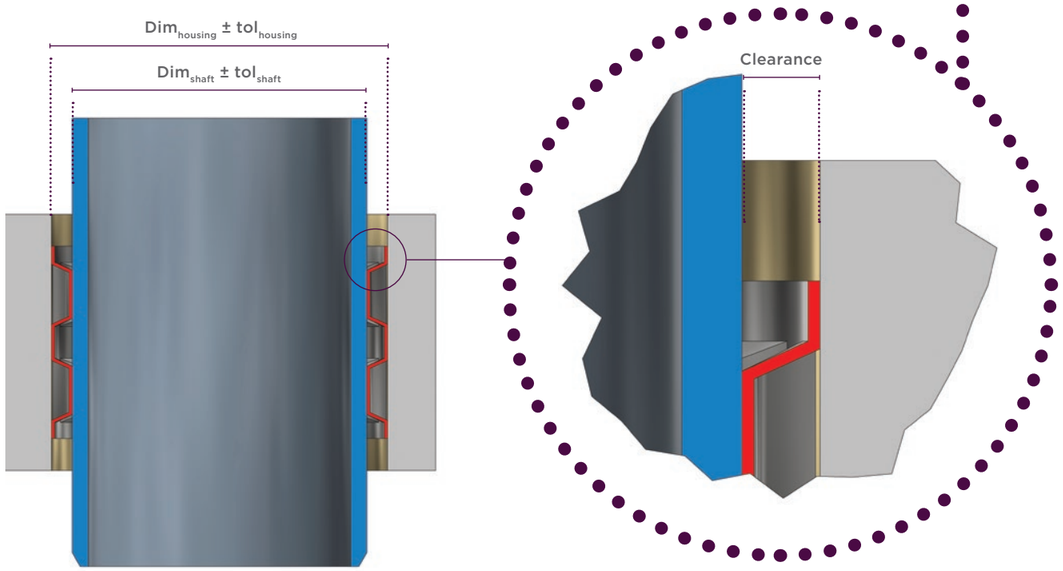
- Precision of the torque slip value is dependent on several factors and may require tight tolerances of the mating components.
- In some cases, grease is needed to control wear if multiple slips are required.
- Custom design and development to suit the requirements of each system.
- FEA tools and physical testing methods are used to develop best solutions for each usage case.

Compensating for mating component tolerances

PERFECT FIT

Mating components such as shafts, housings, bearings or stators are manufactured to certain tolerance ranges. Manufacturing tight tolerances to ensure good fit between parts can be expensive.

This is where RENCOL® Tolerance Rings get their name from as they are able to absorb the tolerance stack ups of mating components, relaxing the need for more expensive precision manufacturing.



$$\text{Clearance} = \frac{Dim_{housing} - Dim_{shaft} \pm (tol_{housing} + tol_{shaft})}{2}$$

Where; $(tol_{housing} + tol_{shaft})$ = tolerance stack-up

A tolerance ring can be designed with different levels of compression depending on the application. For example, a bearing mount has to compensate for large differential thermal expansions achieved with low compression. Torque slip applications need consistent radial forces over a range of mating component tolerances achieved with medium compression. Torque drive applications require higher load capability than bearing mounts, achieved with large compression.

5% compression

25% compression

Reducing noise and vibration

NOISE FREE

In cases where a system produces excessive noise or other NVH issues, a RENCOL® Tolerance Ring can be used to help reduce the overall noise level.

Anechoic test environment

Using our state-of-the-art anechoic chamber, our engineers are able to perform benchmark testing to fully understand the current problems of the customer. Comparison tests with RENCOL® Tolerance Rings then means that our customers can have confidence that our parts will give superior noise and vibration performance, in advance of any testing at the customer's facilities.

The chamber has a 7x7 metre space with a 20 dB noise floor and a 100Hz lower frequency limit so can be used to test most automotive assemblies, no matter how big or how quiet.

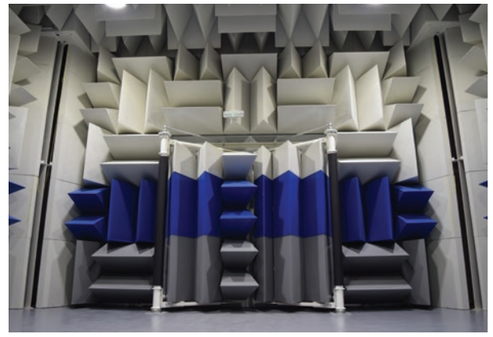
Minimising noise

Our engineers minimise noise by developing solutions that eliminate rattle conditions and absorb or isolate vibrating energy or to avoid natural frequencies by tuning the dynamic stiffness.

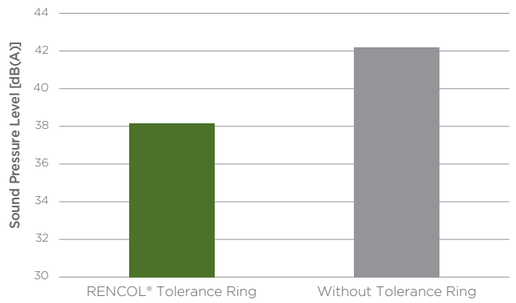
Reducing vibration

Our solutions can be tuned for dynamic stiffness so that problem frequencies can be avoided in a consistent way.

Graph A shows an example where the sound pressure level of an electric motor was reduced by 4 dB(A) by using a RENCOL® Tolerance Ring to mount the bearings.



GRAPH A: ELECTRIC MOTOR NOISE FOR TWO BEARING MOUNT SOLUTIONS



0.2 to 300 Nm
torque range, depending on the applications

Torque control

SMART DESIGN

LONG LIFE

End users want durable products that will last.
To help our customers achieve this, our engineers design torque slip solutions that do just that.

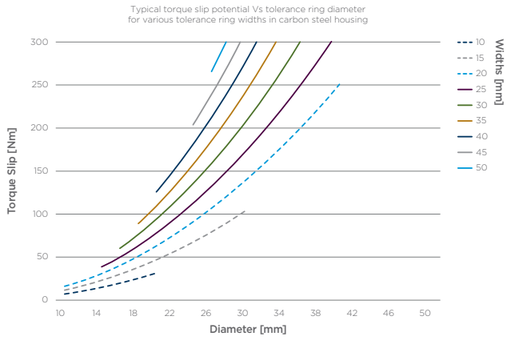
Torque overload protection

Some systems require protection from damage caused by end user misuse or occasional situations beyond the components design specification. Such systems can be found in electric motors for robotics or automotive systems including; rack and pinion, belt drive, steering column anti-theft, powered tailgate hinges and braking assist systems.

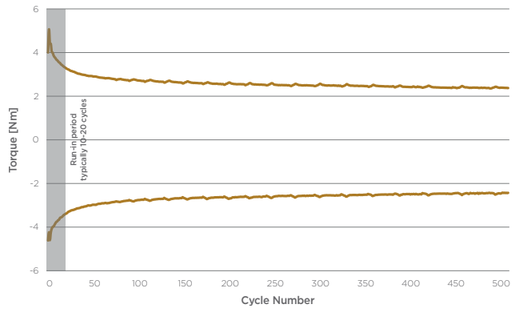
Consistent torque for life

In some applications maintaining consistent torque over a large number of slip-cycles is required. RENCOL® Tolerance Rings can be designed to reduce torque-drop over multiple slip-cycles that is often seen on other torque overload protection devices. Using RENCOL® Tolerance Rings in this way gives consistent performance for the life of the system.

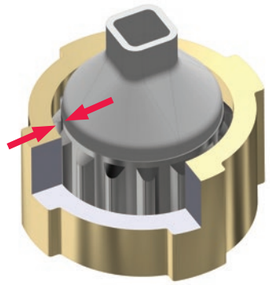
GRAPH A: TORQUE SLIP IN CARBON STEEL HOUSING



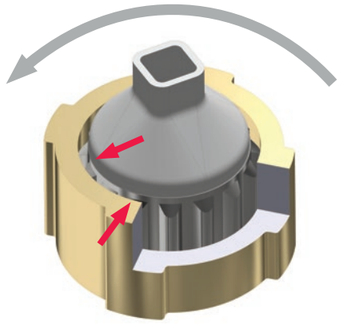
GRAPH B: TORQUE THROUGHOUT 500 SLIP CYCLES



These are theoretical guidance values for typical tolerance ring configurations only. If you have applications that are outside of these limits, contact us and we can recommend other designs.



Pre torque slip



Post torque slip

RENCOL® Tolerance Ring features

RENCOL® Tolerance Rings are engineered solutions that can be tuned for specific performance by modifying the different features.

The simplest of features are the material and thickness of the metal strip that is used to manufacture RENCOL® Tolerance Rings. Predominantly, the materials are carbon steel and stainless steel with various possible coatings. The material thickness can be altered, depending on the forces required in the individual application.

The waves, or corrugations, can be designed to face inwards or outwards, which is generally dependent on the assembly method. When the ring is mounted into the housing first, then tolerance rings known as housing variable (HV) are used, which have waves pointing inwards. Conversely, when the tolerance ring is mounted onto the shaft first, then shaft variable (SV) tolerance rings are used, which have the waves pointing outwards.

However, this is just a guideline and there are other factors that can affect the decision. Our expert engineers can guide you through this choice to find the best solution for your application.

Material choice

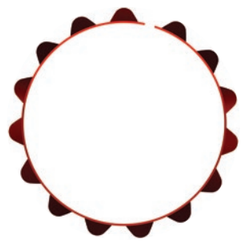
CS – Carbon Steel
SS – Stainless Steel
Coatings –Low friction/High friction etc.

Additional features

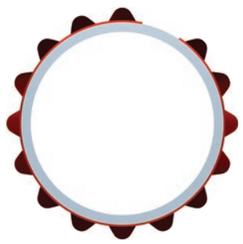
- Tabs for axial location
- Dual band of waves for extra stiffness and/or coaxiality
- End flare for ease of assembly
- Crown waves for ultra low stiffness waves

Standard HV ring in free state condition (large gap)

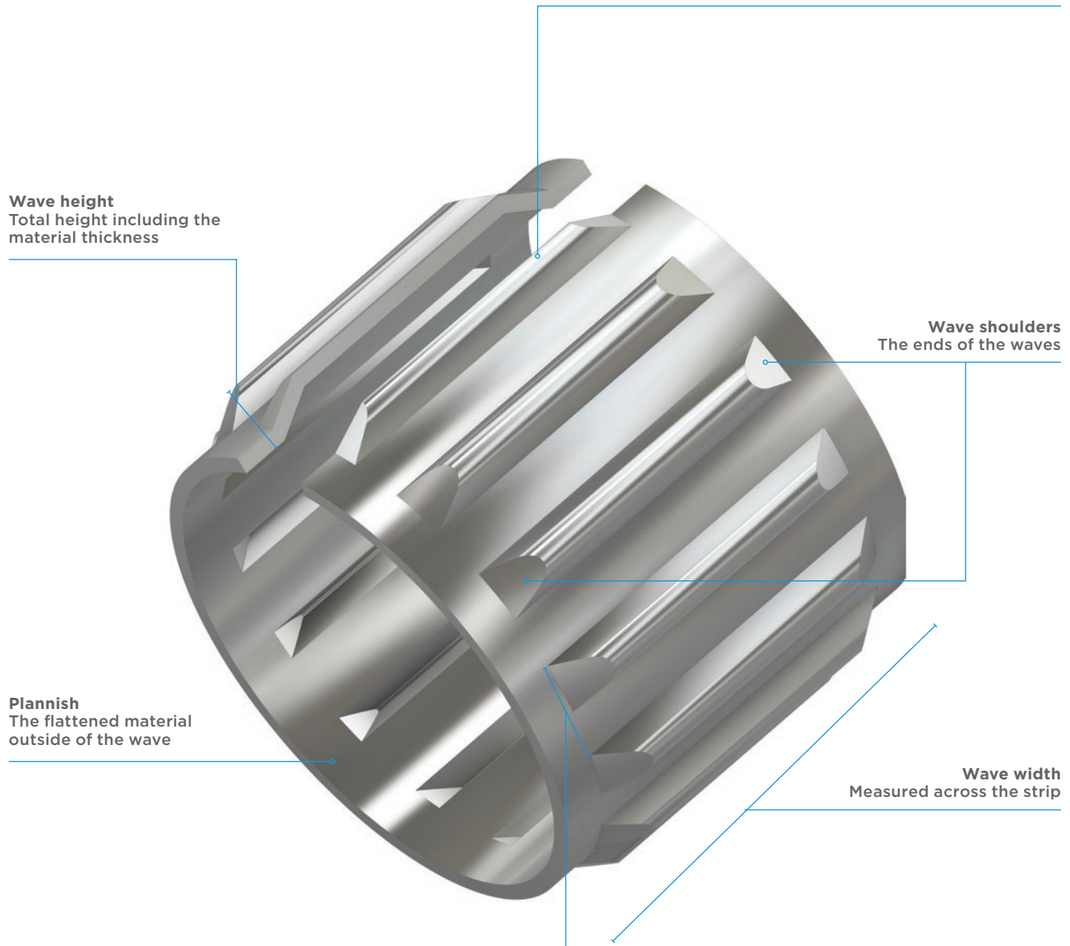
Standard HV ring assembled (reduced gap)



Standard SV ring in free state condition (small gap or overlap)



Standard SV ring assembled (increased gap)



Crown Ring

Tolerance Ring Tabs

Dual Band SVD Tolerance Ring

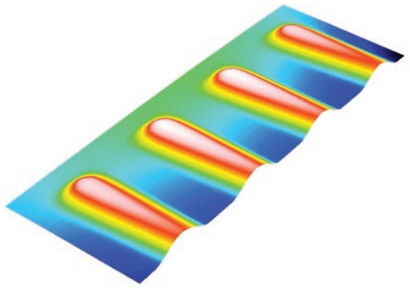
System design of RENCOL® Tolerance Rings

When designing a tolerance ring, it is important to note that the performance of the system is dependent on the mating components and assembly method as well as the tolerance ring.

It is recommended to involve Saint-Gobain engineers as early as possible in the design cycle for the optimal performance, however, we can often design the RENCOL® Tolerance Ring to work with non-optimised components.

Mating component factors that affect the performance of the system are; material, dimensions, tolerances and surface finish. Saint-Gobain engineers are available to give support on all factors from the start of the design project and throughout the production process.

They will help design the tolerance ring for your system and give recommendations if any mating components require modifications. Design considerations include:



Example surface profile of a RENCOL® Tolerance Ring created using the equipment shown on the opposite page

Corrosion resistance

The standard materials used in RENCOL® Tolerance Rings are stainless steel and carbon steel, however, for high corrosion resistance demands we can also use Inconel.

Tuneable stiffness

The stiffness can be adapted to achieve the required performance including consistent performance over a high mating component tolerance stack up, thermal expansions or for tuning the frequency response to reduce noise and vibration.

Heat transfer

Applications such as electric motors require a high thermal conductivity to ensure longevity of the parts and, more importantly, efficient operation. In this case, there are methods we can use to optimise the heat transfer ability of the tolerance rings.

Concentricity

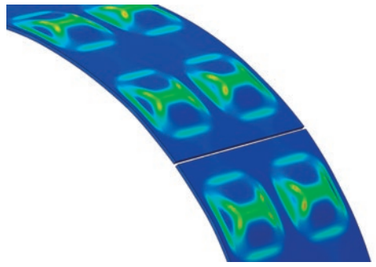
A tolerance ring can be designed to ensure concentricity specifications are met in applications where this is required.

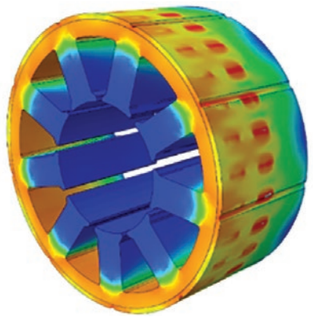
Packaging specification

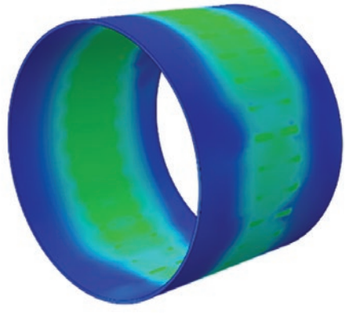
Dependent on the needs of the customer, some applications require for stacked and nested tolerance rings, others have cleanliness requirements, such as with electronics applications. Speak to our engineers to see how Saint-Gobain can accommodate your packaging requirements.

Design Tools

Saint-Gobain engineers have developed sophisticated design tools they can use to ensure the right RENCOL® Tolerance Ring solution for your application.







Design Tools

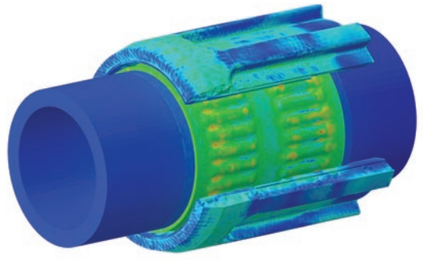
Saint-Gobain's engineers go through a thorough process that includes computational analysis, prototyping and in-house performance benchmarking and testing.

FEA – Finite Element Analysis

Saint-Gobain's FEA engineers have years of experience in modelling customers' components as well as RENCOL® Tolerance Rings and the interaction between them. They help create a RENCOL® Tolerance Ring design based on customer components, even offering design suggestions for the customer components. This way they can ensure you, Saint-Gobain's customer, can end up with the best possible system, not just the best possible tolerance ring.

A Mating Component Review (MCR) is used to assess the suitability of mating components for use with RENCOL® Tolerance Rings. Factors that evaluated include stiffness and strength limits. After this step, FEA is used to optimise a ring design, matching it to the components in order to get the best out of the system.

Where necessary, our engineers perform full assembly analyses to reduce the amount of time spent on creating prototype tolerance rings.

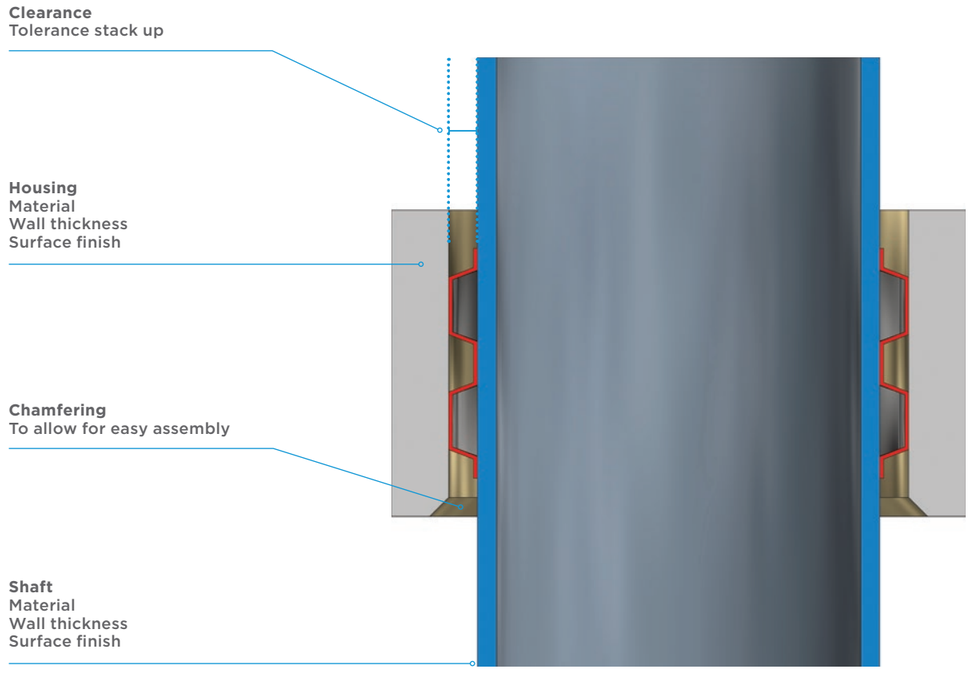


Example of finite element analysis of a steering column anti-theft application.

Prototyping and in-house performance testing

To ensure the right solution has been created for your application, Saint-Gobain creates prototype tolerance rings, which are then tested individually and in customer systems.

A range of testing methods are available to our customers, including; assembly and disassembly forces, torque, NVH, heat-transfer, concentricity and roundness.



Boosting design success

Saint-Gobain engineers can use their powerful FEA and testing capabilities to analyse the performance of the entire assembly, not just the tolerance ring. Our engineers have years of experience performing such analyses and with this insight, they can guide you through the most important factors that need to be considered.

So that we can make sure you get the design performance you need, we have to take into account the three components; the RENCOL® Tolerance ring and the two mating components.

Each application is different, but we commonly need information on the following to do this effectively:

Material properties of mating components

Strength of materials directly affects the performance of the tolerance ring.

The hardness/yield stress is an important factor as it gives the boundaries of radial force that the tolerance ring can exert. We have specialist tools that can check the force capacity of the mating components to see if the desired end performance is possible.

Surface roughness affects friction and, therefore, retention force and torque.

Geometry/dimensions

Tolerance range are the upper and lower actual possible dimensions after manufacture and allow us to understand how much the tolerance ring needs to compensate.

Diameter/width and tolerances determine the possible size of the tolerance ring and the range of performance that can be expected in an application. It is also normally necessary to adjust at least one of the component diameters in order to fit in a tolerance ring, so understanding which components are changeable is important.

Wall thickness can be used to calculate how much force the mating components can withstand before plastically deforming.

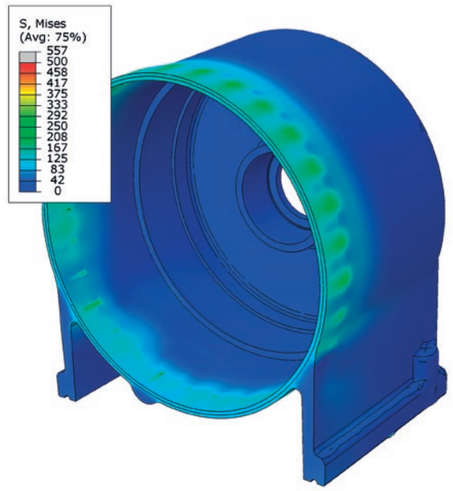
Chamfer/radius on the lead-in edge of the mating part is necessary as sharp corners could dig in and damage the tolerance ring during assembly, sacrificing performance.

Production considerations

Installation can be automated or manual, which can affect the choice of tolerance ring type and also packaging considerations.

Understanding your assembly process steps is important for us to design the right tolerance ring for your needs.

If lubrication is permitted, the tolerance ring design will have to take this into account to achieve an optimised assembly.

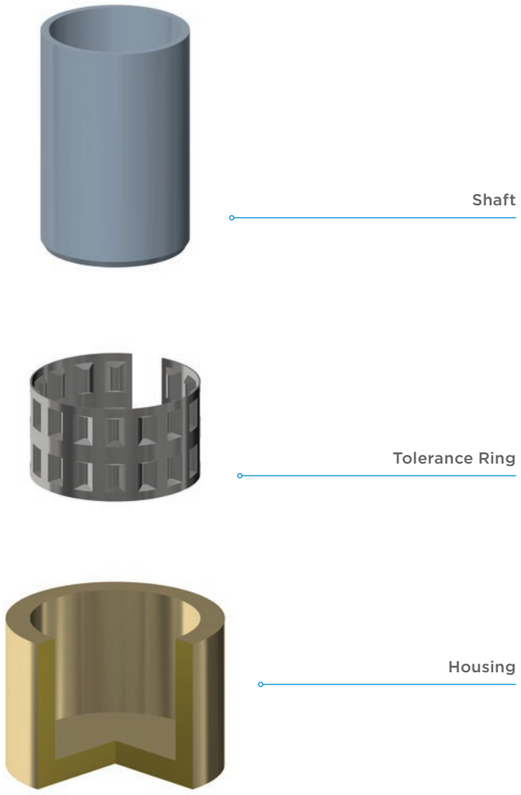


HV style RENCOL®
Tolerance Ring installation

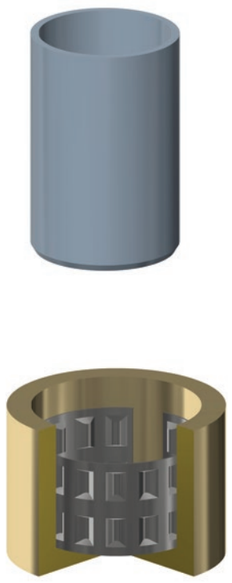
The HV style tolerance ring is open in the free state so that when installed inside a bore, the ring will conform to that bore and be self-retaining. The ring sits in the housing with corrugations on the inside to be compressed by the outer diameter of the mating part.

1. Insert the ring by carefully squeezing the free ends together and placing it into a bore. Care should be taken to ensure that the ring nests squarely in the housing bore.

If there is no shoulder in the housing bore, it will be necessary to use a backing plate behind ring to prevent it from sliding out of position when the inner component (such as a shaft or bearing) is inserted.

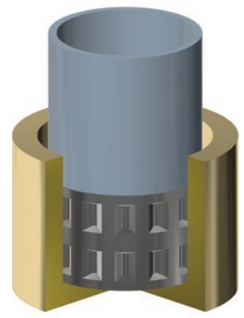


2. Place the housing and ring assembly along with the inner component into an assembly press fixture. A fixture is necessary to ensure that the inner component and bore are held concentric and square to one another.



3. Apply a uniform and consistent force using an arbour press or hydraulic cylinder to fully seat the inner component into the bore.

If required, fixturing can be used for improved concentricity. Work with our engineers to ensure the right assembly solution for your application.



Manual assembly is shown but this can easily be adapted to high volume automated assembly. Saint-Gobain engineers can give advice throughout the whole assembly process.

SV style RENCOL®
Tolerance Ring installation

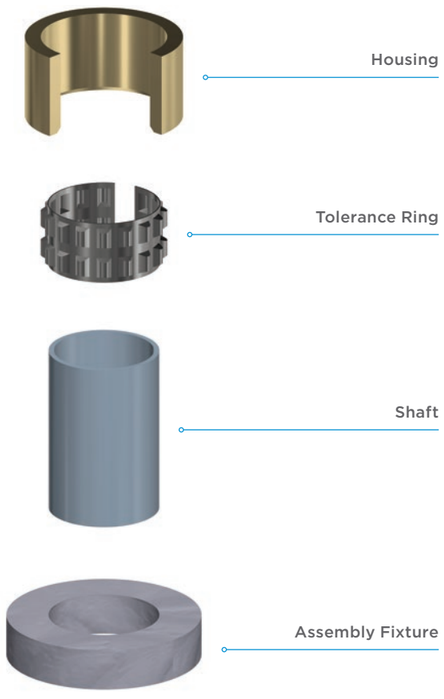
The SV style tolerance ring is normally closed in the free state so that when installed onto a shaft, the ring will conform to that shaft and be self-retaining. The ring sits on the shaft with corrugations on the outside to be compressed by the inner diameter of the mating bore.

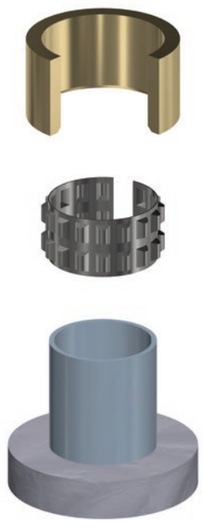
1. Open the free ends of the tolerance ring and place over the shaft. Care should be taken to ensure that the ring nests squarely on the shaft.

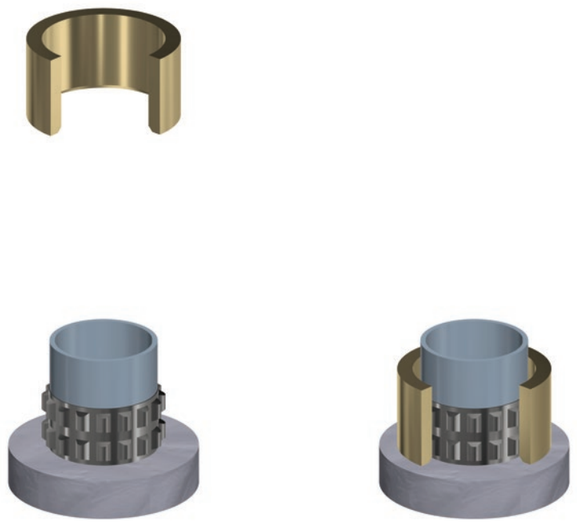
If there is no shoulder on shaft, it will be necessary to use a temporary assembly back stop to prevent the tolerance ring from sliding out of position when the housing bore is pressed onto the shaft/tolerance ring assembly.

2. Place the shaft and ring assembly along with the housing component into an assembly press fixture. A fixture is necessary to ensure that the inner component and bore are held concentric and square to one another.

3. Apply a uniform and consistent force using an arbour press or hydraulic cylinder to fully seat the housing component onto the tolerance ring.

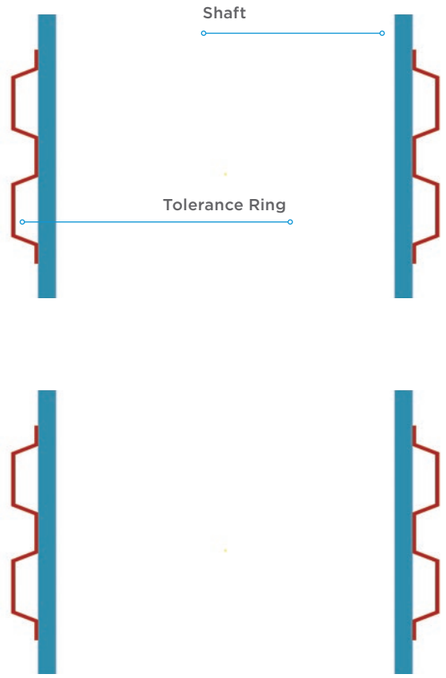


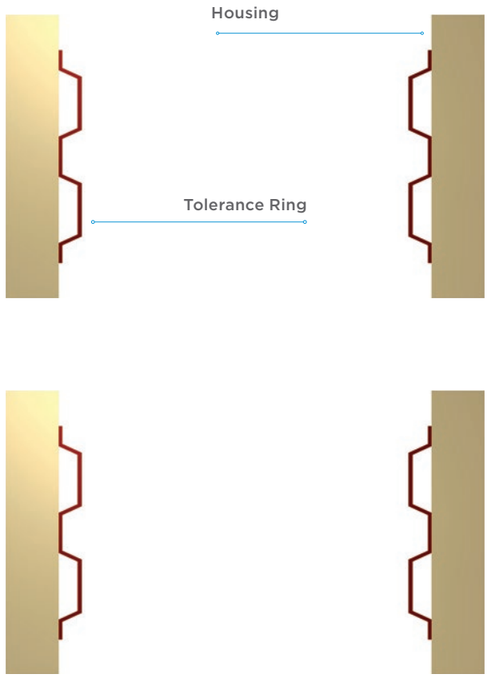




Tolerance Ring Arrangements

Saint-Gobain engineers endeavour to make the assembly process suit the needs of customers. Mating components can be designed, with the help of our engineers, to create a reliable and efficient process.





SV Ring Free Arrangement

HV Ring Free Arrangement

Free Arrangement

This arrangement is the most cost effective assembly method as the mating components do not need any locating features on them. In this arrangement, the Tolerance Ring is subjected to the full radial loading conditions. If these radial loads are high, another type of arrangement may need to be adopted.

More complex fixturing is needed to hold the ring in place while assembling, if the ring is not flush with the end of the shaft or housing.

SV Ring Piloted Arrangement

HV Ring Piloted Arrangement

Piloted Arrangement

This piloted arrangement involves adding a feature to the housing or shaft that is used for locating and positioning the tolerance ring. This is used to simplify the assembly process and also improve the concentricity and radial loading capacity of the system.

SV Ring Centred Arrangement

HV Ring Centred Arrangement

Centred Arrangement

This arrangement provides a groove in the housing for HV rings or a groove in the shaft for SV rings. These grooves capture the ring axially on both sides and simplify assembly.

When the shoulder (stepped) diameter is held close to the nominal diameter, the following advantages occur:

- Improved alignment of parts during installation
- Highest level of concentricity of all assembly conditions
- Highest radial load capacity of all arrangements, as the shoulders of the grooves can be used to withstand excessive radial loads.

Contact us

To discuss your challenges or find out more about us, please call the relevant number below.
Or email us at **makingabigdifference@saint-gobain.com**

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