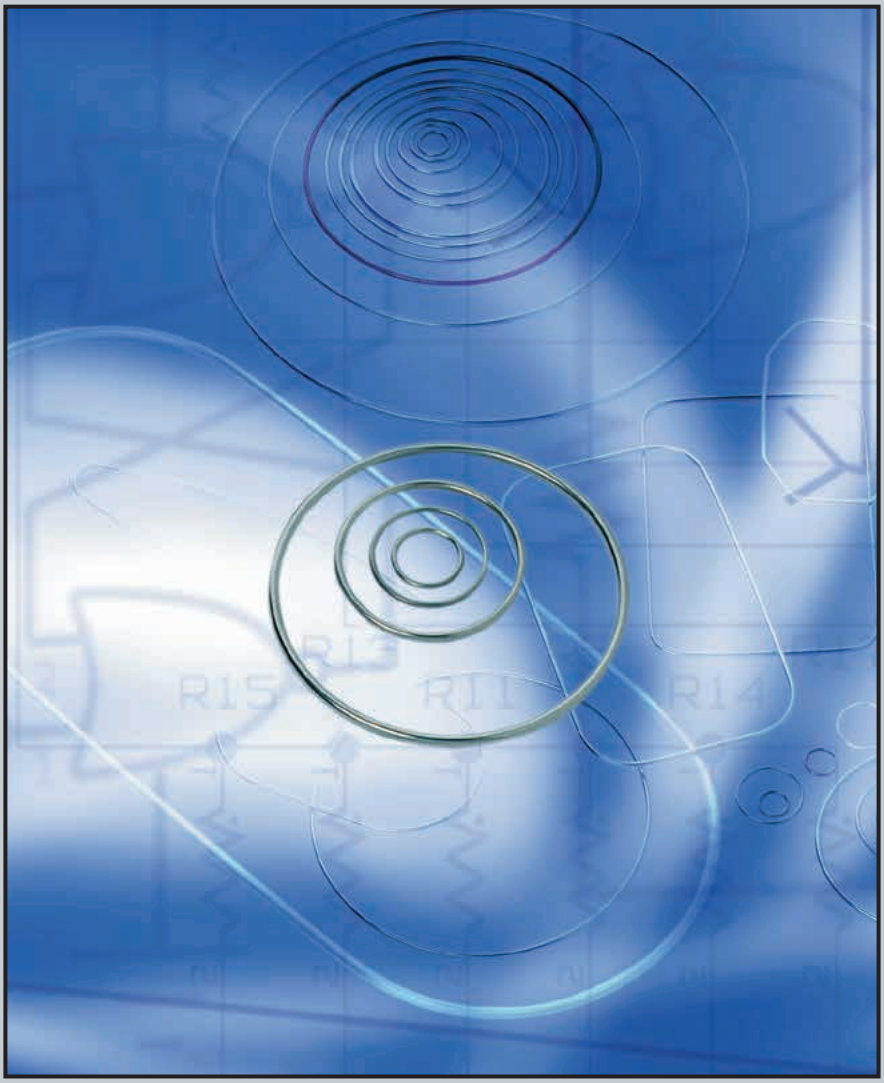
GFD



Metal-O-rings and C-rings
for extreme operating conditions

From ultrahigh vacuum up to 6,800 bar (100,000 psi) pressure
and temperatures from -269 °C cryogenic up to +980 °C
(-425 °F up to 1800 °F).
Resistant to chemicals to a large extent.

Table of contents

General

GFD metal O-rings have been developed as a secure sealing of gases or liquids. They even can be used in case of extreme conditions. These static and metallic sealing elements can be applied in ranges of ultrahigh vacuum and up to a pressure of 6,800 bar. They are suitable in case of continuous temperatures from 269 degrees centigrade below zero up to 980 degrees centigrade above zero and resistant to radioactive radiation, chlorides, corrosion and other aggressive influences. They neither age in use or during storage.

Construction – materials – coating – dimensions

GFD metal O-ring are produced of metal tubes or solid wire material. The material is shaped and welded to rings or other figurations. The O-ring consists of stainless steel or other alloys and can be electroplated with silver, cooper, indium, nickel, gold, lead or other metals or can be coated with Teflon*). The flowing of the coating material improves the sealing especially under high pressure and / or vacuum. GFD offers a variety of heat treatments according to material or customer's specifications, as the resistance to extension and the spring deflection are partially determined by the thermal subsequent treatment. Hollow or solid wire rings can be produced in sizes from 6.4 mm up to 2,500 mm outside diameter.

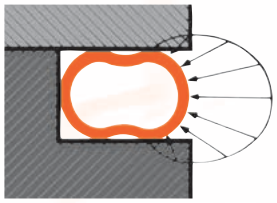
Application and function

The metal O-ring is axially pressed between parallel surfaces, which are arranged at right angles to the flow or to the vessel, as typical application. The sealing is usually placed in an open or closed groove, but can also be installed in a holding device. The working of a groove can be omitted for this reason. The tubing of the seal buckles slightly upon pressing to a predetermined and fixed height. As a result originate two virtual contact widths on the sealing surface and a maximum contact potential between sealing and jointing face. A spring-back effect is obtained, which pursues a positive force, due to the closing of two flanges and the resultant pressing of the O-ring. With the self-energizing performance of metal O-rings, the system pressure increases the sealing force upon the flange facing.

Advantages

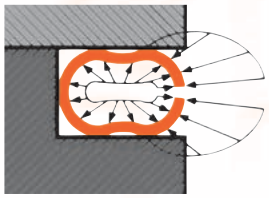
With conventional flanged joints many technical data, from which only very few are precisely available during the design state, have to be known for the calculation. Also the values for the rigidity of the flange, the screws etc. have to be available. The consequence are extensive calculations with imprecise or assumed values and the involved disadvantages. There is always a defined initial tension, no setting and smaller flange and screw dimensions with the GFD metal O-rings or lip seals. The proof has not to be furnished with complicated and difficult calculations about unknown quantities but simply by adding the forces of pressure to the operating pressures.

Especially developed for extreme operating conditions



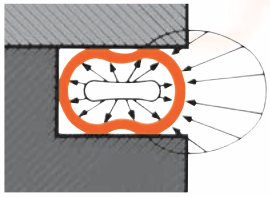
Standard type

This type is not self-energizing or pressure-filled, produced of different metallic tubings or solid wire and the most reasonable O-ring type for low to moderate pressure or vacuum ratios.



Self-energizing type

At the inside or outside diameter the O-ring shows borings and grooves, thereby the same pressure originates in the inside as in the system. The system pressure supports the sealing behavior.

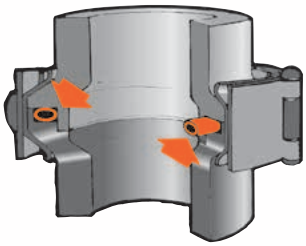


Pressure-filled type

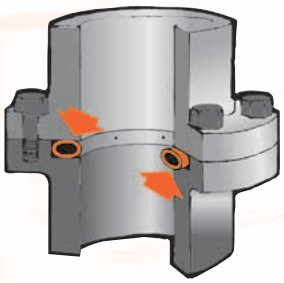
Pressure-filled O-rings have been designed especially for temperatures from 425 degrees centigrade up to 980 degrees centigrade above zero. They are less pressure resistant the self-energizing type, contain a gas filling of approx. 40 bar pressure or more, the gas pressure increases upon higher temperatures and compensates the initial tension deficiency of the flanged joint and increases the sealing force thereby.

Typical applications

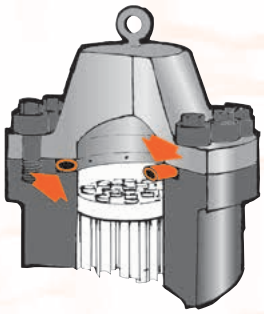
GFD metal O-rings are successfully used in vacuum or high-pressure systems as well in critical ranges for hydraulic units and lubricating oils, jet engines and rocket propellants, liquid metals and combustion gases. They yield positive and leakproof seals in tube systems and with production processes for the chemical, petrochemical, petroleum, natural gas and refinery industry. Many manufacturers of reciprocating engines, heat exchangers, gas turbines, pressure vessels, injection units, high-pressure filters and other elements rely on metal O-rings as a permanent and highly stressable seal. Some common applications are illustrated below:



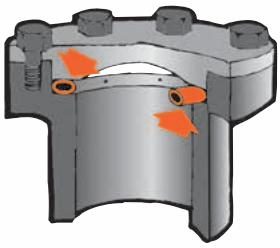
quick release coupling



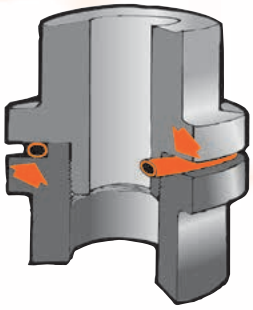
screwed flange



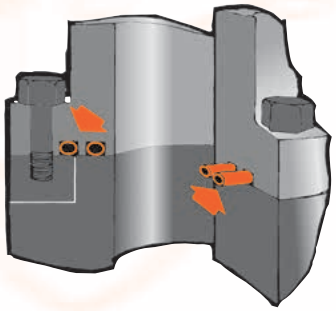
heat exchanger/pressure vessel



screwed cover



screwing with external pressure



nuclear power station pressure vessel

Selection criterions for metal O-rings

In order to be able to select the appropriate metal O-ring for a particular application the pressure, the temperature and the kind of the media to be sealed in the system have to be known:

O-ring type

The selection of the correct O-ring type depends on the system pressure:

pressure	O-ring type
vacuum up to 6.8 bar	standard type
6.8 bar and above	self-energizing
vacuum up to approx. 20 bar	pressure-filled

O-ring material

The selection of the correct O-ring material depends on the used temperature:

temperature	O-ring material	German Material-No.
from cryogenic up to +260 °C	AISI 321 stainless, Inox 321	1.4541
from cryogenic up to +430 °C	Inconel 600	2.4816
from cryogenic up to +980 °C	Inconel X-750	2.4669
more than +980 °C	on demand	

Ring diameter and tube wall thickness

The tube profile section is determined by means of the outside diameter of the rings, the desired force of pressure and the available space. The wall thickness thus has to be selected that an adequate force of pressure accrues upon the appropriate deformation. The following data comprehend the common wall thicknesses, which can be applied for each diameter. With electroplated surfaces, seals with a tube wall thickness ≥ 3.2 mm diameter and load of approx. 72 N/mm peripheral length lead to a plastic deformation of the electroplating. For tubing with a diameter ≤ 3.2 mm a pressing of 140 N/mm peripheral length is required. Teflon*) coatings on rings are plastically deformed with a load of 18 N/mm peripheral length.

tube outside diameter [mm]	ring outside diameter [mm] min.	max.	standard tube wall thicknesses [mm]
0.9	6.4	101	0.15
1.6	15.9	254	0.15 / 0.25 / 0.30 / 0.36
2.4	25.4	508	0.15 / 0.25 / 0.46
3.2	50.8	1016	0.25 / 0.51
4.0	76.2	1270	0.41 / 0.51 / 0.64
4.8	101.0	1524	0.51 / 0.64 / 0.81
6.4	127.0	2500	0.64 / 0.81

Groove dimensions

The correct dimension and quality of finish of the groove are as important as the O-ring itself for the use of the seal. The following recommended groove dimensions for internal and external pressure applications are to be understood as general recommendations for the preparation of sealing faces. The dimensions in the list refer to rings, which are not electroplated. Groove depths for rings with a profile section of 0.9 mm are increased by the double of the coating thickness. Groove depths for electroplated or coated rings with a tube diameter of 1.6 mm or more are not increased.

Recommended groove dimensions: B (= max. outside O-Ring dia.) as well as A (= min. inside O-ring dia.) are values including coating

tube outside dia. [mm]	groove depth [mm] min.	max.	groove width [mm] min.*	spring-back [mm]	groove outside dia. [mm] (for internal pressure)	groove inside dia. [mm] (for external pressure)
0.9	0.60	0.68	1.4	max. 0.03	B+0.10 / +0.20	A-0.10 / -0.20
1.6	1.15	1.25	2.3	max. 0.06	B+0.10 / +0.20	A-0.10 / -0.20
2.4	1.80	1.95	3.4	max. 0.06	B+0.15 / +0.25	A-0.15 / -0.25
3.2	2.40	2.60	4.3	max. 0.08	B+0.20 / +0.35	A-0.20 / -0.35
4.0	3.05	3.25	5.1	max. 0.10	B+0.25 / +0.40	A-0.25 / -0.40
4.8	3.70	3.90	6.4	max. 0.15	B+0.25 / +0.40	A-0.25 / -0.40
6.4	5.00	5.20	8.9	max. 0.20	B+0.30 / +0.50	A-0.30 / -0.50

*lower groove width on request

Coating and quality of finish

Coating or electroplating

By means of coating or electroplating of the metal O-ring a higher adhesion and a more ductile (softer) surface is obtained, so that an adaptation to microscopic irregularities in the groove or flange can be enabled. Based upon the following formula the leakage of liquids can be determined approximately for non electroplated seals:

$$Q = \frac{5.0 \times 10^{-6}\ p}{\mu}$$

Q = leakage cm^3/s
p = pressure difference psi
μ = liquid viscosity with operating conditions in Centipoise

When the calculated leakage is $\geq 10^{-3}$ to $\geq 10^{-4}$ cm^3/s, the effective leakage may possibly be zero owing to the surface tension. When leakage occurs it should be proportional to the sealing diameter and correspond to the value of the above equation multiplied by D/2 (D = sealing diameter). The effective leakage probably will be under the calculated value. Even helium impermeable connections may be produced upon practical selected O-rings, coating or electroplating. The results range at a pressure difference of 1 bar and a leakage between 10^{-6} to 10^{-12} mbar l/s.

Also uncoated rings and customized performances are additionally available to the following indicated coating materials:

coating	order code
silver	S
PTFE	T
copper	C
lead*	P
indium	I
nickel	N
tin	Z

*only on request

coating thickness [mm]	order code
0.01 - 0.03	L
0.03 - 0.05	M
0.05 - 0.07	H
according to specification	X

coating	order code
gold	G

coating thickness [mm]	order code
0.004 - 0.006	1
0.006 - 0.008	2
0.008 - 0.010	3
according to specification	X

temperature limit for coatings:

coating	order code	temperature limit
indium	I	100 °C
lead*	P	150 °C
tin	Z	150 °C
PTFE	T	250 °C
copper	C	700 °C
silver	S	700 °C
gold	G	850 °C
nickel	N	980 °C

*only on request

Quality of finish

The following groove surface roughnesses are usual in practical operation.
Depending on leakage trade:

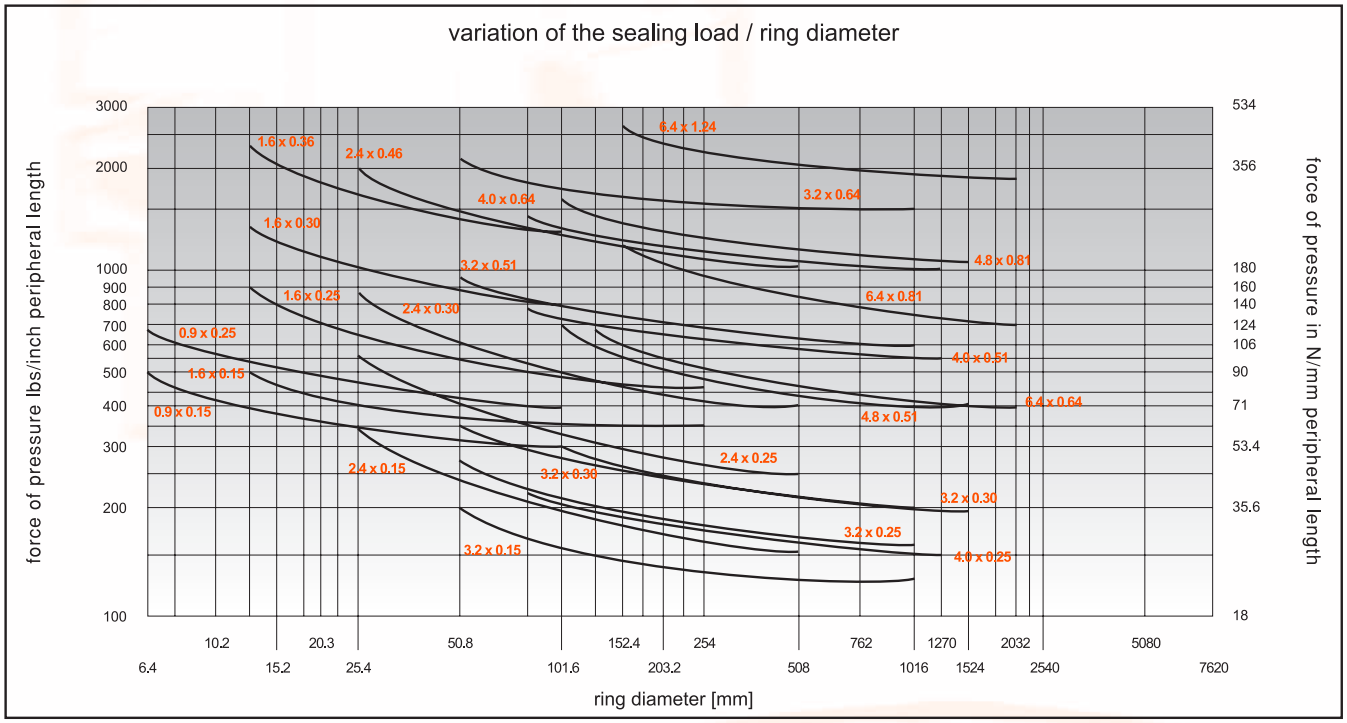
quality of finish (medium)	groove surface roughnesses [µm] for coated O-ring		for uncoated O-ring	
viscous media	Ra = 1.6 – 2.5 (R max. = 6.0)	N7 – N8	Ra = 0.8 – 1.6 (R max. = 3.0)	N6 – N7
liquid media	Ra = 0.4 – 0.8 (R max. = 2.0)	N5 – N6	–	
vacuum / gases	Ra = 0.2 – 0.6 (R max. = 1.0)	N4 – N5	–	

Ghost lines on the groove surface or flange facing have to be free of dirt, grinding dust or other impurities.

Sealing specification

Sealing load or required force of pressure

The following graphic chart shows the required force of pressure referring to the diameter of the sealing ring for different tube outside diameters and wall thicknesses of the stainless tubing. For tubing made of Inconel 600 the indicated values have or be multiplied with factor 1.1 and for Inconel X-750 with factor 1.4.



Sealing specification – order code key

MOR-	3	3	2	- 0096,80	- P F	S	M
metal O-ring	material	tube outside dia.	wall thickness	ring OD	type	coating	coating thickness
	1 = Inox 304*	1 = 0.9	1 = 0.15	(incl. coating)	SI = self-energizing inside	0 = without	L = 0.01 - 0.03
	2 = Inox 316*	2 = 1.6	2 = 0.25		PF = pressure filled	S = silver	M= 0.03 - 0.05
	3 = Inox 321	3 = 2.4	3 = 0.36		NP = standard type	T = PTFE	H = 0.05 - 0.07
	4 = Inconel 600	4 = 3.2	4 = 0.46		SO = self-energizing outside	C = copper	X = specification
	5 = Inconel X-750	5 = 4.0	5 = 0.51		SX = self-energizing according to specification	P = lead	
		6 = 4.8	6 = 0.64		MS = solid wire	I = indium	
		7 = 6.4	7 = 0.81			N = nickel	
		0 = solid wire				G = gold	
						X = specification	
						Z = tin	

The order example describes above “MOR-332-0096,80-PFSM” refers to a metal O-ring of:
Inox 321, with tube outside diameter of 2.4 mm, a wall thickness of 0.25 mm, a ring outside diameter of 96.80 mm (incl. coating), pressure-filled, silver coated with a coating thickness from 0.03 to 0.05 mm
Not all combinations of materials, dimensions and wall thickness are available. Please contact us.

Should you require any further instructions or recommendations, please supply us the following information:
application, ranges of temperature and pressure, available space, material, medium to be sealed, available force of pressure, drawing of the installation position.
*only for solid rings

Our competent and experienced team will always assist you consultative.

Metal C-rings

GFD metal C-rings are static sealing elements for machines and installations with high requirements. Metal C-rings are considerably more elastic than metal O-rings and other metal seals.

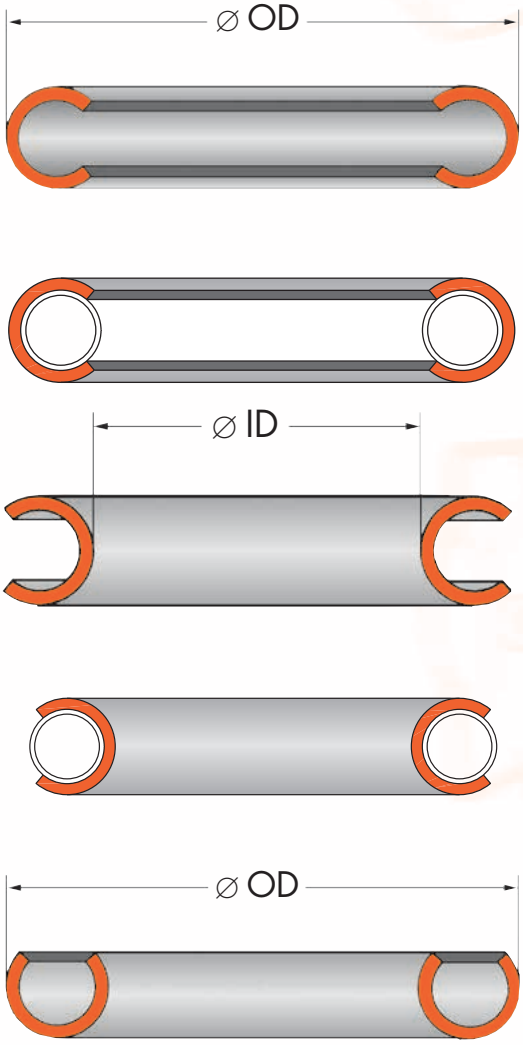
The prestressed forces are approx. at one third of the ones metal O-rings (compare diagram page 7). However these prestressed forces differentiate according to material, heat, tolerances, treatment etc.

The sealing is secured by means of the spring-back of the metal C-rings, as movements inside the flanged joint (in extreme case flange removal) have to be taken into account. The prestress / deformation is approx. a 20% of the ring height.

Metal C-rings are available for internal and external pressure or axial thrust. The seal operates self-energizing as the metal C-rings are open towards the thrust face. C-rings are available with a ring outside diameter from 6.5 mm to 3000 mm as well with round profile section or also in special profiles. Dimensions from 0.9 mm to 6.4 mm are available as profile sections.

The same coatings are available as with O-rings. Inconel 718 (= code no. 7) is the standard material of C-rings. Applications are possible in the range up to 750 °C above cryo. With higher temperatures, please contact us. High-vacuum 10^{-10} mb l/s up to the ultrahigh pressure range of 6,800 bar can be accomplished with metal C-rings.

Metal C-ring types



type MCI
for internal pressure

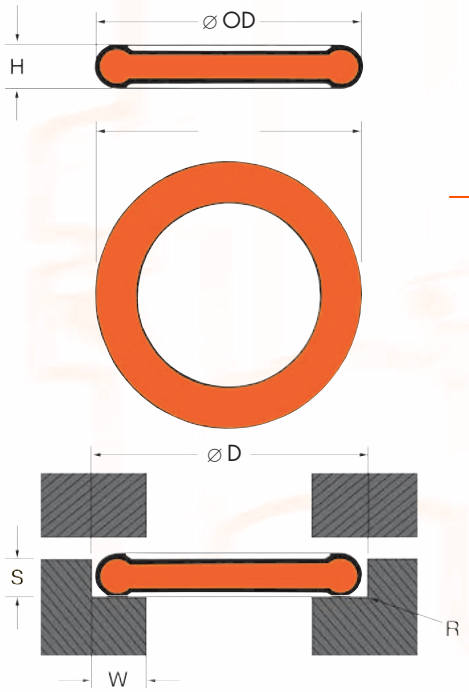
type MCIF
version with spring
for internal pressure

type MCO
for external pressure

type MCOF
version with spring
for external pressure

type MCA
for axial thrust and radial sealing

Performances



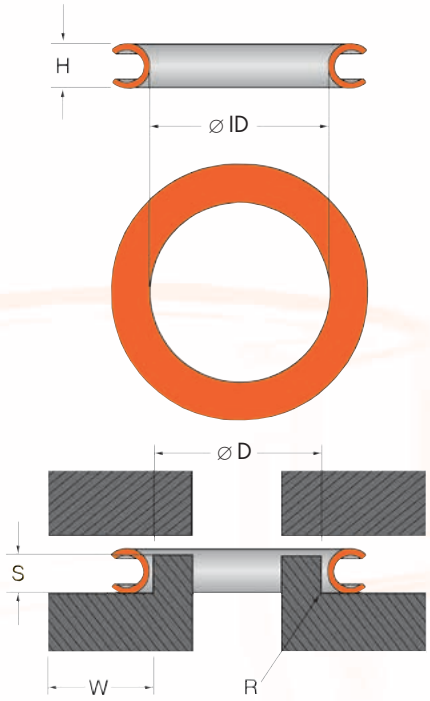
type MCI
MCIF

Metal C-ring for internal pressure

The outside diameter of the metal C-ring for internal pressure is accepted as reference dimension.

The groove outside diameter is somewhat bigger than the ring outside diameter.

Therefore the ring has to be somewhat smaller than the groove outside diameter.



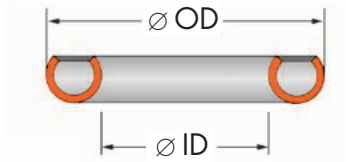
type MCO
MCOF

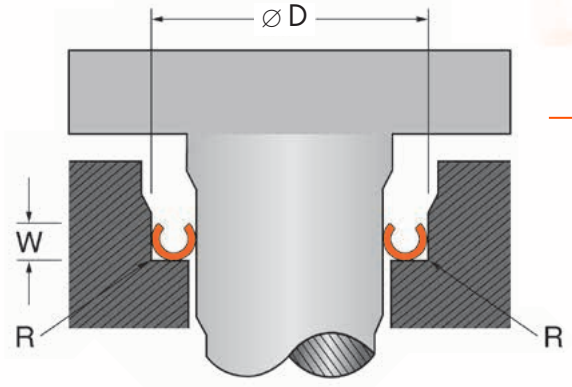
Metal C-ring for external pressure

The inside diameter of the metal C-ring for external pressure is accepted as reference dimension.

The groove inside diameter is somewhat smaller than the ring inside diameter.

Therefore the ring inside diameter has to be somewhat bigger than the groove inside diameter.





type MCA

Metal C-ring for axial thrust and radial sealing

The outside diameter of the metal C-ring for axial thrust and radial sealing is accepted as reference dimension.

The radial sealing is effected by the C-ring between the inside and the outside diameter.

Dimensions and order code key

Groove dimensions

The correct dimension and quality of finish of the groove are as important as the metal C-ring itself for the use of the seal. The following listed recommend groove dimensions for internal and external pressure applications are to be understood as general recommendations for the preparation of sealing faces.

Recommended groove dimensions: outside and inside dia. are values incl. coating

type MCI + MCO + MCIF + MCOF

nominal free height H [mm]	groove depth min. S [mm]		groove width W [mm] min.		diametric difference (play) between seal and groove [mm]	spring-back [mm] max.	
	min.	max.	MCI/MCO	MCIF/MCOF		MCI/MCO	MCIF/MCOF
0.9	0.64 … 0.70		1.2	–	+0.05 / +0.15	0.04	–
1.6	1.25 … 1.30		2.0	2.3	+0.10 / +0.20	0.08	0.10
2.4	1.90 … 1.95		2.8	3.4	+0.15 / +0.25	0.10	0.15
3.2	2.50 … 2.60		3.6	4.3	+0.20 / +0.30	0.15	0.20
4.0	3.20 … 3.30		4.3	5.1	+0.30 / +0.40	0.20	0.25
4.8	3.80 … 3.95		5.2	6.4	+0.35 / +0.45	0.22	0.28
6.4	5.05 … 5.20		7.0	8.9	+0.40 / +0.50	0.30	0.36

MCA (for groove dim. please contact us)

Sealing specification – order code key

MCI	-	5	3	2	-	0096,80	-	1	S	M
metal C-ring		material	C-ring dia.	wall thickness		ring OD or ID (incl. coating)		thermal treatment	coating	coating thickness
MCI = inside press. MCO= outside press. MCA = axial thrust		1 = Inox 304 2 = Inox 316 3 = Inox 321 4 = Inconel 600 5 = Inconel X-750 6 = 7 = Inconel 718	1 = 0.9 2 = 1.6 3 = 2.4 4 = 3.2 5 = 4.0 6 = 4.8 7 = 6.4	1 = 0.15 2 = 0.25 3 = 0.38 4 = 0.46 5 = 0.51 6 = 0.64 7 = 0.81		Ring OD for type MCI Ring ID for type MCO		1 = conventional cold-hardened 2 = simply heat-treatment 3 = special long-term termal treatment 4 = specific thermal treatment (according to application)	0 = without S = silver T = PTFE C = copper P = lead I = indium N = nickel G = gold* X = specification Z = tin	L = 0.01 - 0.03 M= 0.03 - 0.05 H = 0.05 - 0.07 X = specification *gold coating thickness see chart on page 6.

The order example described above "MCI-532-0096,80-1SM" refers to a metal C-ring for internal pressure of the type MCI of:
Inconel X-750, with free height of 2.4 mm, a wall thickness of 0.25 mm, a ring outside diameter of 96.80 mm (incl. coating), conventional cold-hardened, silver coated with a coating thickness from 0.03 to 0.05 mm.
Not all combinations of materials, dimensions and wall thickness are available. Please contact us.

Should you require any further instructions or recommendations, please supply us the following information:
application, ranges of temperature and pressure, available space, material, medium to be sealed, available force of pressure, drawing of the installation position.

For applications with C-ring with spring and type MCA please contact our technical department.

Our competent and experienced team will always assist you consultative.

GFD – a company shows profile

Many years of experience, competence in the execution as well as the sustained further and new development of the own products makes GFD-Dichtungstechnik to an efficient partner. The continuous production control and the high quality claim are the guarantee for premium and above all for reliable GFD seals.
Communication and proximity to the customers are directly connected with successful performance. Therefore some information is necessary for the working out of an suggestion for mounting of seals:

1.) Drawing, where the mounting proportions are shown:
detailed drawings of all parts, with which the seals come into contact with, indicating:
- mounting dimensions and tolerances
- dimensions of the installation phase and the groove radii
- truth of running, mismatch
- material and hardness of the sliding partner
- surface roughness.

2.) Description of the medium to be sealed as well as the medium on the outside: .....

3.) Temperature and pressure ratios inside the medium and on the outside: .....

4.) Description of the motion ratios: (not applicable with static seals as metal O-rings and C-rings)

a) static or not static .....

b) gyratory movement:
- operating speed .....
- continuous or discontinuous operation .....
- maximum speed .....
- admissible moment of friction .....

c) axial movement:
- stroke length .....
- running speed .....
- frequency .....
- admissible frictional force .....

d) oscillating movement:
- torque .....
- running speed .....
- frequency .....
- admissible moment of friction .....

5.) Admissible leakage: .....

Our department for application technique will be at your disposal for design and advice. Benefit form our experience.
Call or write us!

Delivery programme

Elastic seals of PTFE (polytetrafluor ethylene)

… or other highly stressable plastics with a special steel spring for durable elasticity (from 269 degrees centigrade below zero up to 316 degrees centigrade above zero).

Metal O-rings and C-rings

… static seals of gases and liquids under extreme conditions (from 269 degrees centigrade below zero up to 980 degrees centigrade above zero and ultrahigh vacuum to 6,800 bar).

PTFE seals

… all-purpose usable sealing elements, resistant to chemicals, sterilizable and thus suitable for food and pharmaceutical products.

PTFE turning and milling parts

… according to customer's drawing and specification.

Metal etching parts

… of material thickness from 0.01 - 1.0 mm, from 2 x 2 to 500 x 2,000 mm.

Rotary lip seals with PTFE sealing lip

… for high peripheral speeds or adverse lubricating conditions. Long-lasting and almost universal resistance to chemicals.

Metal seals and laser parts

… for small lots, component parts and experiments without incurring tool costs.

Seals of fluorelastomers and perfluorelastomers

*) … Teflon, Kalrez and Viton are registered trade names of Du Pont.

GFD

Seals

Sealing elements

Sealing systems

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