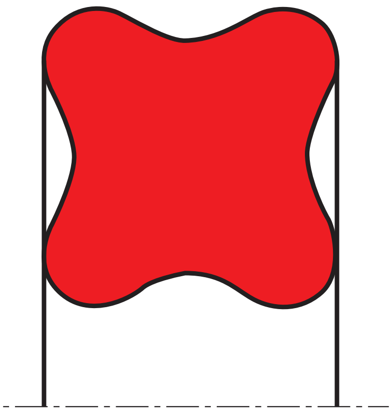
x-ring R16-R

seal spec



description

original R16-R seals are four lipped seals with a specially developed sealing profile.
a wide range of elastomer materials for both standard and special applications allows practically all liquid and gaseous media to be sealed.
R16-R seals are vulcanized as a continuous ring. they are characterized by their annular form with a four lipped profile. their dimensions are specified with the inside diameter (Ød) and the cross-section cs/H (figure 1).

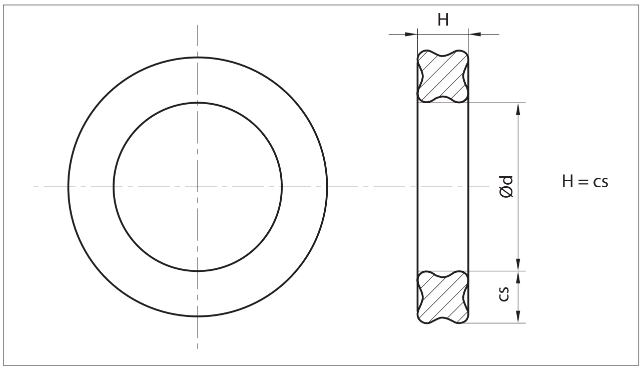
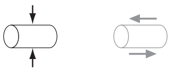


figure 1. R16-R seal dimensioning

R16-R seals are supplied in dependence on the american o-ring standard AS 568 B.

application



not bolded symbols; please consult our technical for application limitations

category of profile

machined or molded/standard/trade product

advantages

in contrast to the o-Ring, R16-R seal has the following advantages:
- avoids twisting in the groove. due to its special profile, the seal does not tend to roll in the groove during reciprocating movement.
- low friction.
- very good sealing efficiency. due to an improved pressure profile over R16-R seal cross-section, a high sealing effect is achieved.
- a lubricant reservoir formed between the sealing lips improves start up.
- unlike an o-ring, the mould line flash lies in the trough, between and away from the critical sealing lips.

method of operation

R16-R seals are self energizing double-acting sealing elements. the forces acting in radial or axial direction due to the installation give R16-R seal its initial leak-tightness (initial squeeze). these forces are superimposed by the system pressure.
an overall sealing force is created which increases with increasing system pressure (figure 2). under pressure, the seal behaves in a similar way to a fluid with high viscosity and the pressure is transmitted uniformly to all sides.

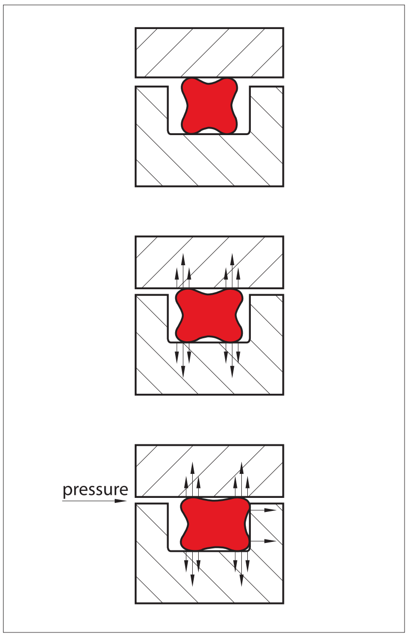


Figure 2 R16-R seal squeeze with and without system pressure.

applications

fields of application

R16-R seals can be used for a wide range of different applications.
R16-R seal is used predominantly for dynamic sealing functions. it's use is always limited by the pressure to be sealed and the velocity.

dynamic applications
- for sealing of reciprocating pistons, rods, plungers, etc.
- for sealing oscillating, rotating or spiral movements on shafts, spindles, rotary transmission leadthroughs, etc.

static applications
- as a radial-static seal, e.g. for bushings, covers, pipes, etc.
- as an axial-static seal, e.g. for flanges, plates, caps, etc.
- as an energizer element for elastomer energized hydraulic seals where there is a risk of the o-ring twisting.

R16-R seal for rotary application

in applications with small cyclic periods of activity, R16-R seal can also be used for sealing rotating shafts. the following points according to the rotary seal principle should be observed:

the rotary seal principle is based on the fact that an elongated elastomer ring contracts when heated (joule effect). with the normal design criteria the seal ring inside diameter (Ød) will be slightly smaller than the shaft diameter, and the heat generated by friction would cause the ring to contract even more. this results in a higher pressure on the rotating shaft so that a lubricating film is prevented from forming under the seal and even higher friction occurs. the result would be increased wear and a premature failure of the seal.

using the rotary seal principle, this is prevented by the seal ring being selected so that its inside diameter is approximately 2 to 5% larger than the shaft diameter to be sealed. the installation in the groove means that the seal ring is compressed radially and is pressed against the shaft by the groove diameter. the seal ring is thus slightly corrugated in the groove, a fact which helps to improve the lubrication.

the rotary seal principle can be neglected at peripheral speeds of less than 0.5 m/s.
when using the R16-R seal as a rotary seal, the use of a suitable surface coating is recommended. please note the information given in our brochure "friction-free running" or contact your local seal-mart company for further details.

technical data

R16-R seals can be used for a wide range of applications. the choice of a suitable material is determined by the temperature, pressure and media. in order to assess the suitability of R16-R seal as a sealing element for a given application, the interaction of all the operating parameters have to be taken into consideration.

working pressure, dynamic application:
reciprocating
up to 5 MPa (50 bar) without back-up ring
up to 30 MPa (300 bar) with back-up ring

rotating
up to 15 MPa (150 bar) with back-up ring

working pressure, static application:
up to 5 MPa (50 bar) without back-up ring
up to 40 MPa (400 bar) with back-up ring
please note the permissible extrusion gaps, see table IV.

speed:
reciprocating: up to 0.5 m/s
rotating: briefly up to 2.0 m/s

operating temperature range:
depending on material and media resistance, for:
general application, NBR: -30°C to + 100°C
general application, FKM: -18°C to + 200°C

when assessing the application criteria, the transient peak and continuous operating temperature and the cyclic duration factor must be taken into consideration. for rotating applications, the increases in temperature due to frictional heat must be taken into account.

media:
with the large range of materials, each with different properties, which are now available, it is possible to seal against practically all liquids, gases and chemicals. please note when selecting the most suitable material the information given in the o-ring catalogue.

materials
the available standard elastomer materials are shown in table I.
if no particular specifications are given for the material, NBR (Nitrile Butadiene Elastomer) in 70 Shore A will be supplied.

table I standard materials for R16-R seals

material-type	NBR acrylonitrile-butadien rubber	FKM fluorocarbon rubber
hardness Shore A (± 5)	70	70
colour	black	black
operating temperature range (°C)	-30°C to + 100°C	-18°C to +200°C
description	standard material for hydraulics and pneumatics. mineral oil-based hydraulic fluids, animal and vegetable oils and fats,aliphatic hydrocarbons, silicone oils and greases, water up to +80°C	mineral oils and greases, flame retardant liquids, aliphatic, aromatic and chlorinated hydrocarbons, petrol, 99 octane petrol,diesel fuels, silicone oils and greases

further special materials on request.
due to the different conditions in the field, e.g. different media, the given material properties and operating temperature ranges could be affected and changed. tests should be done for each application.

operating parameters & materials

diameter range: up to 600 mm

material	temperature	max. surface speed	max. pressure [1]	hydrolysis	dry running	wear resistance
NBR	-30°C...+100°C	0,5m/s	50bar(5MPa)	-	-	O
FKM	-20°C...+200°C	0,5m/s	50bar(5MPa)	-	-	O
EPDM[2]	-50°C...+150°C	0,5m/s	50bar(5MPa)	++	-	O
HNBR	-25°C...+150°C	0,5m/s	50bar(5MPa)	+	O	+
MVQ	-60°C...+200°C	-	50bar(5MPa)			

the stated operation conditions represent general indications. it is recommended not to use all maximum values simultaneously.
surface speed limits apply only to the presence of adequate lubrication film.
[1] pressure ratings are dependent on the size of the extrusion gap.
[2] attention: not suitable for mineral oils!
++ ... particularly suitable o ... conditional suitable
+ ... suitable - ... not suitable
for detailed information regarding chemical resistance please refer to our "list of resistance". for increased chemical and thermal resistance rubber materials are to be preferred, polyurethan materials increase wear resistance.

characteristics and inspection of elastomers

hardness

one of the most often named properties regarding polymer materials is hardness. even so the values can be quite misleading.
hardness is the resistance of a body against penetration of an even harder body – of a standard shape defined pressure.
there are two procedures for hardness tests regarding test samples and finished parts made out of elastomer material:

1. shore A/D according to ISO 868 / ISO 7619 / DIN 53 505 / ASTM D 2240 measurement for test samples.
2. durometer IRHD (International Rubber Hardness Degree) according to ISO 48 / ASTM 1414 and 1415 Measurement of test samples and finished parts.

the hardness scale has a range of 0 (softest) to 100 (hardest). the measured values depend on the elastic qualities of the elastomers, especially on the tensile strength.
the test should be carried out at temperatures of 23 ±2 °C – not earlier than 16 hours after the last vulcanisation process (manufacturing stage).
if other temperatures are being used this should be mentioned in the test report.
tests should only be carried out with samples which have not been previously stressed mechanically.

hardness tests according to shore A/D

the hardness test device shore A (indentor with pyramid base) is a sensible application in the hardness range 10 to 90. samples with a larger hardness should be tested with the device shore D (indentor with spike).
test specimen:
diameter min. 30 mm
thickness min. 6 mm
upper and lower sides smoth and flat
when thin material is being tested it can be layered providing minimal sample thickness is achieved by a maximum of 3 layers. all layers must be at minimum 2 mm thick.
the measurement is done at three different places at a definded distance and time.

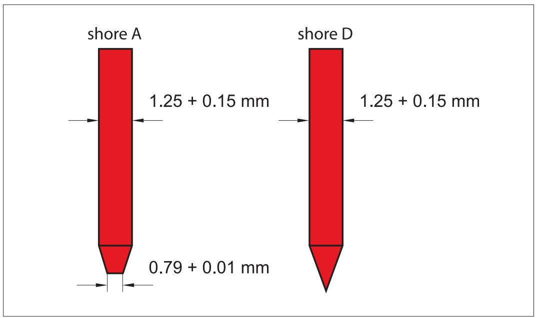


figure 3. indentor according to shore A / D

hardness test according to IRHD

the test of the Durometer according to IRHD is used with test samples as well as with finished goods.
the thickness of the test material has to be adjusted according to the range of hardness. according to ISO 48 there are two hardness ranges.
soft: 10 to 35 IRHD → Sample thickness 10 to 15mm/ procedure "L"
normal: over 35 IRHD → Sample thickness 8 to 10mm/ procedure "N"
Sample thickness 1.5 to 2.5 mm / procedure "M"

the hardness determined with finished parts or samples usally vary in hardness determined from specimen samples, especially those with a curved surface.

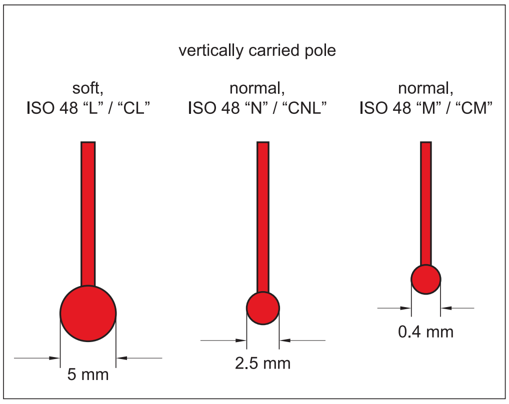


figure 4. indentor according to IRHD

influencing parameters on the hardness test for polymer materials
various sample thicknesses and geometries as well as various tests can show different hardness values even though the same materials have been used.

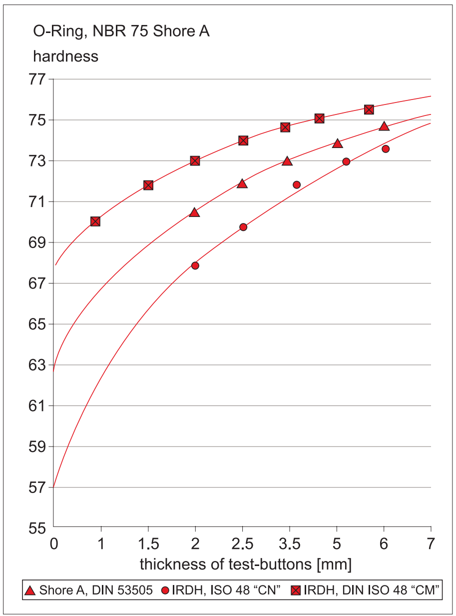


figure 5. ranges of hardness depending on sample thickness and test method

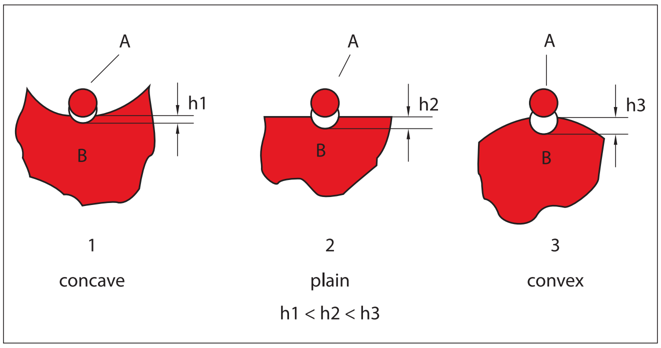


figure 6. range of hardness depending on surface geometry for the equivalent material characteristics.

with equivalent material characteristics of the elastomer sample B, the indentor penetrates the deepest at the surface 3 (convex) and therefore establishes the softest area.
as the convex geometry (3) has a stronger effect on smaller width o-rings, the tolerances on hardness for widths under 2.0 mm should be increased up to +5 / -8 IRHD.

compression set
an important parameter regarding the sealing capability is the compression set (cs) of the o-ring material. elastomers when under compression show aside from an elastic element also a permanent plastic deformation (figure 7).
the compression set is determined in accordance with ISO 815 as follows:

standard test piece:	cylindrical disc, diameter 13 mm and height 6 mm
deformation:	25%
tension release time:	30 minutes

$$cs = \frac{h_0 - h_2}{h_0 - h_1} \cdot 100(\%)$$

where h0 = original height (cross section (cs))
h1 = height in the compressed state
h2 = height after tension release

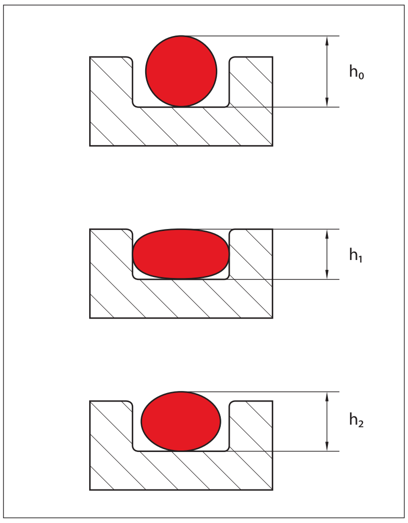


figure 7 illustration of the compression set

design instructions

choice of R16-R seal size

the chosen cross section (cs/H) should be in an appropriate ratio to the inside diameter (Ød). for static applications, R16-R seals with smaller cross sections may be used.

elongation - compression

with a radial sealing configuration, R16-R seal in an internal groove - "external sealing" - should be stretched over the root of the groove. the maximum elongation in the installed state is 6 % for R16-R seals with an inner diameter >50 mm and 8% for R16-R seals with an inner diameter <50 mm.

with external grooves - "internal sealing" applications - R16-R seal is installed in compressed state. the maximum compression in the installed state is 3 %.
information regarding elongation and compression are for guidance only.
exceeding these values will result in an unallowable increase or decrease in R16-R seal cross section. consequently this can affect the service life of the seal. as a rule of thumb: a 1% increase in the inside diameter corresponds to a reduction in the cord diameter of approx. 0.5 %.

initial squeeze

an initial sqeeze of R16-R seal in the groove is essential to ensure its function as a primary or secondary sealing element (figure 8). it serves to:
- achieve the initial sealing capability
- bridge production-dependent tolerances
- assure defined frictional forces
- compensate for compression set
- compensate for wear.

depending on the application, the following values apply for the initial squeeze:

dynamic applications:	6 to 18 %
static applications:	8 to 25 %

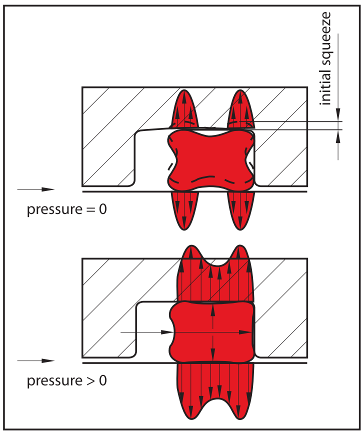


figure 8 sealing force with and without system pressure

methods of Installation of R16-R seals
R16-R seals can be used in components in a wide variety of ways.
at the design stage, the subsequent installation situation should be taken into consideration. to avoid damage during installation it is not recommended to assemble the R16-R seal over edges or bores. where long sliding movements are involved, the seal seat should be recessed, if possible, or the sealing elements arranged so they only have to travel short distances during installation.

radial installation (static and dynamic)
internal sealing
R16-R seal size should be selected so that the inside diameter (Ød) has the smallest possible deviation from the diameter to be sealed d5 (figure 9).
external sealing
R16-R seal size should be selected so that the inside diameter (Ød) is equal to or smaller than the groove root diameter d3.

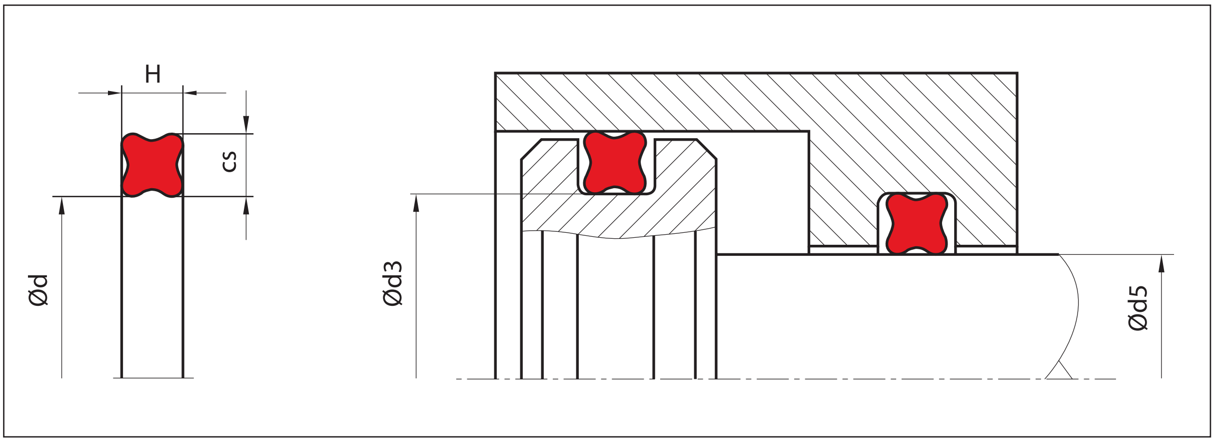


figure 9 radial installation, static and dynamic

axial-static installation
during axial-static installation, the direction of the pressure should be taken into consideration when choosing R16-R seal size (figure 10).
with internal pressure, R16-R seal outside diameter should be chosen approx. 1 to 2 % larger than the groove outside diameter.
with external pressure, R16-R seal is chosen approx. 1 to 3 % smaller than the groove inside diameter.

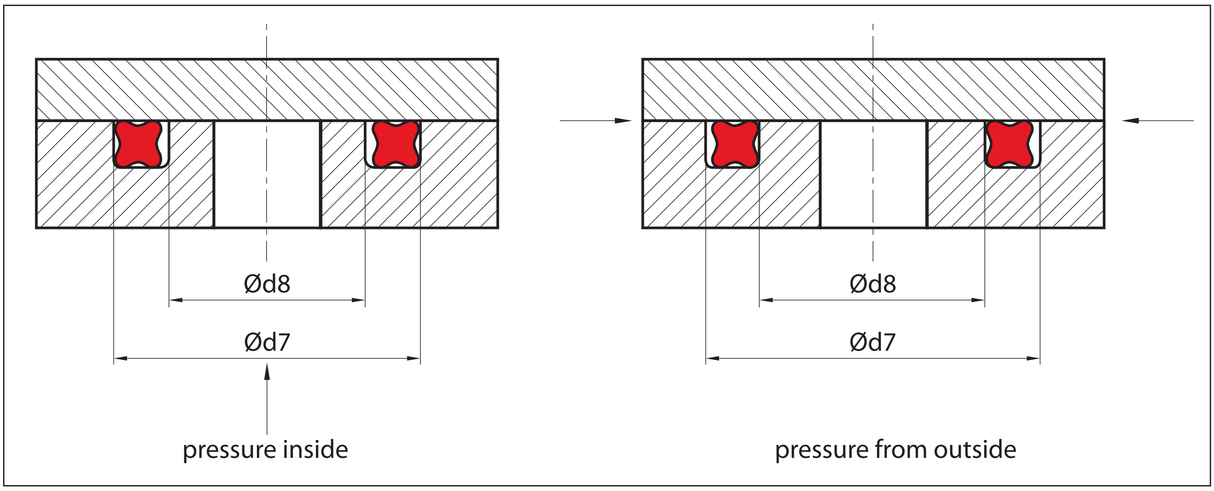


figure 10 axial installation, static

groove design

rectangular groove

R16-R seals are installed in rectangular grooves. the groove widths specified in our recommendations already take into account a limited swelling of the seals. the maximum permissible gap (table IV) must be taken into consideration.

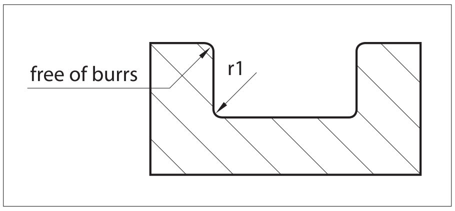


figure 11 groove design

surfaces

under pressure, elastomers adapt to irregular surfaces. for gas or liquid-tight joints, however, certain minimum demands must be made on the surface quality of the surfaces to be sealed.

fundamentally grooves, scratches, pit marks, concentric or spiral machining scores, etc. are not permissible. higher demands must be placed on the surface quality of dynamic mating surfaces than on static sealing surfaces.

at present, no uniform definitions exist for describing the mating surfaces. in practice, the specification of the Ra value is not sufficient to permit an assessment of the surface quality. our recommendations therefore contain amongst others various terms and definitions in accordance with DIN 4768 and DIN EN ISO 4287.

table II surface finish

type of load	surface	Rt (µm)	Rz (µm)	Ra (µm)
radial–dynamic	mating surface* (bore,rod,shaft)	1.0 - 2.5	0.63 - 1.6	0.1 - 0.4
	groove flanks, groove diameter	≤ 10.0	≤ 6.3	≤ 1.6
radial–static axial–static	mating surface groove flanks, groove diameter	≤ 10.0 ≤ 16.0	≤ 6.3	≤ 1.6
	for pulsating pressures mating surface groove flanks, groove diameter	≤ 6.3 ≤ 10.0	≤ 6.3	≤ 0.8 ≤ 1.6

*spiral free grinding.

the above is for guidance only and covers the majority of sealing applications. however seal-mart should be consulted in areas of particular concern.

lead-in chamfers

bearing in mind the subsequent installation requirements during the design of R16-R seal can help to eliminate possible sources of damage and seal failure from the outset.

since R16-R seals are always fitted oversize, lead-in chamfers and rounded edges must be provided (figures 12 and 13).

the lengths of the lead-in chamfers are specified in table III.

the permissible surface roughness of the lead-in chamfer is defined as follows:

Rz < 6.3 µm Ra < 0.8 µm

table III lead-in chamfers

lead-in chamfers length Z min.		R16-R seal cross section (cs/H)
15°	20°	
2.5	1.5	up to 1.78 1.80
3.0	2.0	up to 2.62 2.65
3.5	2.5	up to 3.53 3.55
4.5	3.5	up to 5.33 5.30
5.0	4.0	up to 7.00
6.0	4.5	above 7.00

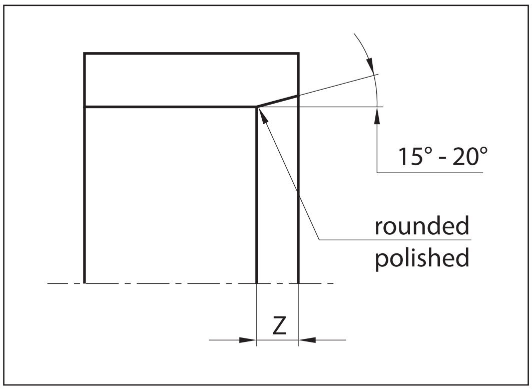


figure 12 lead-in chamfer for bores, tubes

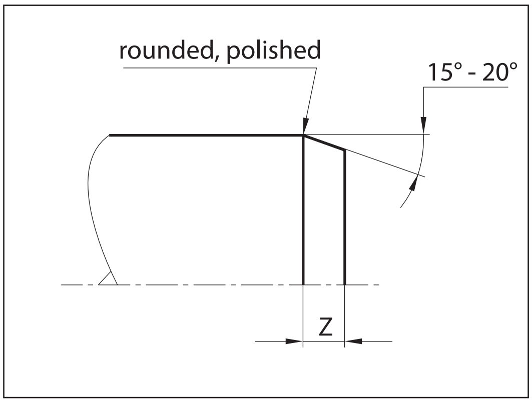


figure 13 lead-in chamfer for rods, shafts

sealing gaps
the tolerances and permissible gap dimensions S given in the installation table IV, must be maintained.
if the extrusion gap is too large, there is a risk of seal extrusion which can result in the destruction of the R16-R seal.
the permissible gap s between the parts to be sealed depends on the system pressure, the cross section and the shore hardness of the R16-R seal.

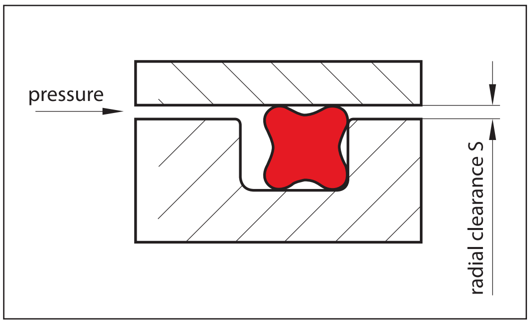


figure 14. radial clearance "S"

installation of R16-R seals with back-up rings
another possible method of protecting R16-R seal from extrusion into the gap is the additional installation of back-up rings.
the installation of back-up rings is generally recommended when at least one of the following conditions exists:
- high pressures - above approx. 5 MPa (50 bar)
- large tolerances or gaps between the parts to be sealed
- high temperatures or temperature fluctuations during expansion of the parts under pressure
- high degree of contaminants in the system.

where the pressure acts from only one side, it is sufficient to install a back-up ring on the side away from the pressure. where the pressure acts from both sides, two back-up rings - one on each side of R16-R Seal - are necessary.
a complete summary of our back-up ring product range can be found in the catalogue "static seals".

the following tables show R16-R - back-up ring combinations:
"external" sealing installation, table VI.
"internal" sealing installation, table VII.
rotary seal installation, table VIII.

the selection series contains two back-up ring types:
- split, spiral-type design, preferred for both external and internal sealing applications (bore and shaft)
- one-piece design, preferably for internal sealing applications (shaft) under radially-dynamic loads.
the usage of other back-up ring types than given is also possible.
the standard material for the back-up ring is virgin PTFE. special materials, e.g. for injection moulded back-up rings, on request.

installation instructions

general recommendations
before starting installation, check the following points:
- lead-in chamfers made according to drawing?
- bores deburred and edges rounded?
- machining residues, e.g. chips, dirt and foreign particles, removed?
- screw thread tips covered?
- seals and components greased or oiled? ensure media compatibility with the elastomer material. seal-mart recommends to use the fluid to be sealed.
- do not use lubricants with solid additives, e.g. molybdenum disulphide or zinc sulphide.

manual installation
- use tools without sharp edges!
- ensure that the R16-R seal is not twisted, use installation aids to assist correct positioning
- use installation aids wherever possible
- do not over stretch R16-R seals

installation over threads, splines etc.
should the R16-R seal have to be stretched over threads, splines, keyways etc., then an assembly mandrel is essential. this mandrel can either be manufactured in a soft metal or a plastic material obviously without burrs or sharp edges.

automatic installation
automatic seal installation requires good preparation. the surfaces of the R16-R seals are frequently treated by several methods (see brochure "friction-free running"). this offers a number of benefits during installation by
- reducing the installation forces
- non-stick effects, easy removal
the handling and installation of dimensionally unstable components requires a great deal of experience. reliable automated installation thus demands special handling of seals.
please ask our specialists for further details.

seal & housing recommendations
please note that we are able to produce those profiles to your specific need or any non standard housing. for detail measurements, please see seal-mart catalog...

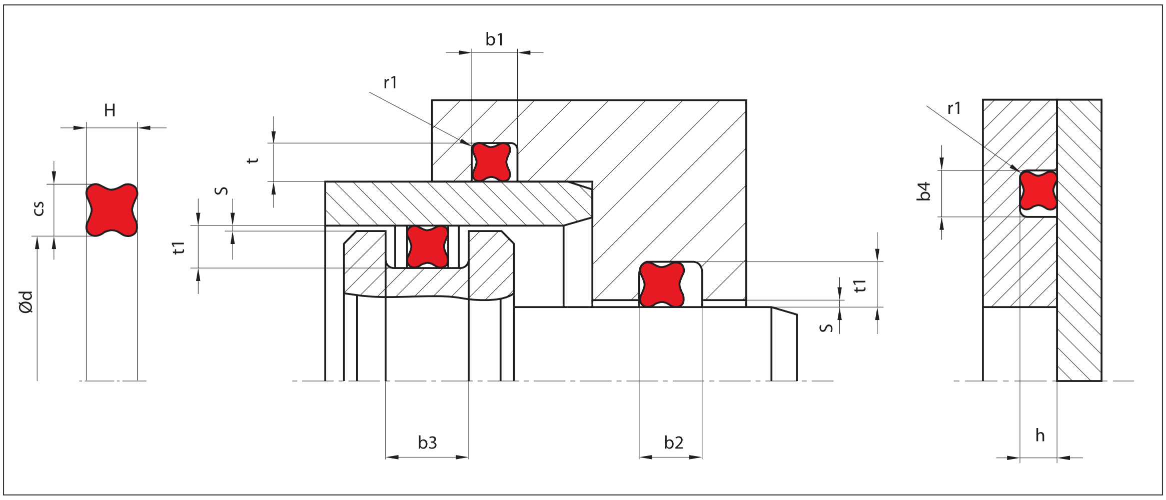


figure 15. installation drawing

table IV installation dimensions

cord diameter (cs/H)	radial initial squeeze *		groove dimensions					radius 3) r_1	radial gap Smax.
			groove depth ** 1)		groove width ***				
	dynamic max. / min.	static max. / min.	dynamic t_1 +0.05	static t/h +0.05	b_1, b_4 +0.2	b_2 +0.2	b_3 +0.2		
1.02	0.300 / 0.115	0.350 / 0.165	0.80	0.75	1.20			0.10	0.03
1.27	0.330 / 0.145	0.430 / 0.245	1.00	0.90	1.40			0.10	0.03
1.52	0.350 / 0.165	0.450 / 0.265	1.25	1.15	1.70			0.22	0.04
1.78	0.360 / 0.175	0.460 / 0.275	1.50	1.40	2.00			0.22	0.05
2.62	0.400 / 0.215	0.450 / 0.265	2.30	2.25	3.00	2)	2)	0.30	0.08
3.53	0.430 / 0.205	0.530 / 0.305	3.20	3.10	4.00			0.40	0.08
5.33	0.560 / 0.250	0.710 / 0.400	4.90	4.75	6.00			0.40	0.10
7.00	0.700 / 0.350	0.950 / 0.600	6.40	6.20	8.00			0.60	0.10

1) also o-ring grooves can be generally used. friction may be higher at dynamic application. back-up rings must be adapted.
2) when using back-up rings the groove is to be increased by the back-up ring thickness.
3) if a back-up ring is used the recommended radius should always be r1 = 0.25 ±0.2 mm.

general notes
*max. or min. values for the radial compression, taking into consideration the permissible tolerances of cord cross-section and groove depth. max. radial squeeze produces a good sealing effect but increases the friction. min. radial squeeze reduces the sealing effect and improves friction.

** the values quoted for groove depth are average values and apply under medium load conditions in hydraulic applications. for eccentric piston positions or bending of the rod and in vacuum and low-pressure applications, the groove depth should be reduced and/or the initial squeeze increased.

*** if a greater swelling of the seal material is anticipated, the groove width can be increased by up to approx. 20%.

the installation dimensions (table IV, VI, VII and VIII) apply to R16-R seals of NBR. basically all moulds for R16-R seal production are laid out for shrinkage behaviour of NBR materials.
therefore the inside diameter and cross section of R16-R seals out of elastomers with a higher shrinkage, such as VMQ or FKM, may differ slightly. owing to this in particular cases the groove depth must be adapted or rather reduced depending on the application and the nominal sizes of the seal.
as a guide value for the higher shrinkage of FKM materials a difference of approximately 0.5 % may be assumed. exact values depend on the material and may deviate from this.

general quality criteria
the cost-effective use of seals and bearings is highly influenced by the quality criteria applied in production. seals and bearings from busak+shamban are continuously monitored according to strict quality standards from material acquisition through to delivery.

certification of our production plants in accordance with international standards QS 9000 / ISO 9000 meets the specific requirements for quality control and management of purchasing, production and marketing functions.

our quality policy is consistently controlled by strict procedures and guidelines which are implemented within all strategic areas of the company.

all testing of materials and products is performed in accordance with accepted test standards and specifications, e.g. random sample testing in accordance with DIN ISO 2859, part 1.

inspection specifications correspond to standards applicable to individual product groups (e.g. for o-rings: ISO 3601).

our sealing materials are produced free of chlorofluorinated hydrocarbons and carcinogenic elements.

the tenth digit of our part number defines the quality characteristics of the part. a hyphen indicates compliance with standard quality criteria outlined in this catalogue. customer-specific requirements are indicated by a different symbol in this position. customers who require special quality criteria should contact their local busak+shamban sales office for assistance. we have experience in meeting all customer quality requirements.

storage and shelf life guidelines
seals and bearings are often stored as spare parts for prolonged periods. most rubbers change in physical properties during storage and ultimately become unserviceable due, e.g., to excessive hardening, softening, cracking, crazing or other surface degradation. these changes may be the result of particular factors or combination of factors, such as the action of deformation, oxygen, ozone, light, heat, humidity or oils and solvents.

with a few simple precautions, the shelf life of these products can be considerably lengthened.

fundamental instructions on storage, cleaning and maintenance of elastomeric seal elements are described in international standards, such as:
DIN 7716 / BS 3F68:1977,
ISO 2230 or
DIN 9088

the standards give several recommendations for the storage and the shelf life of elastomers, depending on the material classes.

the following recommendations are based on the several standards and are intended to provide the most suitable conditions for storage of rubbers. they should be observed to maintain the optimum physical and chemical values of the parts:

heat
the storage temperature should preferable be between +5° C and +25° C. direct contact with sources of heat such as boilers, radiators and direct sunlight should be avoided. if articles are taken from low temperature storage, care should be taken to avoid distorting them during handling at that temperature as they may have stiffened. in this case the temperature of the articles should be raised to approximately +20° C before they are put into service.

humidity
the relative humidity in the store room should be below 70 %. very moist or very dry conditions should be avoided. condensation should not occur.

light
elastomeric seals should be protected from light sources, in particular direct sunlight or strong artificial light with an ultraviolet content. the individual storage bags offer the best protection as long as they are UV resistant. it is advisable to cover any windows of storage rooms with a red or orange coating or screen.

radiation
precaution should be taken to protect stored articles from all sources of ionising radiation likely to cause damage to stored articles.

oxygen and ozone
where possible, elastomeric materials should be protected from circulating air by wrapping, storage in airtight containers or by other suitable means.
as ozone is particular deleterious to some elastomeric seals, storage rooms should not contain any equipment that is capable of generating ozone, such as mercury vapour lamps, high voltage electrical equipment, electric motors or other equipment which may give rise to electric sparks or silent electrical discharges. combustion gases and organic vapour should be excluded from storage rooms as they may give rise to ozone via photochemical processes.

deformation
elastomeric materials should, wherever possible, be stored in a relaxed condition free from tension, compression or other deformation. where articles are packed in a strain-free condition they should be stored in their original packaging.

contact with liquid and semi-solid materials
elastomeric seals should not be allowed to come into contact with solvents, oils, greases or any other semi-solid materials at any time during storage, unless so packed by the manufacturer.

contact with metal and non-metals
direct contact with certain metals, e.g. manganese, iron and particularly copper and its alloys, e.g. brass and compounds of these materials are known to have deleterious effects on some rubbers. elastomeric seals should not be stored in contact with such metals.
because of possible transfer of plasticisers or other ingredients, rubbers must not be stored in contact with PVC. different rubbers should preferably be separated from each other.

cleaning
where necessary, cleaning should be carried out with the aid of soap and water or methylated spirits.water should not, however, be permitted to come into contact with fabric reinforced components, bonded seals (because of corrosion) or polyurethane rubbers. disinfectants or other organic solvents as well as sharp-edged objects must not be used. the articles should be dried at room temperature and not placed near a source of heat.

shelf life and shelf life control
the useful life of a elastomeric seals will depend to a large extend on the type of rubber. when stored under the recommended conditions (above sections) the below given shelf life of several materials should be considered.

AU, thermoplastics	4 years
NBR, HNBR, CR	6 years
EPDM	8 years
FKM, VMQ, FVMQ	10 years
FFKM, Isolast®	18 years
PTFE	unlimited

elastomeric seals should be inspected after the given period. after this giving an extension period is possible.
rubber details and components less than 1.5 mm thick are liable to be more seriously affected by oxidation degradation even when stored in satisfactory conditions as recommended. therefore they may be inspected and tested more frequently than it is mentioned above.

rubber details / seals in assembled components
it is recommended that the units should be exercised at least every six months and that the maximum period a rubber detail be allowed to remain assembled within a stored unit, without inspection, be a total of the initial period stated above and the extension period. naturally this will depend on the design of the unit concerned.

conversion tables

SI - basic units

measures	units	symbol
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
temperature	kelvin	K
luminous intensity	candela	cd
amount of substance	mol	mol

length

	inch	foot	yard	mm	metre
1inch =		0.0833	0.0278	25.4	0.0254
1foot =	12		0.333	304.8	0.3048
1yard =	36	3		914.4	0.9144
1mm =	0.03937	0.0033	0.00109		0.001
1metre =	39.37	3.2808	1.0936	1,000	

torque

	inch-ounce	inch-pound	foot-pound	kg-metre	Newton-metre
1inch-ounce =		0.0625	0.0052	7.2x10-4	7.06x10-3
1inch-pound =	16		0.0833	1.152x10-2	0.1130
1foot-pound =	192	12		0.1383	1.356
1kg-metre =	1,388.7	86.796	7.233		9.80665
1Newton-metre =	141.6	8.850	0.7375	0.1020	

area

	$inch^2$	$foot^2$	$yard^2$	mm^2	m^2
$1inch^2$ =		0.0069	0.00077	645.16	$6.45x10^{-4}$
$1foot^2$ =	144		0.111	92,903	0.0929
$1yard^2$ =	1,296	9		836,100	0.8361
$1mm^2$ =	0.0016	$1.0764x10^{-5}$	$1.196x10^{-6}$		10^{-6}
$1m^2$ =	1,550	10.764	1.196	10^6	

volume

	$inch^3$	US quart	imp.gallon	$foot^3$	US gallon	liter
$1inch^3$ =		0.0173	0.0036	0.00058	0.0043	0.0164
1US quart =	57.75		0.2082	0.0334	0.25	0.9464
1imp.gallon =	277	4.8		0.1604	1.2	4.546
$1foot^3$ =	1,728	29.922	6.23		7.48	28.317
1US gallon =	231	4	0.8327	0.1337		3.785
1liter =	61.024	1.0567	0.220	0.0353	0.264	

temperature

	°K(Kelvin)	°C	°F
°K=		°C + 273.15	(°F - 459.67)5/9
°C=	°K - 273.15		(°F - 32) 5/9
°F=	°K 9/5 -459.67	°C 9/5 + 32	

density

	ounce/inch³	pound/foot³	g/cm³
1 ounce/inch³ =		108	1.73
1 pound/foot³ =	0.0092		0.016
1g/cm³ =	0.578	62.43	

force

	Newton (N)	kilopond (kp)	pound force
1 Newton(N) =		0.10197	0.22481
1 kilopond (kp) =	9.80665		2.20463
1 pound force =	4.4482	0.45359	

velocity (speed)

	foot/s	foot/min	mile/hour	metre/s	km/hour
1 foot/s =		60	0.6818	0.3048	1.097
1 foot/min =	0.017		0.0114	0.00508	0.01829
1 mile/hour =	1.4667	88		0.447	1.609
1 metre/s =	3.280	196.848	2.237		3.6
1 km/hour =	0.9113	54.68	0.6214	0.278	

mass

	ounce	pound	kg
1 ounce =		0.0625	0.0283
1 pound =	16		0.4536
1 kg =	35.274	2.2046	

pressure

	inchHg	psi	atmosphere	torr	mmHg	bar	MPa	kg/cm2
1 inchHg =		0.491	0.0334	25.4	25.4	0.0339	0.00339	0.0345
1 psi =	2.036		0.0680	51.715	51.715	0.0689	0.00689	0.0703
1 atmosphere =	29.921	14.696		760	760	1.0133	0.10133	1.0332
1 torr =	0.0394	0.0193	0.0013		1	0.0013	0.00013	0.00136
1 mmHg =	0.0394	0.0193	0.0013	1		0.0013	0.00013	0.00136
1 bar =	29.53	14.504	0.987	749.87	749.87		0.1	1.020
1 MPa =	295.3	145.04	9.869	7498.7	7498.7	10		10.2
1 kg/cm² =	28.950	14.22	0.968	735.35	735.35	0.980	0.098	