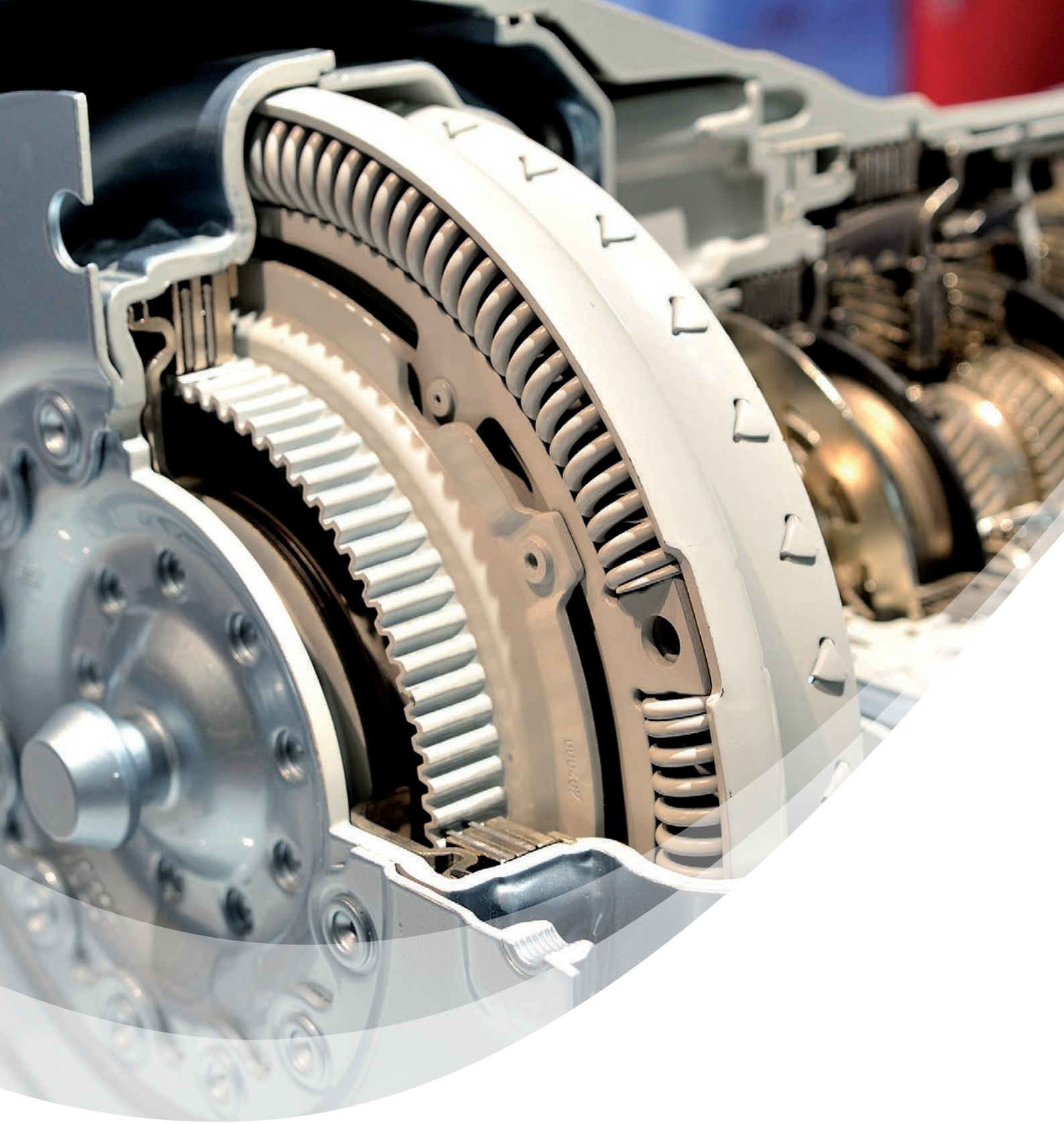


DICHTOMATIK
RADIAL SHAFT SEALS

DICHTOMATIK

FREUDENBERG
INNOVATING TOGETHER

CONTENTS

COMPANY

The Freudenberg Group was founded in 1849 and is still owned by the approximately 300 descendants of the company founder. The resulting financial stability and social awareness are decisive success factors that create trust. Today, Freudenberg is a global, broadly diversified group of companies divided into Business Groups that operate in a wide variety of sectors. The company has always been considered an innovation and technology leader, from Vileda® brand household products to technically complex sealing solutions.

Freudenberg Sealing Technologies (FST) is the largest Business Group in the Freudenberg Group and is part of the Seals and Vibration Control Technology division. FST is a supplier, development and service partner for customers in a wide range of market segments, such as the automotive, civil aviation, mechanical engineering, shipbuilding, pharmaceutical, agricultural, construction machinery and food and beverage industries.

Starting with the Simmerring® developed by Freudenberg in 1929, FST now has a broad, continuously customer-oriented product portfolio of premium sealing technology for highly demanding applications – from tailor-made individual solutions to complete sealing packages. The company benefits from more than 170 years of engineering and materials experience in the research, development and introduction of innovative product and process solutions.

Freudenberg Sealing Technologies rounds off its portfolio with complementary industry-standard solutions from the Dichtomatik product brand. The two-brand strategy is part of FST's comprehensive service portfolio and guarantees a full range of seals and product-related services. Dichtomatik products are manufactured by certified suppliers and are available in numerous seal forms and materials. They are suited for moderate operating conditions in static and dynamic applications and for fluid seals in a wide range of market segments. These include the hydraulics industry, the wind power plant industry, agricultural machinery and systems and components for general mechanical engineering. For more specific applications, e.g. in the food industry, Dichtomatik brand products are also available in certified materials.

Freudenberg Industrial Services offers technical services such as the preparation of drawings, radial force measurements, comprehensive quality and material documentation as well as material modifications and testing to ensure that all seals function reliably even in individual applications. Furthermore, local availability ensures short distances and fast response times to best serve customer needs.

FST SERVES THE ENTIRE SEALING MARKET AND THUS MEETS ALL MARKET REQUIREMENTS – QUICKLY, RELIABLY AND FROM A SINGLE SOURCE.

INDUSTRY-SPECIFIC AND CUSTOMIZED SERVICE CONCEPTS

ONLINE ORDERING PLATFORM EASY

The EASY online ordering platform enables easy order processing, as well as price, delivery time and stock queries around the clock. Besides detailed product information, installation space and cross-sectional drawings are available for download. The EASY Business Connector is used to transfer your orders directly to your SAP system. This ensures that you are always up to date on the status of your order. Register today if you do not yet have an EASY account.

APPLICATION KNOW-HOW

Dichtomatik products are also certified for special applications, e.g. in the food industry. This enables us to find the right solution for every application. To ensure that seals function reliably even in individual applications, our team of experts offers technical services such as drawing preparation, radial force measurements, comprehensive quality and material documentation as well as material modifications and testing. Customer-specific sealing solutions, kitting and single packaging are just some of the other services that can be offered (offerings vary by country).

LOGISTICAL SERVICES AND QUALITY STANDARDS

The 6,500 m² warehouse in Hamburg, which functions as a European logistics hub, has just one objective: delivering Dichtomatik's uniquely high number of warehoused items as quickly as possible to the locations they are needed at. In addition to the roughly 60,000 standard dimensions, around 15,000 customer-specific seals are available from stock. Additional warehouse locations around the world support the supply chain to ensure rapid availability for our customers.

Special logistics solutions, such as Kanban or vendor-managed inventory, quality testing and simplified customs processes due to certifications, simplify order processing. The location in Hamburg (incl. the warehouse) is certified according to DIN ISO 9001 and DIN ISO 14001, thus guaranteeing standardized processes in the quality and environmental management system. In addition, current processes are analyzed and improved in regular Kaizen workshops. Furthermore, warehouse processes are supported by new technologies. For example, the forklifts have been converted into mobile workstations by using tablets and portable printers, and innovative glove scanners are used for scanning processes. Our other warehouses also meet the highest quality requirements and are part of regular certifications.

PRODUCT PORTFOLIO OF THE DICHTOMATIK BRAND

STATIC APPLICATIONS

The whole range of static seals – O-rings, cords, x-rings, cover seals, bolt seals, flange and profile seals, etc. is available in a large number of dimensions including metric, inch and other international standards. The variety of materials, also with application-specific certifications, leaves nothing to be desired.

TRANSLATIONAL MOVEMENTS

Piston seals, rod seals, wipers, guide belts and rings for hydraulics are available from stock in countless standard dimensions in the materials including NBR, PTFE, TPU, hard fabric and NBR fabric-reinforced. Application-specific modifications of the design or material can also be realized.

ROTATING MOVEMENTS

Rotary shaft seals are available in the standard versions with and without protective lips and in the materials NBR and FKM. In addition to the standard designs, the product range also includes special designs of rotary shaft seals, axial seals, shaft sleeves and radial seals for rotary and swivel movements.

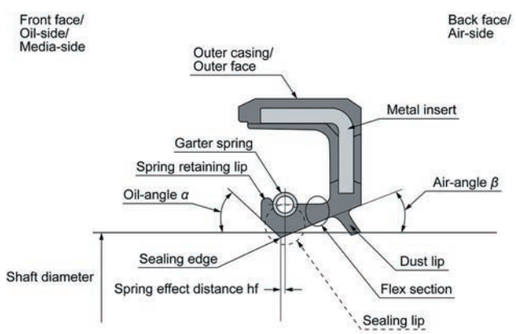
IMPORTANT NOTE

Dichtomatik products comply with the industrial standard. For this reason, they are not recommended for use in the automotive industry, especially in safety-relevant applications. An overview of complementary premium sealing solutions can be found at www.fst.com.

CONSTRUCTION RADIAL SHAFT SEALS

Radial shaft seals are used to seal rotating machine elements against media from inside the system and contaminants from the outside. Selecting the right seal depends on various operating conditions, such as the circumferential speed of the shaft, the operating temperature, the operating medium, the pressure and the ambient conditions on the side facing away from the medium.

Radial shaft seals in the standard design are offered in accordance with DIN 3760 and consist of an elastomer part, a metal stiffening ring and a spring. The standard design is available with an additional protective lip to the bottom side on an optional basis.



COMMON STANDARD DESIGNS*

Profile	Description	Profile	Description	Explanation
	WA		WAS	W-shaft seal A-elastomer outer covering S-protective lip
	WB		WBS	B-metal outer surface
	WC		WCS	C-metallic outer surface with additional stiffening ring

* Additional profiles can be found in the e-Catalog or on page 11

e-Catalog

https://ecatalog.fst.com/seals/dichtomatik/

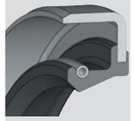
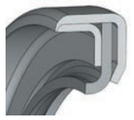
AREAS OF APPLICATION

Radial shaft seals are used to seal rotating machine elements such as shafts, hubs and axles in a wide range of industries:

You'll find detailed information on our products and the available certifications and conformity tests in our e-Catalog or on our online ordering platform EASY.

- DRIVE TECHNOLOGY, E.G. GEAR CONSTRUCTION
- ELECTRIC MOTORS, INTERNAL COMBUSTION ENGINES
- PUMPS
- AGRICULTURAL AND CONSTRUCTION MACHINERY INDUSTRY
- HOUSEHOLD AND INDUSTRIAL WASHING MACHINES ("WHITE INDUSTRY")
- WIND POWER INDUSTRY, SHIPBUILDING AND ROLLING MILLS

OVERVIEW
RADIAL SHAFT SEALS

Profile	Model	Material	Hardness [Shore A]	Temperature [°C]	Circum-ferential speed [m/s]	Pressure [MPa (bar)]	Application
	WA	NBR FKM	70 80	-40 to +80 -25 to +150	≤ 10 ≤ 34	≤ 0.05 (0.5)	• good static sealing with low-viscosity or gaseous media • good resistance to many mineral oils and greases • FKM: broad resistance to chemicals and solvents
	WAO	NBR	70	-40 to +80	≤ 6	0 (0)	• suited for use with grease seals • good static sealing with low-viscosity or gaseous media
	WAY	NBR FKM	80 80	-40 to +80 -25 to +150	≤ 10 ≤ 10	≤ 1 (10)	• use with compressive loads • good resistance to mineral oils and greases • FKM: broad resistance to chemicals and solvents
	WB	NBR	70	-40 to +80	≤ 10	≤ 0.05 (0.5)	• good resistance to various mineral oils and greases • tight and precise fit
	WBO	NBR	70	-40 to +80	≤ 6	0 (0)	• good static sealing with low-viscosity or gaseous media • suited for use with grease seals
	WC	NBR	70	-40 to +80	≤ 12	≤ 0.05 (0.5)	• good resistance to various mineral oils and greases • higher stiffness, tighter and more precise fit due to an additional stiffening ring
	WCP 20	PTFE + carbon fiber FKM		-90 to +250	≤ 40	≤ 1 (10)	• low coefficient of friction • good choice for dry running and lack of lubrication • broad chemical resistance
	WE 5/6/7	NBR FKM	80 80	-40 to +100 -20 to +180	≤ 20 ≤ 25	≤ 0.05 (0.5)	• good resistance to various mineral oils and greases • FKM: broad resistance to chemicals and solvents
	WEPO	PTFE-carbon/ graphite		-50 to +205*	≤ 15	≤ 1 (10)	• broad chemical resistance to nearly all aggressive media

*depending on the O-Ring material chosen

We also offer many of the profiles with an additional protective lip. All data refers to maximum values under ideal conditions and may not be applied simultaneously. The data depends on the circumferential speed, as well as the shaft diameter, material, temperature, pressure, medium and other factors. An individual test run in the application is recommended.

MATERIALS

Various standard and special materials are available for Dichtomatik radial shaft seals, depending on the model and the area of application. The starting material for elastomers is rubber, which can be obtained as natural rubber, but is mainly produced today as synthetic rubber in the chemical industry. Elastomers are distinguished by the underlying base polymer. The final material is produced by mixing the base polymer with appropriate fillers, plasticizers, processing aids, vulcanizing agents, accelerators and other additives. This process makes it possible to achieve the desired material properties and thus to offer standard materials for a wide range of uses as well as special compounds for very specific applications. The elastomer materials are labeled based on the abbreviated designations of DIN ISO 1629 and ASTM D 1418.

ABBREVIATIONS OF THE SEALING MATERIALS FOR RADIAL SHAFT SEALS

Chemical name	Abbreviation
	DIN ISO 1629 / ASTM D 1418
Acrylonitrile butadiene rubber	NBR
Hydrogenated acrylonitrile butadiene rubber	HNBR
Fluorine rubber	FKM
Ethylene propylene diene rubber	EPDM
Silicone rubber	VMQ
Acrylic rubber	ACM
	DIN EN ISO 1043-1 / ASTM D 1600
Polytetrafluoroethylene	PTFE

STANDARD MATERIALS

A wide range of radial shaft seals come available in two varieties of elastomer and two types of PTFE materials:

STANDARD ELASTOMER MATERIALS FOR RADIAL SHAFT SEALS

Base elastomer	DIN ISO 1629	Hardness [Shore A]	Color	Temperature [°C]
Acrylonitrile butadiene rubber	NBR	70	black	-40 to +80, +100 for a brief time
Fluorine rubber	FKM	80	brown	-25 to +150

* Temperature data applies to the area of the sealing lip. Operating conditions such as the medium, fresh oil supply, heat dissipation and friction can influence the temperature at the sealing lip.

STANDARD PTFE MATERIALS FOR RADIAL SHAFT SEALS FOR THE MODELS WEPO AND WCP20

Base polymer	DIN EN ISO 1043-1	Fillers	Hardness [Shore D]	Temperature [°C]*	Design
Polytetrafluoroethylene	PTFE	Charcoal/graphite	62	-30* to +205	WEPO*
Polytetrafluoroethylene	PTFE	Carbon fiber	61	-90 to +250	WCP20

* The temperature range is given by the FKM O-Ring used in the WEPO model.

NBR-ACRYLONITRILE-BUTADIENE RUBBER

Radial shaft seals made of NBR are known for their high abrasion resistance and good resistance to common mineral oil-based lubricating oils and greases. On the other hand, resistance to ozone, weathering and aging is low.

FKM – FLUORORUBBER

FKM materials are known for their very high temperature and chemical resistance. They age well, are resistant to ozone and have very low gas permeability making them well suited for vacuum applications. By contrast, FKM is not resistant to hot water, steam, polar solvents, glycol-based brake fluids and low-molecular organic acids.

PTFE – POLYTETRAFLUOROETHYLENE

PTFE offers virtually universal resistance to chemicals, has a broad thermal application range (-90 °C to +250 °C), an extremely low coefficient of friction and very high resistance to ozone, weathering and aging.

SPECIAL MATERIALS

In addition to the standard materials described, various special materials are also available for special applications. These include material variants with lower friction properties due to sliding-intensifying fillers such as graphite or molybdenum disulfide (MoS2), as well as optimized materials for better resistance to media and temperature. Additional material variants in other hardnesses and colors are available on request.

Base elastomer	DIN ISO 1629	Hardness [Shore A]	Color	Temperature [°C]
Hydrogenated acrylonitrile-butadiene rubber	(HNBR)*	70	black	-40 to +150
NBR High nitrile	NBR	70	black	-30 to +100
NBR High temperature	NBR	70	black	-30 to +120
NBR Low temperature	NBR	70	black	-50 to +90
NBR Graphite	NBR	70	black	-40 to +100
NBR MoS22	NBR	70	black	-40 to +100

*( ) = not included in the standard

MATERIALS FOR TENSION SPRING

STANDARD MATERIAL

The standard tension springs integrated into the radial shaft seals are made of unalloyed spring steel according to DIN EN 10270-1.

SPECIAL MATERIAL

On request, we also offer springs in stainless and acid-resistant steel 1.4301 (AISI 304).

MATERIALS FOR STIFFENING RINGS

STANDARD MATERIAL

We offer stiffening rings made of unalloyed steel according to DIN EN 10139.

SPECIAL MATERIAL

On request, we can also offer the stiffening rings in stainless and acid-resistant steel 1.4301 (AISI 304).

SEALING FUNCTIONS

A RADIAL SHAFT SEAL ESSENTIALLY HAS TWO TASKS TO FULFILL:

1. Sealing between the outer diameter and the housing bore, taking various influencing variables into account such as temperature, pressure, vibrations, the material the housing is made of, the material of the shaft seal outer diameter, etc.

2. Sealing to the shaft, where many influencing variables must be taken into account, such as speed/the circumferential speed of the shaft, the temperature, the application, the medium to be sealed, the pressure, the installation situation, etc.

In order to fulfill these tasks, various specifications must be observed for the housing bore and the shaft.

SEALING TO THE HOUSING BORE

To ensure reliable sealing against a wide variety of media when installed, an overlap (interference fit) of the shaft seal ring to the housing bore must be guaranteed under all operating conditions. Both the manufacturing tolerances of the housing bore and its expansion, e.g. due to the rise in temperature during operation, must be taken into account.

In addition, care must be taken that the roughness of the housing bore is not too great to avoid "creep" of the medium to be sealed through this rough structure.

If the roughness is too low, this can vastly increase the assembly forces (especially in shaft seals with an elastomer outer covering), which can cause damage to the outer diameter.

This predetermined structure also ensures a securely tight fit of the fully encased shaft seals so they can't migrate out of the bore during operation.

Meeting both requirements (sealing and a tight fit), corresponding values are specified in DIN 3670 and ISO 6194.

THE TABLE ONLY APPLIES IF THE HOUSING DIAMETERS ARE MANUFACTURED ACCORDING TO TOLERANCE CLASS IT H8

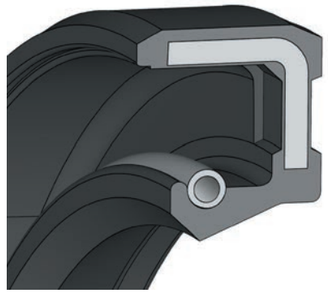
Nominal outside diameter [mm]	Press fit allowance for different shaft seal designs	
	Design WA (smooth elastomer outer covering) Values according to DIN 3760 and ISO 6194	**Models WB, WC (metallic outer covering) Values according to ISO 6194**
≤ 50	+ 0.30 + 0.15	+ 0.20 + 0.08
> 50 - 80	+ 0.35 + 0.20	+ 0,23 + 0.09
> 80 - 120	+ 0.35 + 0.20	+ 0.25 + 0.10
> 120 - 180	+ 0.45 + 0.25	+ 0.28 + 0.12
> 180 - 300	+ 0.45 + 0.25	+ 0.35 + 0.15
> 300 – 500*	+ 0.55 + 0.30	+ 0.45 + 0.20

* the value is 530 in ISO 6194

DESIGN OF THE OUTER SURFACES – INFLUENCE OF THE DIFFERENT MODELS

Radial shaft seals are typically offered with an elastomer outer covering or a metallic outer surface and are also available with an additional protective lip.

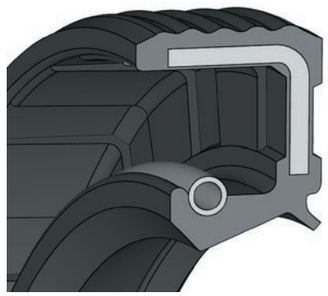
SMOOTH, ELASTOMER-COATED OUTER SURFACE: MODELS WA, WAS



Advantages:

- very good static sealing
- can be used for split housings, with possible edge breakage and/or butt offset
- use with light metal housings with high thermal expansion or with all housings that have a greater coefficient of expansion than steel
- use with low-viscosity or gaseous media
- use in pressure applications (within the limits of use)
- can seal larger surface roughnesses (within the standardized values)
- no fretting if corrosion occurs
- if mounted and dismounted correctly, the housing bore will not be damaged

GROOVED, ELASTOMER-COATED OUTER SURFACE: MODEL WAG (WITH A PROTECTIVE LIP)

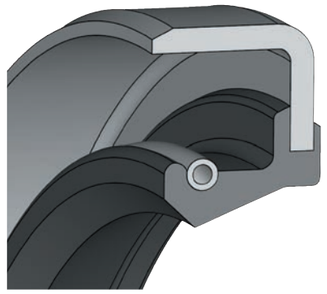


The elastomeric outer covering is grooved in the circumferential direction.

Advantages:

- easier assembly because lower press-in force is required
- reliable static sealing, especially for housings with increased thermal expansion because the grooved, rubber-covered outer surface is designed with a higher interference fit allowence

METALLIC OUTER SURFACE: MODELS WB, WBS



With model WB radial shaft seals, the metallic, smooth outer surface of the stiffening ring is ground, drawn or turned.

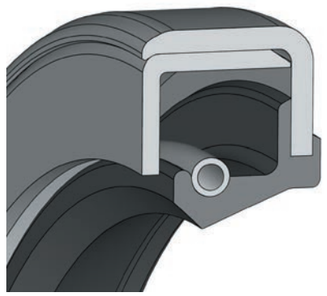
Advantages:

- a particularly precise (centric) and tight fit in the bore is ensured
- can be used for split housings, with possible edge breakage and/or butt offset

Disadvantages:

- the outer surface must be designed with a tighter interference fit allowance
- better surface quality of the housing bore is required
- cannot be used in split housings
- problematic with large thermal expansions of the housing, rough bore surfaces, pressure applications or very low-viscosity media

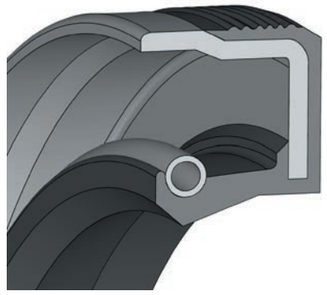
METALLIC OUTER SURFACE WITH A STIFFENING RING: MODELS WC, WCS



Type WC radial shaft seals have a smooth metallic outer surface like models WB/WBS and additionally a metallic stiffening ring. It is used successfully in case of particularly difficult mounting conditions, rough operating conditions and larger dimensions. Model WC radial shaft seals have a higher rigidity than model WB radial shaft seals. Due to the additional stiffening ring, the WC design is very insensitive to installation errors.

For advantages and disadvantages, see models WB/WBS

PARTLY ELASTOMER-COATED OUTER SURFACE: MODEL WAB



The so-called “half-shoulder design” is a special design that is not covered as standard. It combines the advantages of models WA (rubber-covered outer surface → good sealing effect) and WB (metallic outer surface → a tight fit).

STATIC SEAL TO THE SHAFT

The seal to the shaft is created because the sealing lip of the seal has a smaller diameter than the shaft. The resulting overlap causes the sealing lip to enclose the shaft with a certain force, the so-called radial force. In addition, a screw tension spring is installed with a certain preload, which largely compensates for a reduction in the radial force due to aging of the elastomer material or wear. The total radial force (FR) is thus composed of the elastomer component (FE) and the spring component (FF).

A static seal is thus achieved. The surface of the shaft shouldn’t be too rough to prevent a medium from infiltrating the sealing lip via the rough surface structure of the shaft.

An Rz value of 4 µm is specified as the maximum roughness.

DYNAMIC SEAL TO THE SHAFT

Several factors must be taken into account for sealing during operation, i. e. when the shaft is rotating. To prevent the sealing lip from wearing during operation, it must be ensured that a light lubricating film always forms between the shaft and the sealing lip (the contact area). For this purpose, the shaft is machined so that a minimum roughness of 1 µm is achieved. This structure allows some oil to enter the contact area between the shaft and the sealing lip (capillary effect), thus preventing extreme wear due to permanent dry running. However, oil would then also reach the air side via this path and this must be prevented. How this works is described in the so-called distortion hypothesis.

DYNAMIC SEALING MECHANISM

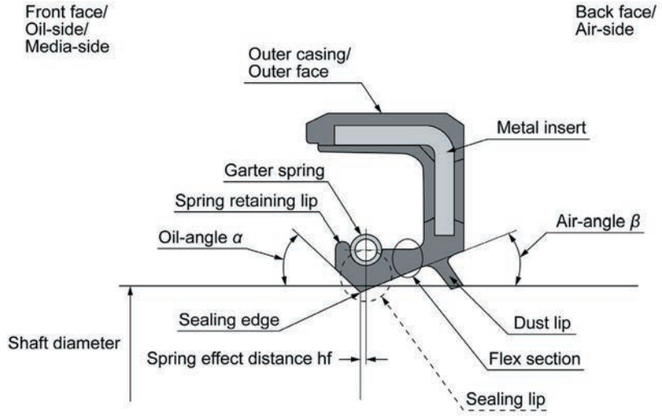
SEALING EFFECT WITH A ROTATING SHAFT

Several conditions must be met to ensure that the contact area is lubricated during operation, but that no oil can escape to the outside.

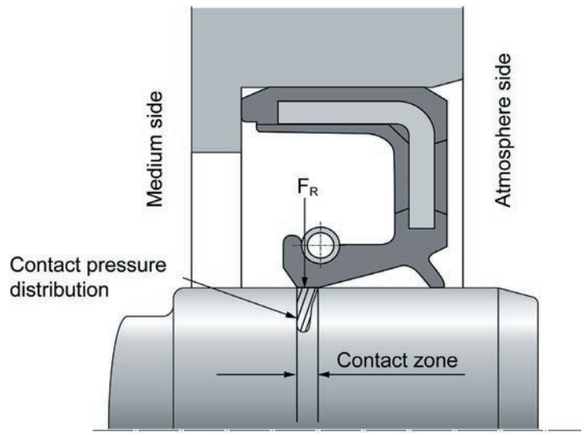
The geometry of the sealing lip must meet certain geometric criteria when installed:

- the oil angle “β” of the sealing lip should be approx. 45°– 60°
- the air angle “α” should be made much smaller

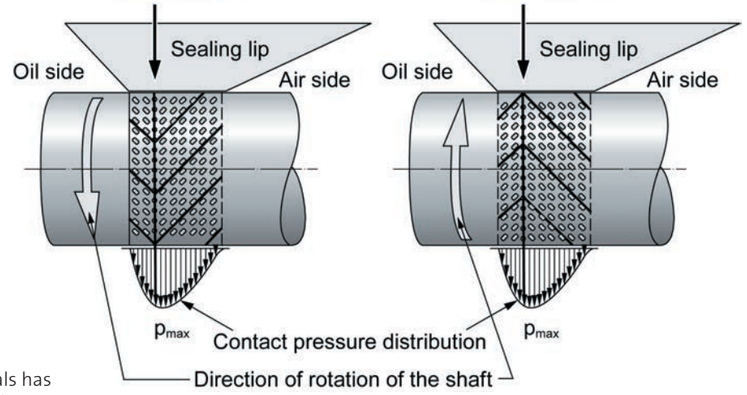
DESCRIPTIONS ON THE SHAFT SEALING RING



This special geometric design results in uneven pressure distribution in the contact area.



Each manufacturer of shaft seals has developed its own sealing lip design here, however it is based on these general rules.



Besides the specialized geometry, it is important that the sealing lip and the shaft "run in" to each other in the contact area. This involves slightly roughening the contact area of the sealing lip, which then produces a special surface structure. This structure in the contact area of the sealing lip ensures that sufficient fresh oil is allowed to flow under the sealing lip on the one hand and that the oil is returned on the other hand. Ideally, this results in a permanent exchange of fresh oil under the sealing lip to help ensure a long service life.

SPECIAL APPLICATIONS

In reality, there are many deviations from the ideal operating conditions, such as

- sealing under negative pressure or vacuum
- separation of two media
- sealing in case of very heavy dirt impact (e.g. agriculture)
- deficient lubrication

We can develop appropriate solutions for these and other special applications.

OPERATING CONDITIONS

TEMPERATURE AND PRESSURE

Due to the rotation of the shaft and the resulting friction at the sealing edge, the actual temperature at the sealing edge is higher than in the oil bath.

tD = tOil + tO

tD = Temperature at the sealing edge [°C]

tOil = Temperature in the oil bath [°C]

tO = Overtemperature [°C]

This temperature difference between the oil bath and the sealing edge is called overtemperature. The level of the overtemperature depends on the following parameters:

- circumferential speed/speed
- lubrication condition/oil level
- heat dissipation
- pressure load
- design of the radial shaft seal
- surface condition of the shaft
- material of the radial shaft seal
- medium

With increasing circumferential speeds, the excess temperature at the sealing edge also increases. Depending on the circumferential speed, the overtemperature can be as high as +40 °C. If the maximum permissible operating temperatures for the elastomer material used are exceeded, this will lead to premature hardening of the elastomer material and severe wear. For the permissible operating temperatures of our elastomer materials, please refer to the tables in the Materials chapter or our website. The high temperatures listed in the tables refer to the temperature at the sealing edge.

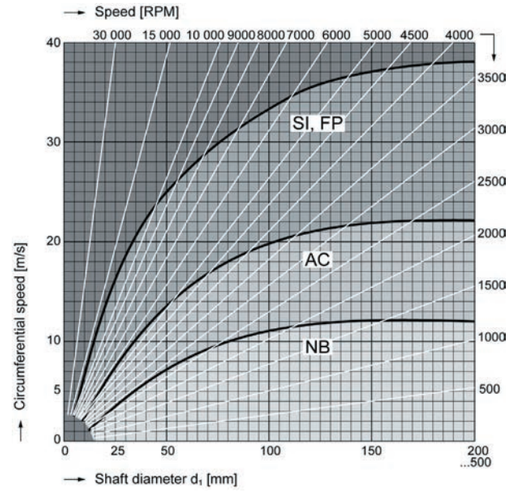
PRESSURELESS OPERATION

Radial shaft seals are generally designed for pressureless operation, whereby pressures of up to 0.5 bar can be sealed, depending on the respective operating conditions (temperature, speed, medium to be sealed).

Reference values for the selection of materials for pressureless applications as a function of the maximum permissible circumferential speed are shown below.

To prevent overtemperatures that endanger the function at the sealing edge, which can lead to a hardening of the elastomer or the formation of oil carbon, the maximum permissible circumferential speed may not be exceeded.

The reference values listed are empirical values in accordance with DIN 3760. No manufacturer-specific properties of the radial shaft seals, such as the geometry of the sealing lip or radial force, are taken into consideration. These reference values apply only in the case of unpressurized operation, adequate lubrication conditions with mineral oil and good heat dissipation at the sealing point. In the event of insufficient lubrication or pure grease lubrication, the limit values should be reduced by half. The reference values should also be reduced in the event of pressurization, poor surface quality in the running area and large runout deviations. Higher circumferential speeds are permissible for shafts with larger diameters since heat dissipation is better.



Limits for circumferential speed/speed depending on the diameter of the shaft and the material.

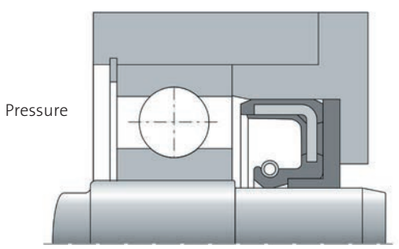
PRESSURIZATION FOR STANDARD MODELS

Standard radial shaft seals are still adequately designed for use at very low pressures of up to 0.5 bar. They seal spaces with small pressure differences against liquids, greases and even air.

OPERATION WITH PRESSURIZATION

The existing operating conditions, pressure and circumferential speed, are decisive for the selection of the proper radial shaft seal. In the case of pressurized radial shaft seals, the sealing lip is pressed strongly against the shaft, which increases the radial force as a function of the pressure. However, this process also increases the thermal load and the frictional power at the sealing edge, which can lead to premature wear and hardening.

Back-up rings
Pressure differences in excess of 0.5 bar can also be sealed with standard radial shaft seals and an additional back-up ring (preferably made of POM). The maximum permissible pressures depend on the speed and the shaft diameter. In combination with a back-up ring, only designs without a protective lip can be used because the back-up ring supports the sealing lip under the diaphragm. For this reason, the back-up ring must be precisely adapted to the respective sealing lip profile. For each standard model (without a protective lip), the respective back-up ring drawing can be requested. A sealing system of this type is ideal where the WAY/WASY model that can withstand pressure is not available.



A shaft seal (WA) with an additional back-up ring.

WAY/WASY model
The WAY/WASY model is recommended for pressure differences in excess of 0.5 bar, pulsating pressures and vacuum applications. Compared to the standard version (WA/WAS), the WAY/WASY model is characterized by a compact sealing lip profile. Due to its short and reinforced sealing lip, this design is less sensitive to pressure loads.

MEDIA TO BE SEALED

The selection of the right radial shaft seal, in particular the right material, depends not only on the circumferential speed of the shaft, the pressure load and the friction-related temperature increase, but also decisively on the medium to be sealed and its temperature. In particular, the chemical resistance of the radial shaft seal to the medium used has a significant influence on the service life of the seal.

A chemical attack of the medium can lead to

- softening of the material by swelling or
- hardening and premature aging phenomena, favored by high temperatures.

Thanks to decades of experience, the behavior of the individual material groups against a wide range of media can be easily determined using the resistance tools from Freudenberg Sealing Technologies. When using new media, in the event of ambiguities or even if maximum application parameters (e.g. temperature, pressure, circumferential speed) occur simultaneously, we recommend performing a test (storage test) in advance. For even higher requirements with regard to media resistance, a design with a PTFE sealing lip or that is completely made of PTFE is available in model WCP20 (type WEPO).

FREQUENTLY USED MEDIA

Mineral oil-based oils and greases
There is generally good resistance with NBR and FKM standard materials. A test is recommended only in the case of highly additivated media, for which no empirical values are available.

Synthetic oils and greases
The structure of synthetic lubricants is essentially characterized by the base oil and many different additives. Depending on the type of base oil and additives, the standard NBR material can be used for low additive lubricants. For higher additive oils, especially at temperatures above +80 °C, FKM is better suited as a sealing material. However, resistance problems may occur due to the large number and combination of additives in synthetic lubricants. We therefore recommend verifying the suitability of the material in advance by performing a test.

Further information on the areas of application and resistance of radial shaft seals and the materials used can be found in our Resistance Guide.

Resistance Tools

https://resistanceguide.fst.com/en/

INSTALLATION SPACE AND CONSTRUCTIVE RECOMMENDATIONS

ABOUT THE SHAFT

THE SHAFT

The shaft, along with the radial shaft seal, is an important machine element in the radial sealing system and must therefore meet a number of technical requirements to ensure a good sealing effect. The proper design of the shaft in the running surface area of the sealing edge of the radial shaft seal is very important for the service life and sealing function of the radial sealing system.

TOLERANCES

For the shaft diameter d1 in the running surface area of the sealing edge of the radial shaft seal, the ISO tolerance zone h11 according to DIN ISO 286 must be ensured to achieve the overlap required for the sealing lip. Tolerance class IT 8 is required for the roundness of the shaft.

SURFACE FINISH OF THE SHAFT

The surface roughness, measured in the longitudinal direction, should be within the following ranges:

- Rz = 1.0 to 4.0 µm
- Rmax ≤ 6.3 µm

Excessively smooth shaft surfaces in conjunction with high circumferential speeds lead to malfunctions. The lubricant supply to the sealing edge is disrupted, the hydrodynamic lubricant film under the sealing edge breaks off and causes thermal damage to the sealing edge.

Excessively rough shaft surfaces lead to premature wear of the sealing edge. Both types result in severe leakage.

SURFACE HARDNESS OF THE SHAFT

The service life of the sealing point also depends on the tread hardness on the shaft. The surface hardness should be at least 45 HRC. In case of access of contaminated media or dirt from the outside, as well as at circumferential speeds ≥ 4 m/s, the surface hardness should be at least 55 HRC – 60 HRC. For surface hardening, a hardening depth of at least 0.3 mm is required. Chrome-plated, cadmium-plated, nitrided, and phosphated shaft surfaces are special treatment processes. Their suitability must be decided on from case to case.

PROCESSING OF THE SHAFT SURFACE

The shaft must be machined free of twists in the running surface area of the sealing edge so that no conveying or pumping effect and thus no leakage occurs at the sealing point. Correct machining of the running surface is very important for the sealing function.

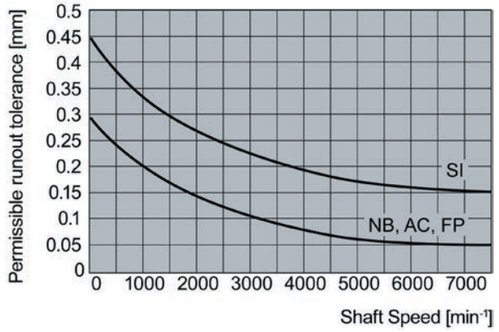
The most frequently used method is plunge grinding (grinding without axial feed of the grinding wheel), as this achieves a completely twist-free mating surface. The burnout time must be 30 seconds to achieve a high degree of safety. The grinding wheel is dressed with a multigrain dresser to prevent twisting. During grinding, an integer transmission ratio between the speed of the shaft (e.g. 50/min) and the speed of the grinding wheel (e.g. 1,500/min) must be avoided.

Other machining processes, such as hard turning and smooth-rolling, are special processes that are only used in a few applications.

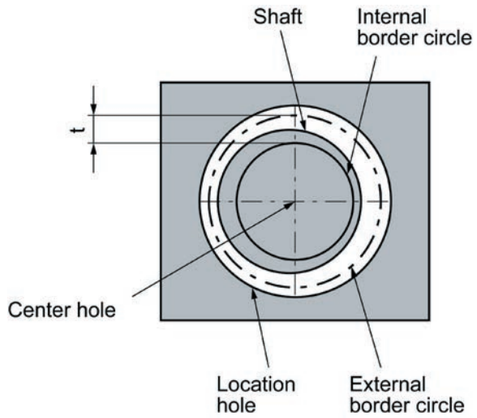
CONCENTRICITY DEVIATION

A concentricity deviation (runout) or dynamic eccentricity of the shaft should be avoided as far as possible or may not exceed certain limits depending on the speed. At high speeds, there is otherwise a risk that the sealing lip will no longer be able to follow the shaft due to its inertia. If this results in too large of a gap between the sealing edge and the shaft on one side, the medium to be sealed will escape and leakage will occur.

It is therefore advisable to arrange the radial shaft seal in the immediate vicinity of the bearing and to keep the bearing clearance as narrow as possible. The permissible values for the concentricity deviation as a function of speed are shown in the diagram below. Restricted values apply to our WAY/WASY versions that can be pressurized, since the sealing lip is designed to be considerably stiffer here.



Permissible shaft concentricity tolerance



Display of the concentricity tolerance

CHAMFER ON THE SHAFT

In order to not damage the sealing lip during installation and to prevent the sealing lip from tilting, the following two constructive designs of the shaft shoulder are proposed:

Mounting direction Z of the shaft:
Round off the shaft shoulder with r1 = 0.6 to 1 mm.

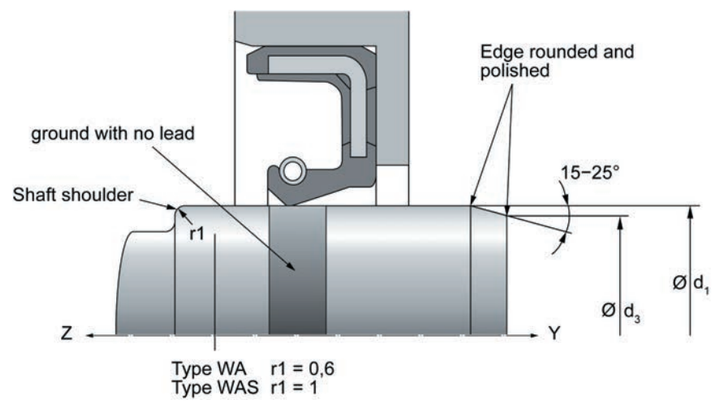
Mounting direction Y of the shaft:
Chamfering of the shaft shoulder, recommended angle 15° to 25°. The chamfering diameter d3 is listed in the adjacent table.

MOUNTING BEVEL

d_1 [mm]	d_3 [mm]
< 10	d_1 - 1.5
10 < 20	d_1 - 2
20 < 30	d_1 - 2.5
30 < 40	d_1 - 3
40 < 50	d_1 - 3.5
50 < 70	d_1 - 4
70 < 95	d_1 - 4.5
95 < 130	d_1 - 5.5
130 < 240	d_1 - 7
240 < 500	d_1 - 11

DAMAGE TO THE SHAFT

All types of damage, such as scoring, scratches, bumps, shrinkage cavities, pores and corrosion on the running surface of the shaft must be avoided at all costs. They can lead to premature failure and leakage. 30 percent of leakages are caused by incorrect shaft machining or damage. Therefore, the shafts should be carefully protected from production to final assembly. Transport devices or special molded or slid-on protective plastic covers can be used.



HOUSING BORE

The design of the housing bore is important in order to achieve a firm and tight fit in the housing bore. The following technical requirements must be observed:

TOLERANCES

The tolerance zone ISO H8 must be ensured for the bore diameter d2 in order to achieve a good static sealing effect in conjunction with the standard-compliant design of the radial shaft seal.

SURFACE FINISH OF THE HOUSING BORE

permissible values for model WA

Rz = 10 to 20 µm
Rmax ≤ 25 µm

permissible values for models WB, WC

Rz = 6.3 to 16 µm
Rmax ≤ 16 µm

In the case of radial shaft seals with a metallic outer casing and/or use in conjunction with low-viscosity media or gas, very good surface quality is necessary, i.e. the surface in the housing bore should be free from damage and machining marks of all kinds, e.g. scratches, scores, cavities and impact points.

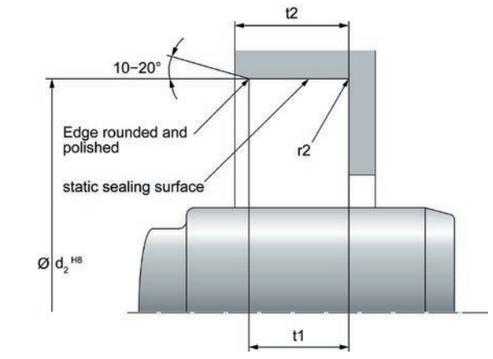
HOUSING DIMENSION

The housing dimensions are listed in the table as a function of the radial shaft seal height b:

b [mm]	t_1 min. [mm]	t_2 min. [mm]	r_2 [mm]
7	5.95	7.3	0.5
8	6.8	8.3	0.5
10	8.5	10.3	0.5
12	10.3	12.3	0.7
15	12.75	15.3	0,7
20	17	20.3	0.7

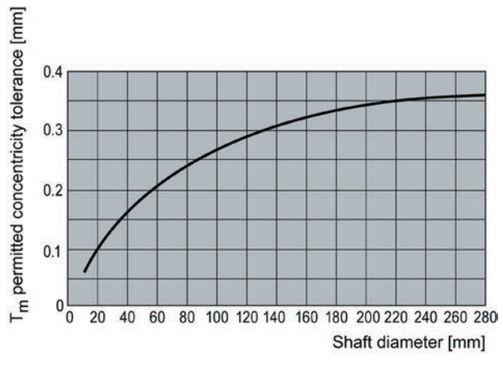
CHAMFER ON THE HOUSING BORE

The housing bore should have a chamfer of 10 - 20° and the transitions should be made without burrs to allow for trouble-free installation of the radial shaft seal.



CONCENTRICITY TOLERANCE OF THE HOUSING BORE

The permissible concentricity tolerance Tm (centricity deviation) between the housing bore and the shaft is shown in the table below. The concentricity leads to uneven stress on the sealing lip and greater wear in this area. On the opposite side, leakage can occur due to insufficient contact pressure between the sealing lip and the shaft.



Permissible concentricity tolerances of the shaft to the housing bore

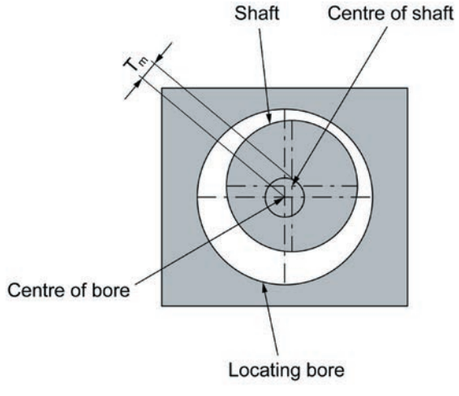


Illustration of the concentricity tolerances

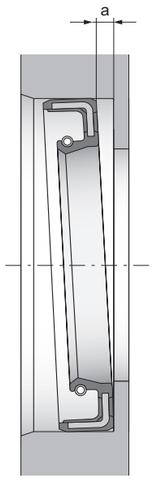
PERMISSIBLE SKEW

The installed radial shaft seal must be installed as centrically as possible and perpendicular to the shaft. The straightness tolerance according to DIN 3761 should not exceed the values in the adjacent table. Larger deviations (misalignment) lead to uneven wear of the sealing lip and have a negative effect on the sealing result.

HOUSING DESIGN

When radial shaft seals are fitted in filigree housings, there is a risk that they may be severely deformed and/or expanded. This can lead to migration of the oil seal or to leakage. It is recommended that you use radial shaft seals with an elastomer outer covering (e.g. WA). We also offer the version with a grooved outer covering (e.g. WAK) on request.

In the case of split housings, attention must be paid to the design of the edges of the housing to avoid damage to the shaft seal or leakage. We recommend designs with an elastomer outer covering for split housings.



Shaft diameter [mm]	Straightness tolerance a [mm]
up to 25	0.1
over 25 to 80	0.2
over 80	0.3

Representation of the skew

INSTALLATION

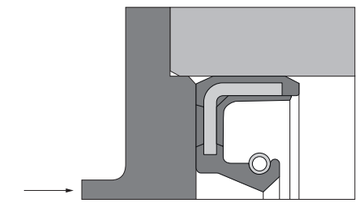
Approximately 30 percent of all failures and damage to radial shaft seals can be attributed to incorrect installation or unsuitable installation aids. We therefore recommend that radial shaft seals be installed in accordance with DIN 3760.

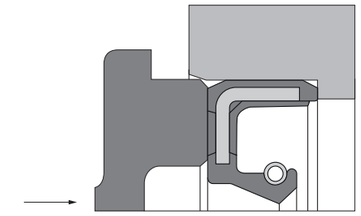
Accordingly, the installation space and radial shaft seal should be carefully cleaned before installation. Otherwise, dirt particles adhering to the seal or installation space could lead to leakage shortly after the start of operation. A hydraulic or mechanical press-in tool is preferably used to press the radial shaft seal into the housing bore. This engages over a large area on the outside of the radial shaft seal so that the pressing force acts as close as possible to the outside diameter and any skewing of the radial shaft seal is reduced to a minimum. The press-in tool should be held in the end position for a while. This reduces springback or skewing of the radial shaft seal to a minimum. If a radial shaft seal has to be guided over sharp-edged surfaces, e.g. grooves, threads or shaft ends, the appropriate mounting sleeves must be provided. It is important to make sure the sleeve does not have any damages such as scratches or rough surfaces. For a tight fit, ensure that the outer sleeve is fully pressed into the housing bore. Otherwise, there is a risk of the radial shaft seal "migrating" out of the housing bore.

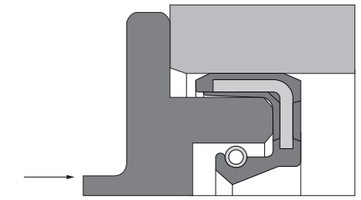
If the gap between the protective lip and the sealing lip is filled with grease, the following should be observed:

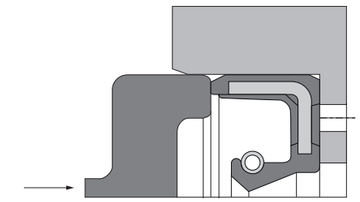
- max. grease filling of the gap 30 – 40%
- apply grease with a wooden or metal spatula (not with a brush)
- keep the sealing lip free from grease
- suggested grease: Klüber Petamo GHY 133 N

VARIOUS INSTALLATION AIDS FOR RADIAL SHAFT SEALS









QUALITY ASSURANCE

For Dichtomatik brand products, we actively strive for “zero defect target” product quality by working closely with our customers and production. Our batch print tracking allows us to trace every step in the supply chain and to provide information on the product characteristics and ingredients. Batch information is provided on the product labels as well as on the corresponding delivery bills.

DIMENSIONAL TESTING

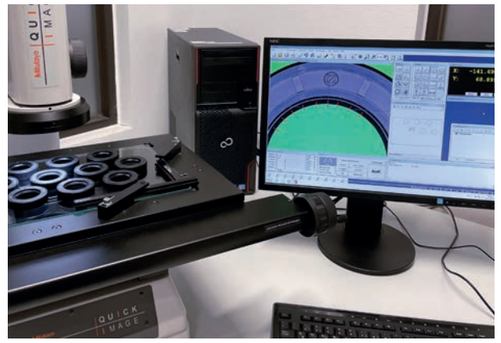
A wide range of measuring equipment and instruments are available for the dimensional inspection of radial shaft seals, usually for the measurement of inner and outer diameters as well as height. These include optical measuring machines and measuring microscopes, calipers, depth gauges, circumferential measuring tapes and many more. The measurement of the inner diameter of the sealing edge and/or the protective lip is preferably carried out with the help of non-contact optical measuring machines and measuring microscopes. For larger dimensions, and depending on the material and the design, calipers or inside circumference measuring tapes are also used. Profile cross-sections (drawing views) can be tested destructively. For this purpose, sections of the RWDR are cast in resin, cut to size and the surface to be measured is leveled. Testing and measurement are then generally carried out using non-contact optical measuring machines and measuring microscopes.

RADIAL FORCE MEASUREMENT

The radial force is measured using the two-jaw measuring method in accordance with DIN 3761-9. The radial force is the sum of the force components of the sealing lip of a radial shaft seal acting perpendicularly on the parting plane of the measuring jaws to the selected shaft diameter. Corresponding measuring jaws are available for the usual standard dimensions.

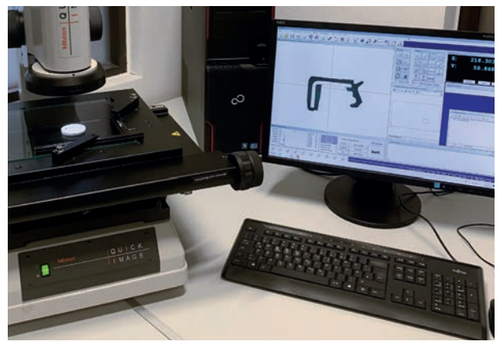
SHAPE AND SURFACE TESTING

The quality specifications for radial shaft seals are based on DIN 3761. Additional requirements can be agreed upon as a basis for delivery when the order is placed. Monitoring of compliance with the quality specifications is carried out by using magnifying lamps and digital microscopes.

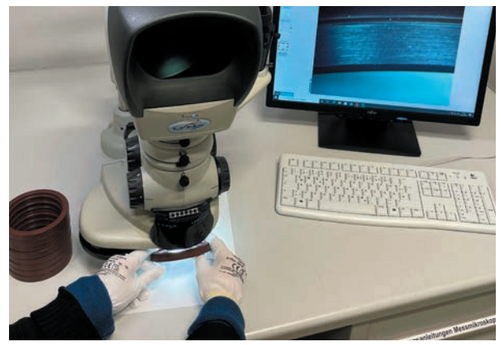


Dimensional inspection of a radial shaft seal using a measuring microscope

Radial force measurement of a radial shaft seal



Profile cross-section inspection of a radial shaft seal



Surface inspection of a radial shaft seal using an electronic microscope

SHAFT REPAIR SLEEVES

WSH-R

The shaft repair sleeve WSH-R is part of our standard bearing program.

DESCRIPTION

Product group:	WSH shaft repair sleeve
Design:	R Repair
Material:	stainless and acid-resistant steel 1.4301 (AISI 304)

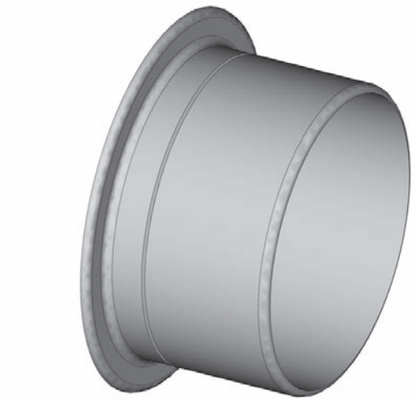
OPERATING LIMITS

The operating limits, such as the temperature, circumferential speed and pressure, are specified by the radial shaft seal chosen. The WSH-R generally covers the operating conditions for all common radial shaft seals.

TECHNICAL DATA

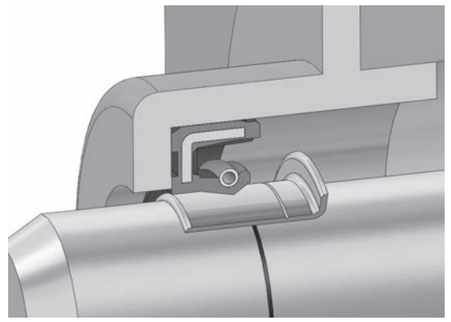
The following technical requirements must be met by shaft repair sleeves:

Surface finish/ roughness values:	Rz = 1 to 5 µm Rmax ≤ 6.3 µm
Machining of the surface:	twist-free ground
Surface hardness:	HV 220 (95 HRB) wear-resistant machined
Wall thickness:	0.28 mm thin-walled version



APPLICATION

WSH-R shaft repair sleeves are used to repair worn-in or worn running surfaces of radial shaft seals on shafts, e.g. in drive technology. They offer a cost-effective alternative to replacement or costly reworking of the worn shaft and are easy to install. Reworking the damaged shaft may well result in a decisive reduction in the original diameter and the previous WDR no longer fitting in the inner diameter. This problem can be easily rectified by using a WSH-R without having to dismantle the shaft and carry out costly reworking.



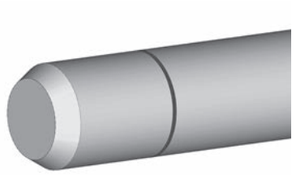
Shaft repair sleeves in operation between the radial shaft seal and the shaft

FUNCTION AND ADVANTAGES

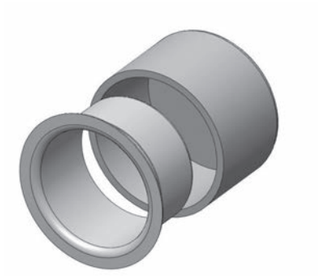
By using the WSH-R in case of repair, proper function can be restored quickly and permanently.

WSH-R shaft repair sleeves offer the user the following advantages:

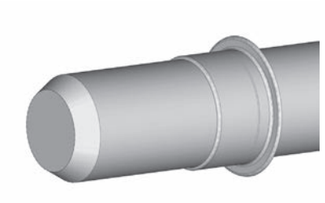
- simple and quick repair, the mounting sleeve is included in the delivery
- less costly restoration of the running surface on the shaft, as the shaft does not need to be dismantled and reworked
- elimination of costly machine downtime, as repairs are reduced to a minimum. The running surface of the radial shaft seal is permanently and fully functionally restored
- secure fit on the shaft due to the interference fit
- retention of the original seal dimension



Shaft with an inlet track



Mounting sleeve with a shaft repair sleeve



Shaft repair sleeve on the shaft

INSTALLATION INSTRUCTIONS

1. Clean the surface of the worn shaft and remove any burrs you find. Run-in marks, notches, grooves or noticeable roughnesses must be evened out using an appropriate epoxy filler compound
2. The shaft sleeve should be selected based on the shaft diameter d1
3. Lightly grease the surface of the shaft before you install it (makes installation easier)
4. Place the WSH-R with the flange side on the shaft
5. Slide the mounting sleeve over the WSH-R. The mounting dimension Z can be achieved using the mounting sleeve supplied. If the mounting sleeve is too short, a tube with a similar diameter can also be used
6. Apply light hammer blows to the mounting sleeve (or use a pressing device) to push the WSH onto the worn area
7. If the mounting flange interferes with the function of the RWDR or the unit, it can be easily removed at the predetermined breaking point provided for this purpose

   a) After mounting the WSH-R, cut the flange with a side cutter up to the predetermined breaking point and tear it off at the pre-turned line (the predetermined breaking point)

   b) In difficult cases, e.g. when there is little installation space, it might be necessary to cut the flange already before assembly
8. Check the surface of the shaft again for burrs after assembly
9. Degrease the WSH-R before installing the seal
10. Install the radial shaft seal

The shaft repair sleeves are available from stock for diameter ranges between 12 and 200 mm. With correspondingly longer delivery times, we also offer shaft repair sleeves up to 370 mm and thicker wall thicknesses.

All assortment articles including availabilities and prices can be viewed directly on our online ordering platform EASY. Additional dimensions can be manufactured.

The technical data in this catalog are based on tests and experience specified by standards and repeated as part of quality assurance. This information should be regarded as general and non-binding guide values. It is quite possible that these values will be exceeded or fallen short of. We therefore recommend that specific cases of application in which limit values could be reached be discussed with our technical department.

No changes to the catalog details will be announced. Previous editions lose their validity when a new edition of the catalog is published.

INDUSTRY PROVEN

COMPREHENSIVE PRODUCT PORTFOLIO FOR SEALING APPLICATIONS

Freudenberg Sealing Technologies (FST) has a broad, customer-oriented product portfolio of premium sealing technology for highly demanding applications – from customized individual solutions to complete sealing packages.
The range is rounded off by complementary industrial standard solutions from the Dichtomatik product brand. The two-brand-strategy is part of Freudenberg Sealing Technologies' comprehensive service portfolio and guarantees a full range of seals and product-related services. Dichtomatik products are manufactured by certified suppliers and are available in many different seal shapes and materials. They are suited for moderate operating conditions in static, dynamic and rotary applications.
FST serves the entire sealing market with this complementary product portfolio and thus meets all market requirements – quickly, reliably and from a single source.
www.fst.com | dichtomatik.fst.com

NOTES

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DICHTOMATIK

FREUDENBERG
INNOVATING TOGETHER