




RESILIENT METAL SEALS

PRODUCT GUIDE

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HTMS
High Tech Metal Seals

The Company

HTMS, short for High Tech Metal Seals, is a privately owned company, founded in 1999 by a group of sealing specialists. For more than 20 years we have been designing, developing and manufacturing elastic or resilient metal sealing solutions for the most demanding applications in numerous markets.

A passionate and determined team that has built tremendous design and production expertise throughout the years makes HTMS one of the global leaders in the metal sealing industry.

Driven by operational excellence and the common goal to find and deliver the best possible solution on the market is what makes HTMS the preferred partner for our customers. Together we develop metal sealing solutions of the highest quality standard meeting customer specifications.

- Metal O-Seal
- Spring Energised Metal O-Seal
- Metal C-Seal
- Spring Energised Metal C-Seal
- Spring Energised Aluminum C-Seal
- Metal Oysterseal®
- Metal Commaseal®

HTMS' resilient metal seals are used in a wide variety of applications where normal seals cannot cope with extremes of temperature, pressure, medium or combinations thereof.

Markets

HTMS specialises in metallic seals, serving all markets including aerospace, nuclear, oil & gas (both subsea and topside), automotive, industrial, medical...

Quality

HTMS is dedicated to produce resilient metal seals under the most stringent quality procedures. The company is ISO 9001, AS 9100 and ISO 14001 certified.

CERTIFIED ISO 9001 | CERTIFIED AS 9100 | CERTIFIED ISO 14001

Capabilities

- 100% LP test on O-Ring seal welds
- X-ray of weld area on request
- Fully integrated Helium leak test facility
- Hydrostatic pressure testing up to 1000 bar
- Seating load and spring back measurement equipment
- XRF on plating layers
- CNC optical measurement for in-line and end control

Expertise

- More than 100 years of experience
- In-house testing
- R&D for new products
- Close cooperation with universities
- Development of new production methods and new sealing solutions

Flexibility

- Short lead times
- Procedure for rush production
- Quick response time
- Custom-made sealing solutions
- Dedicated staff

Production Capabilities

- Seal diameter range from 5 mm up to 4 m
- Cross sections from 0.79 mm up to 12.70 mm
- Non-standard cross sections available on request
- Shaped seals, race track, rectangular and other shapes on request
- Tailor-made seals as per customer specifications
- In-house plating and coating facilities
- In-house heat treatment facilities
- In-house laboratory for testing purposes

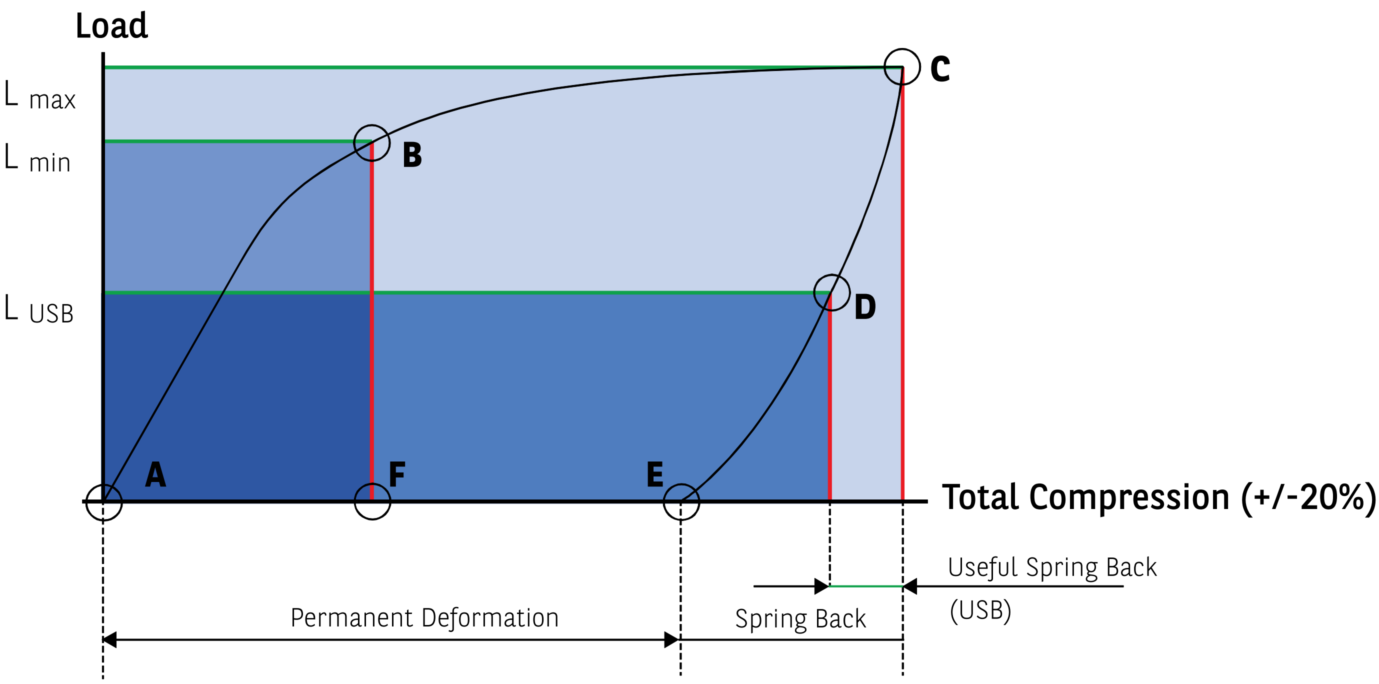
General Metal Seal Properties

- Unlimited shelf life
- Radiation and corrosion resistance
- Low load compared to Ring Type Joints (RTJ's) and similar flat gaskets
- High elastic recovery over an extended service life
- Temperature from -270 °C up to +650 °C (higher temperatures on request)
- Pressure from ultra-high vacuum up to +500 MPa
- Leakage rates better than 1E-10 mbar*l/s possible with proper design
- No explosive decompression issues

For specific seal selection contact HTMS

Introduction to Metal Seals

Generic Compression-Decompression Graph



Seal Dynamics

The sealing performance of any elastic metal seal is based on the relatively high **specific contact load** between the seal and the mating surface. This **linear load** or **seating load** is generated by the reaction of the seal (with or without spring) against its deformation by compressing the seal to a well-defined groove depth.

The graph above represents the **compression** and **decompression** characteristics of a standard metal seal. The curve "A-B-C" gives the increasing linear load by compression rate, whereas the curve "C-D-E" represents the reduction of linear load when the seal flanges separate and compression is reduced.

The curve shows a plastic deformation of the metal seal. Point "B" on the compression curve is the transition point between elastic and plastic deformation. As a rule of thumb, in this point, almost 80% of the maximum linear load is achieved. Point "C" indicates the point of **maximum compression (min. groove depth)**. Metal seals should be compressed approximately 20%, as higher compression rates can lead to seal failure due to **heavy plastic deformation**.

The **total spring back or elastic recovery** is represented between point "C" and "E". As a rule of thumb, the spring back varies between 4 and 6% of the original cross section of the seal. It must be clear that as soon as the flange separation equals the total spring back, the seal's performance is over. Therefore it is strongly advised to avoid flange movement or rotation at all times. If this movement or rotation cannot be avoided it should not exceed 30% of the total spring back. This is called the useful spring back and is influenced by multiple factors:

- Acceptable leak rate
- Seal design
- Hardware

Spring Back of a Seal

For a given seal cross section and seal type, it is generally true that with maximum load the spring back is lowest. Consequently, a low load seal will generate the highest spring back because of its higher **flexibility**.

Seating Stress

The initial line contact between the seal and the mating surface will gradually increase with the rate of compression to form a footprint. The width of the footprint depends on the seal type, the cross section and the compression rate. The **seating stress** (MPa) will approximately equal the linear load (N/mm) divided by the **foot print width**.
(MPa =N/mm²)

Linear loads vary from as low as 20 N/mm to more than 500 N/mm seal circumference.
The seal width or footprint usually varies from less than 0.3 mm to about 3 mm for the bigger cross section seals.
Based on this, the seating stress varies from a minimum of 30 MPa to over 150 MPa. With a heavy duty spring, the seating stress can be increased to above 300 MPa.
The high seating stress is required to make the selected plating or coating **flow into the irregularities** of the flanges, thereby sealing off all leak paths.

Non-Standard Designs

Resilient metal seals often have to perform under **extreme conditions**. Standard solutions as given in this catalogue may not always fulfill these requirements.
In case the application requires seal properties outside the scope of the standard designs, HTMS can **develop** a seal with the necessary physical properties.
Close cooperation with **universities and material suppliers** allows HTMS to optimize the seal characteristics in no time.
At all times it is recommended to select the biggest possible cross section for a given diameter. By doing so, the useful spring back will be at its largest, enabling performance within the widest possible tolerance range for that given diameter (line C-D) and as such creating a more robust sealing solution. A higher spring back allows more flange movement/rotation due to internal or external loads.

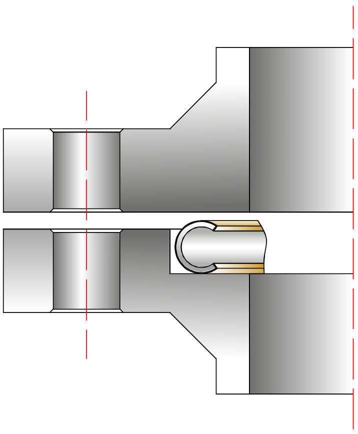
Considerations for Seal Selection

The selection of the most suitable seal for any service condition is often a delicate trade-off between load and spring back of the seal. The higher the requested load to compress the seal the better the tightness level, whereas the useful spring back of the seal will determine how well this tightness will be maintained with varying temperatures and pressures.

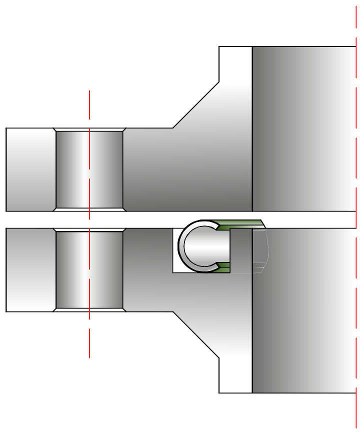
For a given seal cross section and seal type, it is generally true that with maximum load the spring back is lowest. And of course, a seal with minimum load will generate the highest spring back.

However, there are other parameters and circumstances that will influence the performance of a selected metal seal, e.g. type of flanges and fitting method, pressure and temperature cycles, bolt grade, bolt tension and method to stress the bolts (see Technical Data on pages 40 and 41).

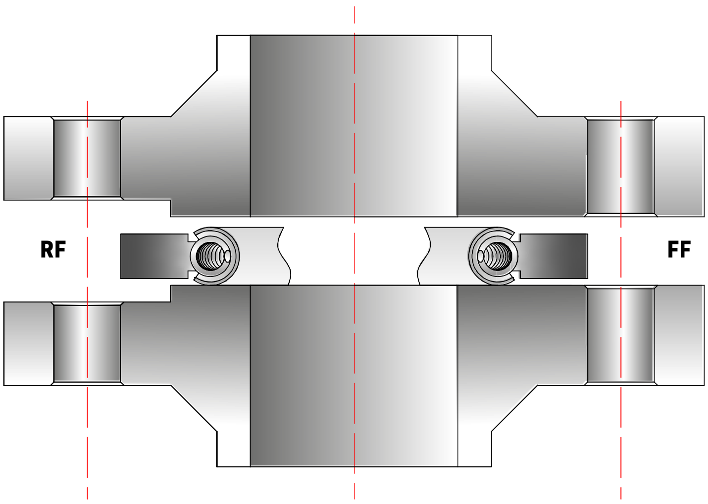
Types of standard flanges:



Metal seal fitted in "OPEN GROOVE". Cfr. "Male-female assembly"



Metal seal fitted in "CLOSED GROOVE". Cfr. "Spigot-recess assembly"



Metal seal + retainer fitted between RF- or FF-flanges
RF: Raised Face flange
FF: Full-Face flange

Flange Rotation / Lift-off

In all cases, the goal should be to achieve a **construction as rigid as possible** to overcome movements (lateral and/or axial) caused by varying pressure and/or temperature changes and external loads.

Flanges, bolts and seal can all be considered **"spring elements"** within the system of which the seal is often a highly non-linear element in its load recovery behaviour.

Therefore, an assembly where **metal-to-metal-contact** between flanges occurs after bolting is the most rigid and stable one.

After the seal has been compressed in its groove, further tightening of the bolts against the system pressure does not have any negative effect on the seal.

Bolted Seal Assembly

The initial bolt load will generate the initial load (cfr seating stress) on the seal. Because of the system pressure **the hydrostatic load tends to "unload" the seal**, resulting in flange lift-off.

The degree of residual stress (energy) left, will determine the final leak rate.

Stress Relaxation

Stress relaxation can be caused by

- flange rotation / flange lift-off
- flow (creep of the seal material)
- bolt relaxation
- cycling application conditions
- external loads
- ...

Conclusion

To obtain the target leak rate, it is recommended to:

- design the assembly as stiff and rigid as possible
  - Select the flange type
  - Select bolts of suitable strength and quantity
- go for the seal requiring the best ratio load vs. elastic spring back
- use soft plating types if allowed and possible
- select the biggest possible cross section for the given diameter
- use metal seal grades having the best mechanical properties, even at high temperatures

Seal Selection Criteria

Parameters and Questions to Consider

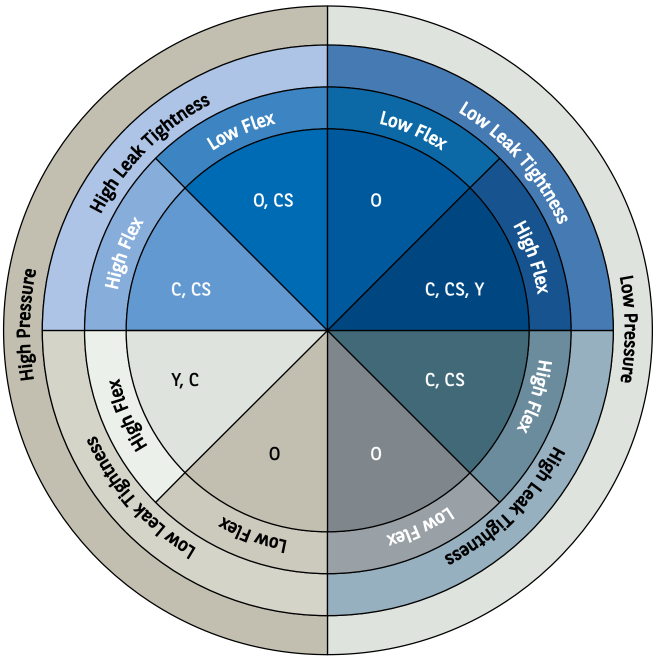
The table below shows per subject a couple of parameters and questions to be considered before choosing a sealing solution. Note that these are not all possible parameters or questions but a selection of the most common and important ones.

Subject	Parameters	Questions to be considered
Seal Type	Semi dynamic (C(S)A, Commaseal®) or static (all other seal types)	
Material Grades (seal)		Which material is compatible / incompatible?
Application Data	Medium to seal	Liquid / gaseous, viscosity,...
	Temperature	Cryogenic, high temperature, cycles
	Pressure	UHV, high pressure, cycles
	Leak rate	Measured at: - Standard conditions: T° ambient/ΔP 1 bar/He - Process conditions
Flanges / Bolting	Type of flange	- Material grade - Surface finish
	Bolts / clamps	- Material grade - Number and dimensions - Max Bolt load / available force
	Movement / displacement of the Flanges	Axial and / or radial displacement (Useful spring back of seal)

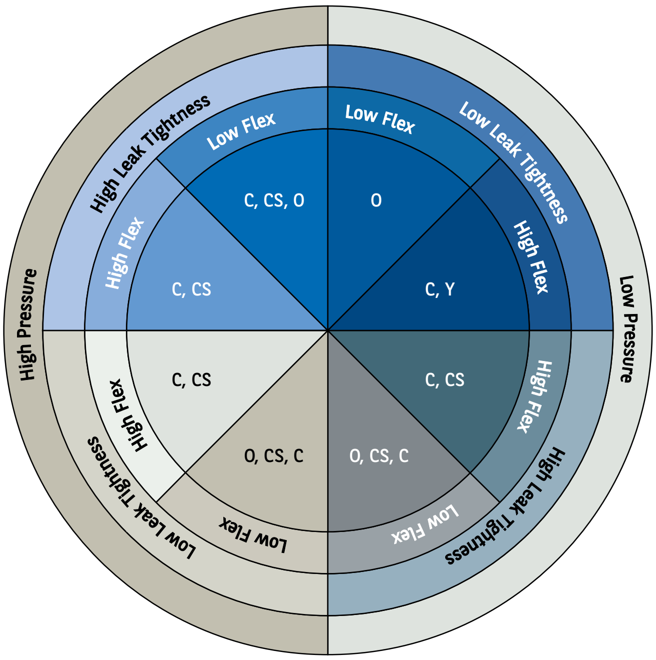
Seal Type Selection Wheels

The wheels below are a tool to indicate the right seal type for the application.
First the correct wheel has to be picked according to whether the seal has to work in a **gaseous** or a **liquid** medium. The medium information is indicated next to the wheels. **From the outside work your way in** by first picking the right **pressure condition**, then the required **leak rate** and finish with picking the needed **flexibility** of your seal. Very rigid systems with barely any flange movement or vibrations can use low flex seals. The seal types connected to the last choice are those that are the sealing possibilities in your system. Further information about the different seal types can be found on their respective product pages.

Liquids



Gases

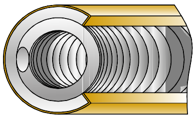
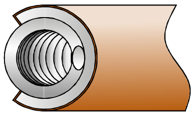
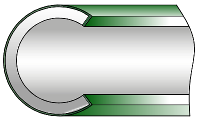
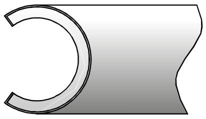
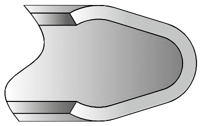
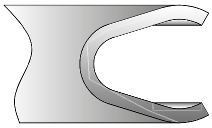


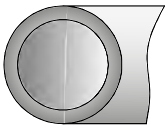
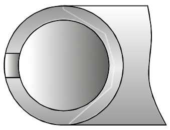
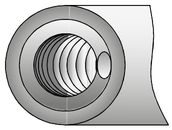
Low pressure	0 > 200 bar
High pressure	50 > 2000 bar
Low leak tightness	1E-2 > 1E-7 mbar*l/s
High leak tightness	1E-5 > 1E-12 mbar*l/s

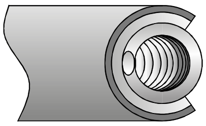
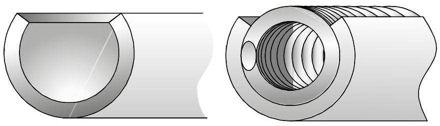
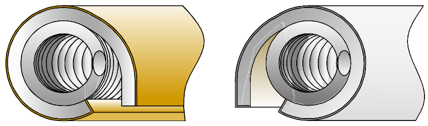
The given leak values are always in controlled conditions, the leak rate always depends on the sealing load, groove surface finish, seal finish and design of the application.

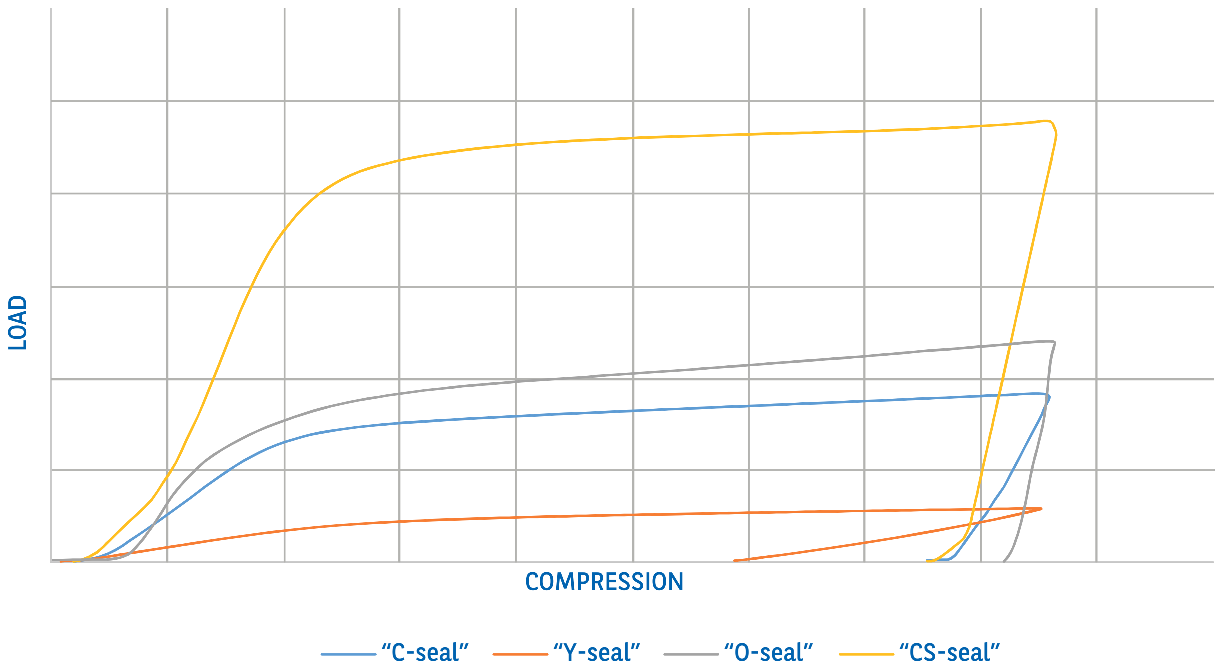
High load seals are designed for high pressure and excellent tightness performance.
When low load is required, soft platings and coatings are recommended to improve the leak tightness

Seal Overview

CS-Type		C-Type		Y-Type	
					
Internal pressure	**External pressure**	**Internal pressure**	**External pressure**	**Internal pressure**	**External pressure**
High load		Medium to high load		Low load	
High leak tightness		Medium to high leak tightness		Low leak tightness	
Medium spring back		Medium spring back		High spring back	
Available in shaped seal		Available in shaped seal		Not available in shaped seal	
Pages 20-21		*Pages 18-19*		*Pages 24-25*	

O / OG-Type	OVI / OVE-Type		OS-Type
			
Internal & external pressure	**Internal pressure**	**External pressure**	**Internal & external pressure**
Medium to high load	Medium to high load		High load
Medium to high leak tightness	Medium to high leak tightness		High leak tightness
Low spring back	Low spring back		Low spring back
Available in shaped seal	Available in shaped seal		Available in shaped seal
Pages 16-17	*Pages 16-17*		*Pages 16-17*

JCE-Type	CA / CSA-Type	CO-Type	
			
External pressure	**Axial pressure**	**Internal pressure**	**External pressure**
Medium to high load	Medium to high radial load	Medium to high load	
High leak tightness	Medium leak tightness	Medium leak tightness	
Medium spring back	Close tolerances on shaft and bore	Low spring back	
Available in shaped seal	Not available in shaped seal	Not available in shaped seal	
Pages 22-23	*Pages 26-27*	*Pages 28-29*	



Product Code Selection

CI-009931-3.96M-2/0-1-SN50

Seal Type

Axial Section & Wall Thickness

Heat Treatment

The applied heat treatment with "1" being work hardened.

Seal Diameter

The seal diameter is described in millimeters with 2 digits behind the decimal point. For seal types indicated with "I", such as CI, CSI, OI, etc. the diameter in the product code is the outer diameter of the seal. For seal types indicated with "E" the diameter in the product code, such as CE, CSE, OE, etc., the diameter in the product code is the inside diameter of the seal.

To choose the right diameter it is important to take into account both the diametrical clearance and the plating. The seal diameter in the product code is always without plating.

To select the right diameter for "E" seals the following formula must be applied:
DSI = Groove Diameter (DG) + Diametrical Clearance (DC) + Plating Thickness x 2

To select the right diameter for "I" seals the following formula must be applied:
DSO = DG – DC – Plating Thickness x 2 *(See figure below)*

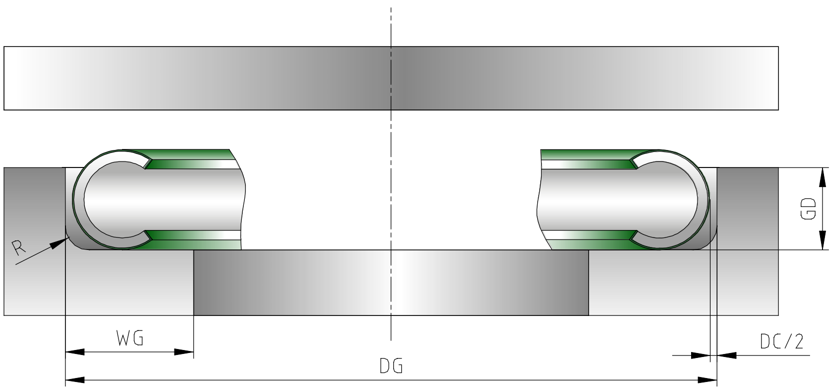
For an example see the next page.

Material

The first digit designates the base material, the second the spring material. The second digit is "0" in case no spring is present.

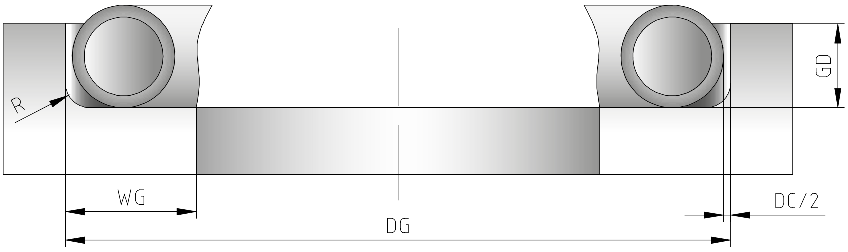
Plating

Information about the plating code and the thickness code can be found on the tab on the last page.



Example: Product Code Calculation

This example starts out to choose the right **seal dimension** for a known flange.
For the sake of the example an **O-ring** made out of **Stainless Steel 321** without a heat treatment, with **50 µm silver plating** is required.
The **groove diameter** (DG) of the flange below is **100.00 mm**. The **groove depth** is **2.60 mm**.



Assuming an excess pressure on the inside the choice will be made for an OVI-seal.

OVI- ______ - ______ - __ / __ - __ - ____

For an internal pressure seal the diameter of the seal is the outside diameter. To determine the right diameter for the seal the following formula must be applied:

OD = DG – DC – 2 x maximum plating thickness

The diametrical clearance depends on the chosen axial section of the seal. In this case the groove depth of 2.60 mm corresponds to the groove depth of a seal with an axial section of 3.18 mm, for the sake of the example the M version of the section is chosen. The **diametrical clearance** for a seal with this axial section is **0.25 mm**. (see pages 16-17)

As stated above the maximum plating thickness will be 50 µm.

This gives us:

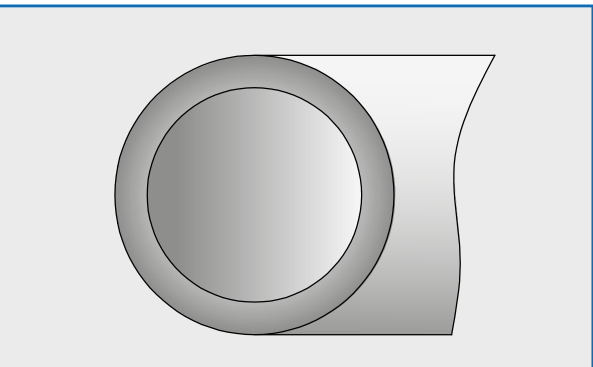
100.00 mm – 0.25 mm – 2 x 50 µm = 99.65 mm

OVI-009965-3.18M- __ / __ - __ - ____

The information given in the first paragraph of this page is needed to complete the part number.
The code that corresponds with **Stainless Steel 321** is "**3**".
The O-seal does not contain a spring, hence the **spring code** is "**0**".
Seals in cold worked condition get the code "**1**" for **heat treatment**. (see page 36)
The plating code for a seal with **50 µm of silver** is "**S50**".

This results into the following product code for this particular setup:

OVI-009965-3.18M-3/0-1-S50



Metal O-Rings
Internal and External Pressure
OI-OE

Features & Benefits

Features / Requirements	Benefits
Easy & approved design	Feasibility of complex shapes
No cavity	Functionality not influenced by the medium (plastic, abrasives, pollution,...)
Lower spring back	
Medium to high load	
Adaptable to specific application demands • Vented (OVI - OVE) • Gas filled (OGI - OGE) • Spring Energised (OSI - OSE)	 • Higher pressure • High temperature (+600°C) • Extremely high pressure
Wide sealing surface, low seating stress	
	Chamfer joints (three point sealing)
Very high temperature resistant (gas filled)	
	Unlimited shelf life

Performance Indicators

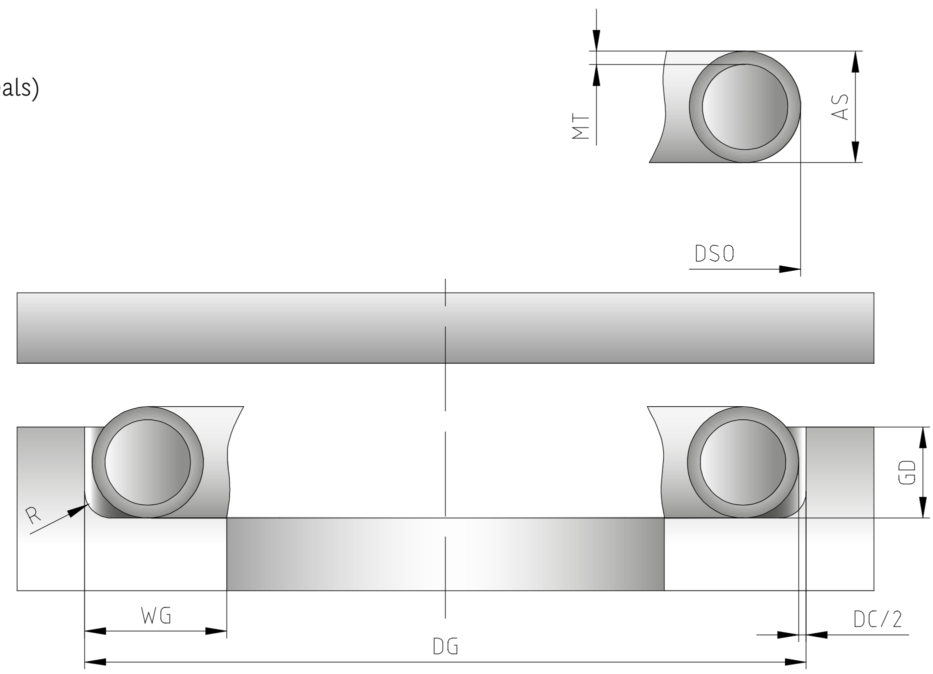
- Unplated 1E-2 to 1E-3 mbar*l/s
- Plated 1E-3 to 1E-7 mbar*l/s
- Plated + spin polished 1E-5 to 1E-10 mbar*l/s

Typical Applications

- Hot mold equipment
- Nuclear (Reactor vessel and connection seals)
- Gas turbines
  - Fuel systems
  - Exhaust connectors
  - Heat exchangers

OG- & OS-seals

Some O-rings can be gas filled or used in combination with a spring for very rare applications. Please contact HTMS for the feasibility if you consider one of these specific O-rings.



HTMS High Tech Metal Seals

Seal & Groove Dimensions

Be aware that the tolerance on **GD**, the **DC**, different **materials, plating and diameter** can have a huge impact on the actual load and spring back of a seal. Please contact HTMS to evaluate your specific case.

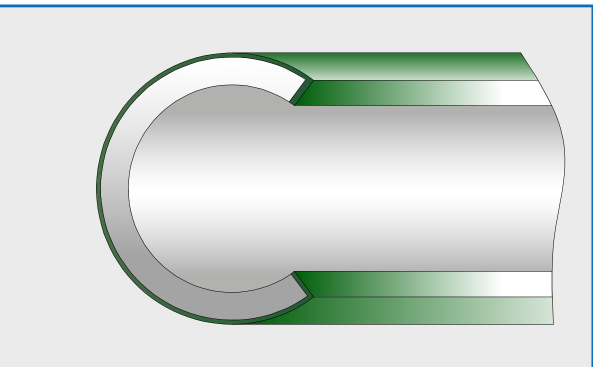
Seal Dimensions						Groove Dimensions			Data*			
DG	AS		MT		DC	GD	WG	R	Average Load		Indicative SB	
Diameter Groove (range)	Axial Section	Tolerance on AS (Cross Section)	Material Code / Thickness		Diame-trical Clearance	Groove Depth (min/max)	Width Groove (min)	Radius (max)	N/mm Circumference		Spring back in mm	
			M	H					M	H	M	H
6 - 25	0.89	+0.08 / -0.03	0.15	NA	0.20	0.64 - 0.69	1.40	0.25	65	NA	0.02	NA
10 - 50	1.19	+0.08 / -0.03	0.20	NA	0.25	0.94 - 1.02	1.78	0.30	NA	80	0.03	NA
12 - 200	1.57	+0.08 / -0.03	0.25	0.36	0.28	1.14 - 1.27	2.29	0.38	110	220	0.03	0.02
25 - 200	2.39	+0.08 / -0.03	0.25	0.46	0.33	1.88 - 2.01	3.18	0.51	45	180	0.05	0.03
50 - 400	3.18	+0.08 / -0.03	0.25	0.51	0.43	2.54 - 2.67	4.06	0.76	40	160	0.07	0.04
75 - 650	3.96	+0.10	0.41	0.51	0.61	3.18 - 3.30	5.08	1.27	70	115	0.10	0.07
100 - 800	4.78	+0.13	0.51	0.64	0.71	3.84 - 3.99	6.35	1.27	90	150	0.10	0,08
200 - 1200	6.35	+0.13	0.64	0.81	0.76	5.05 - 5.28	8.89	1.52	100	180	0.20	0.10
300 - 2000	9.53	+0.13	0.97	1.24	1.02	8.26 - 8.51	12.70	1.52	145	350	0.19	0,12
800 - 3000	12.70	+0.15	1.27	1.65	1.27	11.05 - 11.43	16.51	1.52	185	365	0.25	0.18

* Seal data based on Inconel® X-750 and only for O, OV and OG, NOT for OS-seals. Load and spring back figures are based on Inconel® X-750 in the work hardened (HT1) condition.

Most common Materials & Codes

Jacket		Spring	
Code	Material	Code	Material
1	Alloy X-750	0	None
3	321 SS	1	Alloy X-750
4	Alloy 600	2	Alloy 718
		9	302 SS

Other materials on request



Metal C-Rings
Internal and External Pressure
CI-CE

Features & Benefits

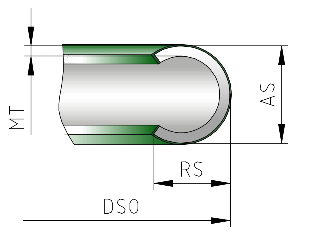
Features / Requirements	Benefits
Low to moderate sealing load	Suitable for softer flange materials (Al,...)
	Lower bolt force required
Increased spring back	Allows flange lift-off
Small sealing surface (line contact)	
Moderate seating stress	High sealing capability at low compression force
	Pressure activated
Critical circular surface finish required	
	Increased capabilities to withstand back pressure

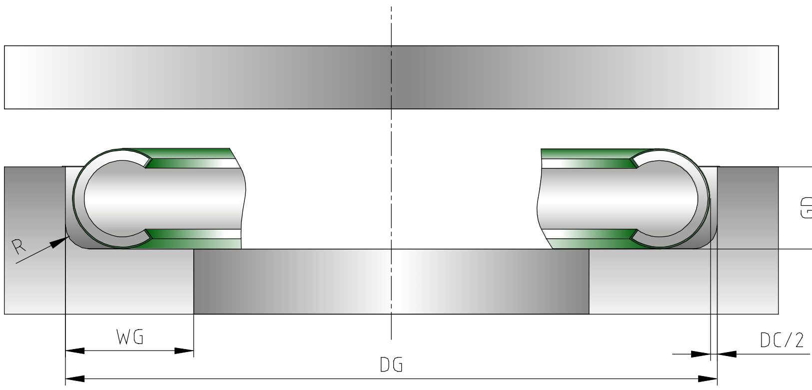
Performance Indicators

- Unplated E-2 to E-4 mbar*l/s
- Plated E-4 to E-9 mbar*l/s
- Plated + spin polished E-5 to E-10 mbar*l/s

Typical Applications

- Aerospace (GT, fuel systems, hydraulics, satellites, propulsion)
- Oil and gas & power generation
  - GT, ST-casing, injection systems, heat exchangers
  - Nuclear waste (cask seals)
  - Equivalent for boss-seals
  - Valves
- High-end industrial applications
  - Valves
  - Cryocoolers
  - Turbo chargers
  - Exhaust
  - Lasers
- Vacuum applications
  - Double sealing solutions
  - Remote handling
- Hot mold





Seal & Groove Dimensions

Be aware that the tolerance on **GD**, the **DC**, different **materials, plating and diameter** can have a huge impact on the actual load and spring back of a seal. Please contact HTMS to evaluate your specific case.

O.R. = On Request

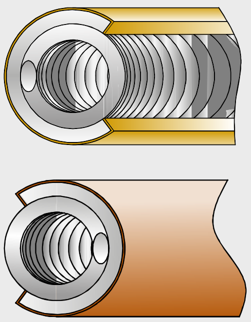
Seal Dimensions							Groove Dimensions			Data*			
DG	**AS**		**RS**	**MT**		**DC**	**GD**	**WG**	**R**	**Average Load**		**Indicative SB**	
Diameter Groove (range)	Axial Section	Tolerance on AS	Radial Section	Material Code / Thickness		Diametrical Clearance	Groove Depth (min/max)	Width Groove (min)	Radius (max)	N/mm Circumference		Spring back in mm	
				M	H					M	H	M	H
6 - 25	0.79	±0.05	0.71	0.13	0.18	0.08	0.64 - 0.69	1.02	0.25	30	60	0.04	0.03
8 - 50	1.19	±0.05	0.96	0.13	0.20	0.13	0.94 - 1.02	1.40	0.30	20	50	0.05	0.04
8 - 200	1.57	±0.05	1.26	0.15	0.25	0.15	1.27 - 1.37	1.91	0.38	15	50	0.08	0.06
10 - 200	2.00	±0.05	1.60	0.25	O.R.	0.20	1.60 - 1.68	2.30	0.45	35	O.R.	0.06	O.R.
10 - 200	2.20	±0.05	1.76	0.25	O.R.	0.22	1.76 - 1.85	2.50	0.47	30	O.R.	0.08	O.R.
10 - 400	2.39	±0.05	1.91	0.25	0.38	0.24	1.91 - 2.01	2.67	0.51	27	70	0.12	0.08
18 - 400	2.79	±0.05	2.25	0.38	O.R.	0.28	2.23 - 2.34	3.10	0.55	70	O.R.	0.11	O.R.
25 - 600	3.18	±0.08	2.54	0.38	0.51	0.32	2.54 - 2.67	3.43	0.76	50	105	0.15	0.12
32 - 600	3.60	±0.08	2.88	0.41	O.R.	0.36	2.88 - 3.02	3.90	0.90	55	O.R.	0.18	O.R.
32 - 750	3.96	±0.08	3.17	0.41	0.61	0.39	3.18 - 3.30	4.32	1.27	40	115	0.20	0.17
40 - 800	4.40	±0.08	3.52	0.41	O.R.	0.44	3.52 - 3.69	4.70	1.27	40	O.R.	0.21	O.R.
45 - 900	4.78	±0.10	3.82	0.51	0.76	0.47	3.84 - 3.99	5.08	1.27	60	140	0.23	0.18
75 - 900	5.00	±0.10	4.01	0.51	O.R.	0.50	4.00 - 4.20	5.30	1.27	55	O.R.	0.27	O.R.
75 - 900	5.20	±0.10	4.16	0.51	O.R.	0.52	4.16 - 4.37	5.50	1.27	50	O.R.	0.28	O.R.
75 - 1000	5.60	±0.10	4.50	0,51	O.R.	0.56	4.48 - 4.70	5.90	1.27	50	O.R.	0.30	O.R.
90 - 1200	6.35	±0.10	5.08	0,64	0.97	0.64	5.08 - 5.28	6.60	1.52	65	170	0.35	0.30
100 - 1500	7.90	±0.10	6.32	0.97	O.R.	0.79	6.32 - 6.58	8.22	1.52	120	O.R.	0.35	O.R.
100 - 2000	9.53	±0.10	7.62	0.97	1.27	0.96	7.62 - 8.03	9.65	1.52	100	185	0.50	0.32
500 - 3000	12.70	±0.13	10.16	1.27	1.65	1.27	10.16 - 10.67	12.70	1.52	125	230	0.55	0.48

* Seal data based on Alloy 718 with HT4, without plating.

Most common Materials & Codes

Jacket	
Code	Material
1	Alloy X-750
2	Alloy 718

Other materials on request



Metal CS-Rings - Spring Energised Internal and External Pressure

CSI-CSE

Features & Benefits

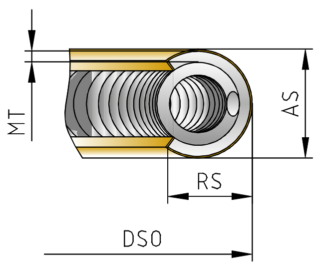
Features / Requirements	Benefits
Medium to high load seal design	
Increased spring back	Allows flange lift-off
Wider sealing surface	Can be used with rougher surface finish
Higher seating stress	
	Pressure activated
Adaptable seal characteristics	Adaptable sealing performance (load, spring back, leak rate,...)
Specific circular surface finish required	
	Increased capabilities to withstand back pressure

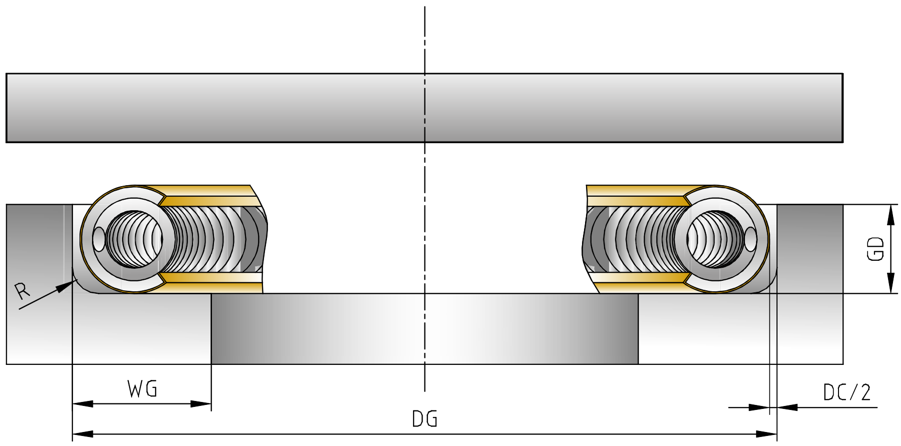
Performance Indicators

- Unplated E-2 to E-5 mbar*l/s
- Plated E-2 to E-10 mbar*l/s
- Plated + spin polished E-5 to E-12 mbar*l/s

Typical Applications

- Aerospace (fuel systems, hydraulics, satellites, propulsion)
  Oil and gas & power generation
  - GT, ST-casing
  - Injection systems
  - Heat exchangers
  - Valves
- Nuclear
  - Reactor vessel and connections seals
  - Nuclear waste (cask seals)
- High-end industrial applications
  - Valves
  - Turbo chargers
  - Exhaust
- Vacuum application
  - Double sealing solutions
  - Remote handling
- Window seals





Seal & Groove Dimensions

Be aware that the tolerance on **GD**, the **DC**, different **materials, plating and diameter** can have a huge impact on the actual load and spring back of a seal. Please contact HTMS to evaluate your specific case.

O.R. = On Request

Seal Dimensions						Groove Dimensions			Data*			
DG	**AS**		**RS**	**MT**		**DC**	**GD**	**WG**	**R**	**Average Load ****		**Indicative SB**	
Diameter Groove (range)	Axial Section	Tolerance on AS (Cross Section)	Radial Section	Material Code Spring Load	Material Thickness Jacket	Diametrical Clearance	Groove Depth (min/max)	Width Groove (min)	Radius (max)	N/mm Circumference		Spring back in mm	
										M	H	M	H
8 - 280	1.57	±0.05	1.42	M / H	0.15	0.15	1.27 - 1.37	2.05	0.35	70	175	0.08	0.07
10 - 300	2.00	±0.05	1.75	M / H	0.25	0.20	1.60 - 1.68	2.50	0.40	150	240	0.08	0.08
10 - 300	2.20	±0,05	1.95	M / H	0.25	0.22	1.76 - 1.85	2.86	0.45	150	230	0.09	0.08
10 - 400	2.39	±0.05	2.14	M / H	0.25	0.24	1.91 - 2.01	3.10	0.50	135	330	0.11	0.10
18 - 500	2.79	±0.05	2.41	M / H	0.38	0.28	2.23 - 2.34	3.60	0.50	210	270	0.11	0.10
25 - 600	3.18	±0.08	2.80	M / H	0.38	0.32	2.54 - 2.67	4.10	0.75	125	270	0.12	0.12
32 - 750	3.60	±0.08	3.19	M /H	0.41	0.36	2.88 - 3.02	4.68	0.75	145	350	0.12	0.11
32 - 750	3.96	±0.08	3.55	M / H	0.41	0.39	3.18 - 3.30	5.10	1.20	130	300	0.19	0.15
40 - 800	4.40	±0.08	3.99	M / H	0.41	0.44	3.52 - 3.69	5.72	1.20	175	255	0.20	0.18
45 - 900	4.78	±0.10	4.37	M / H	0.51	0.47	3.84 - 3.99	6.20	1.20	195	420	0.20	0.18
75 - 900	5.00	±0.10	4.49	M / H	0.51	0.50	4.00 - 4.20	6.50	1.20	185	390	0.28	0.25
75 - 900	5.20	±0.10	4.69	M / H	0.51	0.52	4.16 - 4.37	6.76	1.20	240	365	0.29	0.26
75 - 1000	5.60	±0.10	5.09	M / H	0.51	0.56	4.48 - 4.70	7.30	1.20	220	330	0.29	0.27
90 - 1800	6.35	±0.10	5.71	M / H	0.64	0.64	5.08 - 5.28	8.30	1.50	320	700	0.37	0.27
100 - 3000	7.90	±0.10	6.93	M / H	0.97	0.79	6.32 - 6.58	10.40	1.50	335	675	0.40	O.R.
100 - 3000	9.53	±0.10	8.56	M / H	0.97	0.96	7.62 - 8.03	12.40	1.50	520	730	0.43	0.35
500 - 7600	12.70	±0.13	11.43	M / H	1.27	1.27	10.16 - 10.67	16.50	1.50	600	320	0.50	0.40

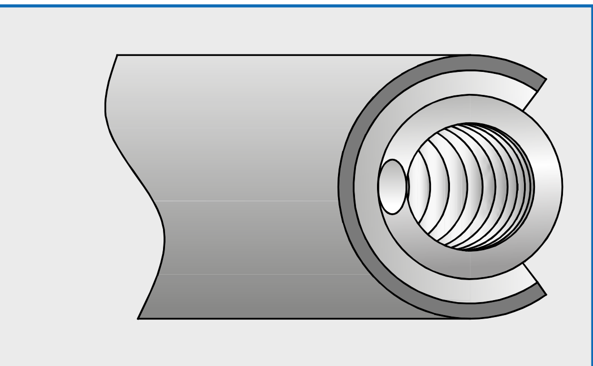
* Seal data based on Alloy 718 jacket and Inconel 718 spring without heat treatment (HT1), without plating.

** In case spring is placed after forming or plating, usually for seals with a diameter > 200 mm, the + tolerance on AS will be slightly higher than standard (see table page 42).

Most common Materials & Codes

Jacket		Spring	
Code	Material	Code	Material
1	Alloy X-750	1	Alloy X-750
2	Alloy 718	2	Alloy 718
5	304 SS	9	302 SS
-		A	Elgiloy
-		E	Nimonic 90

Other materials on request



Metal CS-Rings - External Pressure Spring Energised Aluminium Jacket Seal

JCE

“JC” stands for jacketed C-ring. A primary jacket, in a high alloy steel, transmits the spring load to the ultra soft secondary aluminium layer.

The extreme soft layer guarantees the best tightness for any kind of surface finish.

JCE seals can be used in applications with both internal or external pressure.

Features & Benefits

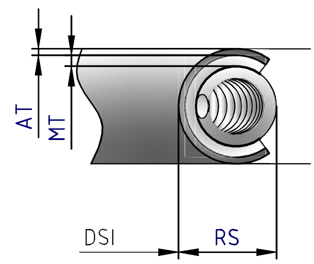
Features / Requirements	Benefits
	Capability to cope with higher surface finish
Soft outer layer	Ability to seal against soft flange material
	Suitable for radioactive applications

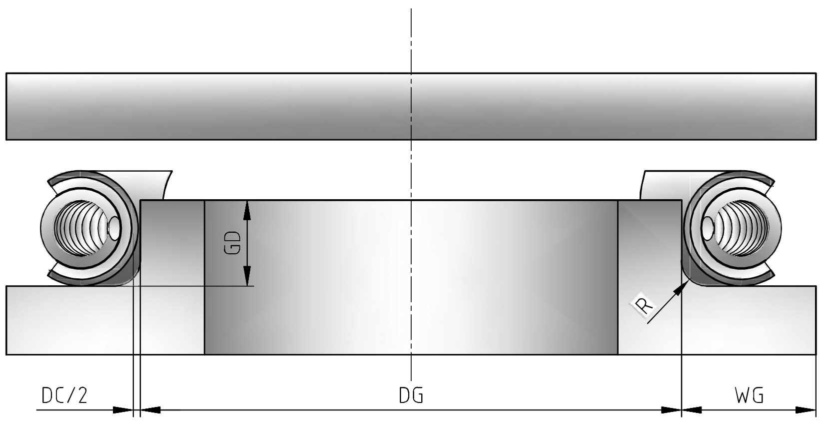
Performance indicator

- E-5 up to E-12 mbar*l/s

Typical applications

- Vacuum
- ANSI flanges
- Ultra-high sealing capability
- Tritium environments
- Cryogenic applications
- Accelerators





Seal & Groove Dimensions

Be aware that the tolerance on **GD**, the **DC**, different **materials, plating and diameter** can have a huge impact on the actual load and spring back of a seal. Please contact HTMS to evaluate your specific case.

O.R. = On Request

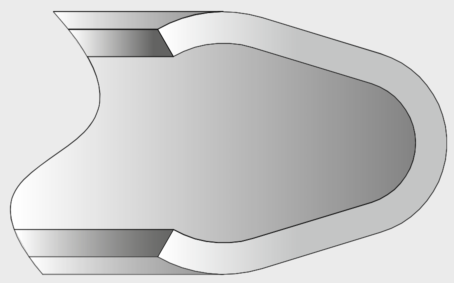
Seal Dimensions								Groove Dimensions		
DG	AS		RS	MT/AT			DC	GD	WG	R
Diameter Groove / seal (range)	Axial Section	Tolerance on AS (Cross Section)	Radial Section	Material Code Spring Load	Material Thickness Jacket	Al Layer Thickness	Diametrical Clearance	Groove Depth (min/max)	Width Groove (min)	Radius (max)
20 - 180	2.00	-0.10 / +0.20	1.65	M	0.15	0.20	0.20	1.60 - 1.68	2.50	0.40
20 - 180	2.60	-0.10 / +0.20	2.20	M	0.25	0.20	0.26	2.08 - 2.18	3.50	0.50
35 - 300	3.50	-0.10 / +0.20	2.92	M	0.38	0.20	0.35	2.80 - 2.94	4.60	0.75
40 - 400	4.00	-0.10 / +0.20	3.39	M	0.41	0.20	0.40	3.20 - 3.36	5.10	1.20
50 - 500	4.50	-0.10 / +0.20	3.79	M	0.41	0.30	0.45	3.60 - 3.78	5.80	1.20
60 - 600	4.80	-0.10 / +0.20	4.19	M	0.41	0.20	0.48	3.84 - 4.03	6.20	1.20
80 - 750	5.60	-0.10 / +0.20	4.79	M	0.51	0.30	0.56	4.48 - 4.70	7.30	1.20
100 - 750	6.20	-0.10 / +0.20	5.39	M	0.51	0.30	0.62	4.96 - 5.20	8.10	1.40

Seating load is case sensitive, as an average 230N/mm can be used for bold calculation. Please contact HTMS if you need more detailed information.

Most common Materials & Codes

Jacket		Spring	
Code	Material	Code	Material
2	Alloy 718	E	Nimonic 90

Other materials on request
Outer Al layer in Aluminum 1050 or Aluminum 6060



Oysterseal®
Internal Pressure
YI-YE

Features & Benefits

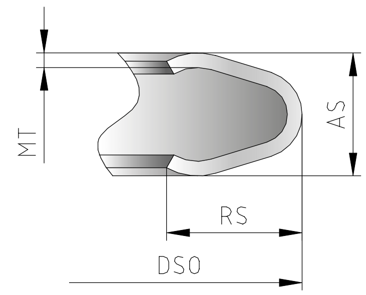
Features / Requirements	Benefits
Low load seal	Lower bolt force required
High spring back	Allows higher flange lift-off
Limited leak tightness	
Specific circular surface finish required	
	Highly pressure activated

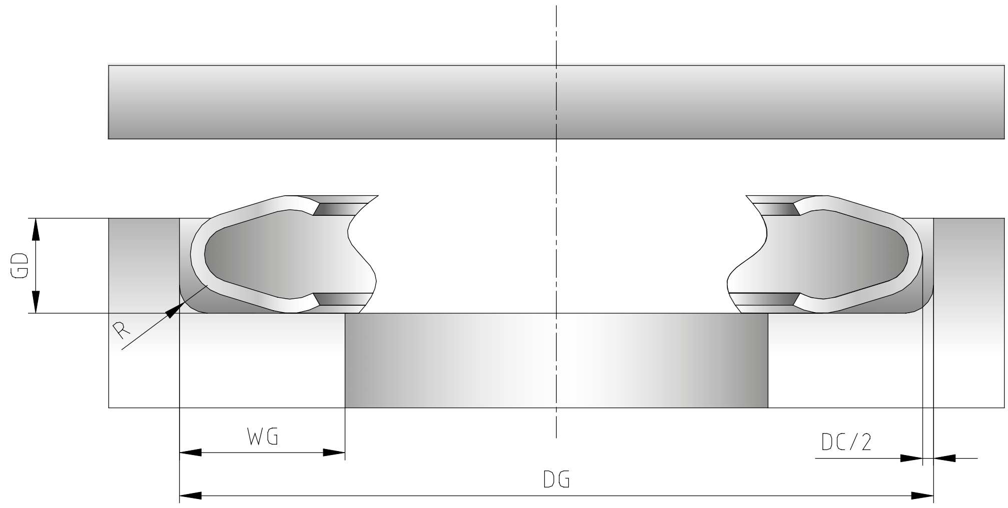
Performance Indicator

- Unplated E-1 to E-3 mbar*l/s
- Plated E-2 to E-4 mbar*l/s
- Plated+spring+polish E-3 to E-7 mbar*l/s

Semi-dynamic and static Applications

- Gas & steam turbines
- Valves
- Swivels
- Turbochargers





Seal & Groove Dimensions

Be aware that the tolerance on **GD**, the **DC**, different **materials, plating and diameter** can have a huge impact on the actual load and spring back of a seal. Please contact HTMS to evaluate your specific case.

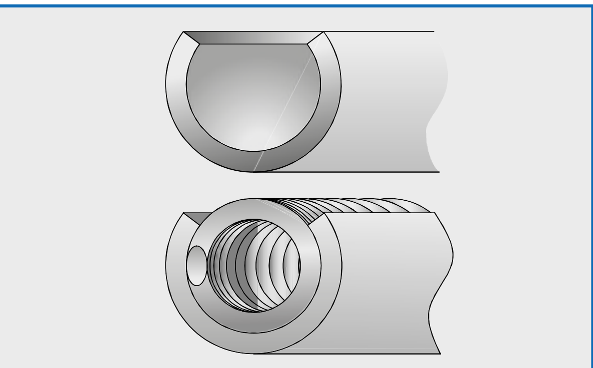
Seal Dimensions							Groove Dimensions			Data*	
DG	**AS**		**RS**	**MT**		**DC**	**GD**	**WG**	**R**	**Load**	**SB**
Diameter Groove / seal (range)	Axial Section	Tolerance on AS	Radial Section	Material Code	Material Thickness	Diame-trical Clearance	Groove Depth (min/max)	Width Groove (min)	Radius (max)	N/mm Circum-ference	Spring back in mm
30 - 400	2.39	±0.05	2.63	M	0.25	0.14	1.91 - 2.01	3.10	0.50	20	0.28
45 - 600	3.18	±0.08	3.50	M	0.38	0.19	2.54 - 2.67	4.10	0.75	25	0.35
65 - 750	3.96	±0.08	4.36	M	0.41	0.24	3.18 - 3.30	5.10	1.20	25	0.46
70 - 900	4.78	±0.10	5.26	M	0.51	0.29	3.84 - 3.99	6.20	1.20	25	0.70
80 - 1000	5.60	±0.10	6.16	M	0.51	0.34	4.48 - 4.70	7.30	1.20	22	0.80
120 - 1800	6.35	±0.10	6.99	M	0.64	0.38	5.08 - 5.28	8.30	1.50	30	0.85
300 - 3000	9.53	±0.10	10.49	M	0.97	0.57	7.62 - 8.03	12.40	1.50	45	0.90
600 - 7600	12.70	±0.13	13.98	M	1.27	0.76	10.16 - 10.67	16.50	1.50	57	1.20

* Seal data, load and spring back values/figures are based on Inconel® X-718 in hardened condition. Actual load and spring back values can differ hugely up to 100% from the given data due to a specific seal design and application parameters.

Most common Materials & Codes

Jacket		Spring	
Code	Material	Code	Material
2	Alloy 718	2	Alloy 718

Other materials on request



Metal C-Rings - Axial Pressure

CA-CSA

Axial C-Rings and Spring Energised axial C-Rings are metal C-Rings being stretched on the ID and being compressed on the OD, thereby creating a certain seating stress.

The elastic recovery is therefore limited.

They do not feature relatively high elasticity as the C-Rings and Spring Energised C-Rings used between two parallel planes.

It is recommended to assure a best of class surface finish on both the ID as well as the OD mating surfaces. For assembly reasons, an entry slope on ID and OD is highly recommended. Typical entry angles are around 5° and sufficiently long. Except for an excellent surface finish it is also important that the mating surface has a sufficient hardness. For high abrasive dynamic applications a hardness higher than 60 HRC is recommended.

Silver plating enhances tightness performance and it lowers friction during assembly and operation.

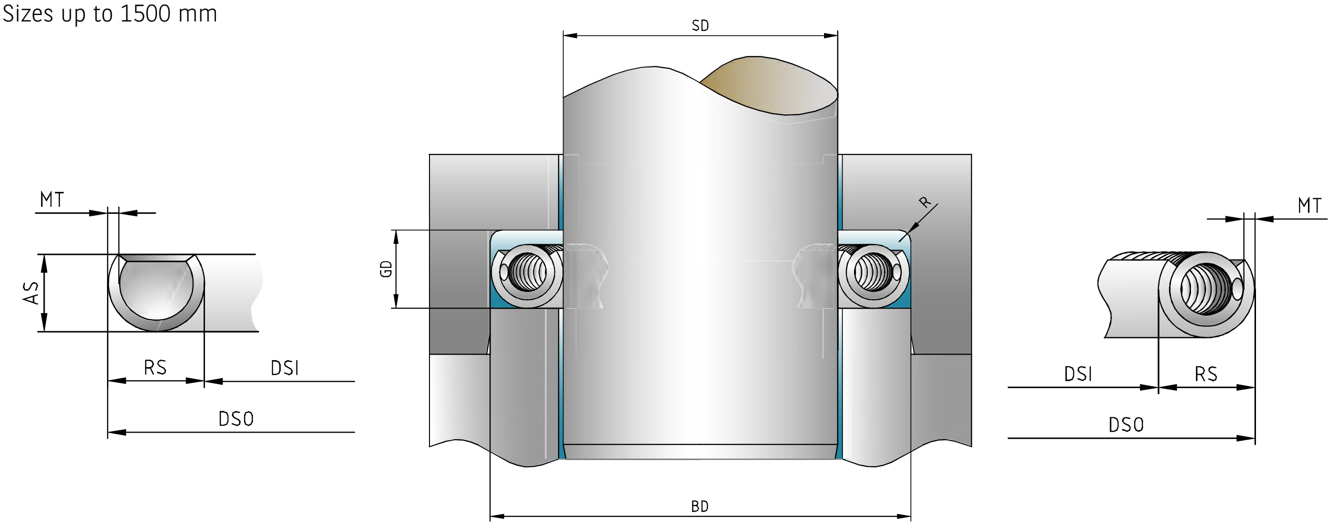
Features & Benefits

Features / Requirements	Benefits
Radial alignment of sealing position	Allows to be used between two circular bodies.
Optionally with spring	The spring stabilises the design and prevents unwanted deformation of the seal, during assembly and operation. Increased capabilities to withstand back pressure

Typical Applications

- Piston seal
- Rod seal
- Semi-dynamic, rotational and reciprocating applications

Sizes up to 1500 mm



HTMS
High Tech Metal Seals

Seal & Groove Dimensions

Be aware that the tolerance on **GD**, the **DC**, different **materials, plating and diameter** can have a huge impact on the actual load and spring back of a seal. Please contact HTMS to evaluate your specific case. RS and GD values in the table below are those for CA-Rings.

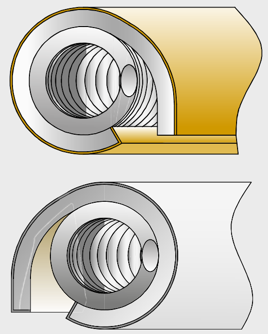
Seal Dimensions										Groove Dimensions					
D	**MC**	**AS**		**RS**	**MT**	**DSO**		**DSI**		**BD**		**SD**		**GD**	**R**
Diameter (range)	Material Code	Axial Section	Tolerance on AS	Radial Section	Material Thickness	Diameter Seal Outside	Tolerance on DSO	Diameter Seal Inside	Tolerance on DSI	Bore Diameter	Tolerance on BD	Shaft/Rod Diameter	Tolerance on SD	Groove Depth (min)	Radius (max)
14 < 38	1.57M	1.35	+0.05 / -0.10	1.64	0.20	BD+0.08	+0.06 / -0.03	DSO-3.28	+0.03 / -0.06	SD+3.12	+0.03 / -0	BD-3.12	-0.03	1.50	0.25
38 - 45	1.57M	1.35	+0.05 / -0.10	1.64	0.20	BD+0.10	+0.06 / -0.03	DSO-3.28	+0.03 / -0.06	SD+3.07	+0.03 / -0	BD-3.07	-0.03	1.50	0.25
30 < 38	2.39M	1.99	+0.05 / -0.10	2.42	0.25	BD+0.08	+0.06 / -0.03	DSO-4.85	+0.03 / -0.06	SD+4.70	+0.03 / -0	BD-4.70	-0.03	2.14	0.28
38 - 85	2.39M	1.99	+0.05 / -0.10	2.42	0.25	BD+0.10	+0.06 / -0.03	DSO-4.85	+0.03 / -0.06	SD+4.65	+0.03 / -0	BD-4.65	-0.03	2.14	0.28
50 < 85	3.18M	2.65	+0.05 / -0.15	3.22	0.38	BD+0.10	+0.06 / -0.03	DSO-6.45	+0.03 / -0.06	SD+6.25	+0.03 / -0	BD-6.25	-0.03	2.80	0.38
85 < 150	3.18M	2.65	+0.05 / -0.15	3.22	0.38	BD+0.15	+0.08 / -0.05	DSO-6.45	+0.05 / -0.08	SD+6.15	+0.05 / -0	BD-6.15	-0.05	2.80	0.38
150 - 300	3.18M	2.65	+0.05 / -0.15	3.22	0.38	BD+0.20	+0.08 / -0.05	DSO-6.45	+0.05 / -0.08	SD+6.05	+0.05 / -0	BD-6.05	-0.05	2.80	0.38
50 < 150	3.96M	3.30	+0.05 / -0.20	4.01	0.38	BD+0.15	+0.08 / -0.05	DSO-8.03	+0.05 / -0.08	SD+7.72	+0.05 / -0	BD-7.72	-0.05	3.45	0.51
150 - 300	3.96M	3.30	+0.05 / -0.20	4.01	0.38	BD+0.20	+0.08 / -0.05	DSO-8.03	+0.05 / -0.08	SD+7.62	+0.05 / -0	BD-7.62	-0.05	3.45	0.51
85 < 150	4.78M	3.96	+0.05 / -0.20	4.81	0.51	BD+0.15	+0.08 / -0.05	DSO-9.63	+0.05 / -0.08	SD+9.32	+0.05 / -0	BD-9.32	-0.05	4.11	0.51
150 - 300	4.78M	3.96	+0.05 / -0.20	4.81	0.51	BD+0.20	+0.08 / -0.05	DSO-9.63	+0.05 / -0.08	SD+9.22	+0.05 / -0	BD-9.22	-0.05	4.11	0.51
210 - 300	6.35M	5.27	+0.05 / -0.25	6.40	0.64	BD+0.20	+0.08 / -0.05	DSO-12.80	+0.05 / -0.08	SD+12.40	+0.05 / -0	BD-12.40	-0.05	5.42	0.76
600 - 1500	9.53M	7.63	+0.05 / -0.25	9.58	0.96	BD+0.20	+0.10 / -0.05	DSO-19.16	+0.05 / -0.1	SD+18.75	+0.05 / -0	BD-18.75	-0.05	7.90	1.00

Important Note: in case of CSA groove depth will be 15% more compared to the values mentioned above.

Most common Materials & Codes

Jacket		Spring	
Code	Material	Code	Material
1	Alloy X-750	1	Alloy X-750
2	Alloy 718	2	Alloy 718
5	304 SS	9	302 SS
-		A	Elgiloy
-		E	Nimonic 90

Other materials on request



Commaseal® - Axial Pressure

COI-COE

Commaseals® for shaft sealing (COI) and bore sealing (COE) are a further development of the axial C-Ring.

The elastic recovery in radial direction is still limited, yet the leakage over the outer diameter in case of a COI is well controlled by the seating load generated by the compression of the C-Ring part of the design.

The ID lip in case of a COI is gently pressed against the shaft by the compression of the C-Ring part of the design.

Compression of the seal shall only be done with the shaft in position. Concentric assembly of seal ID and shaft diameter are extremely important. In case a COE is used, the bore diameter and seal OD must be concentric prior to compression of the commaseal.

Except for an excellent surface finish it is also important that the mating surface has a sufficient hardness. For high abrasive dynamic applications a hardness higher than 60 HRC is recommended.

Silver plating enhances tightness performance and it lowers friction during assembly and operation.

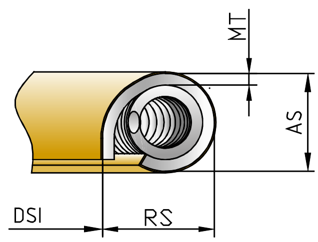
Features & Benefits

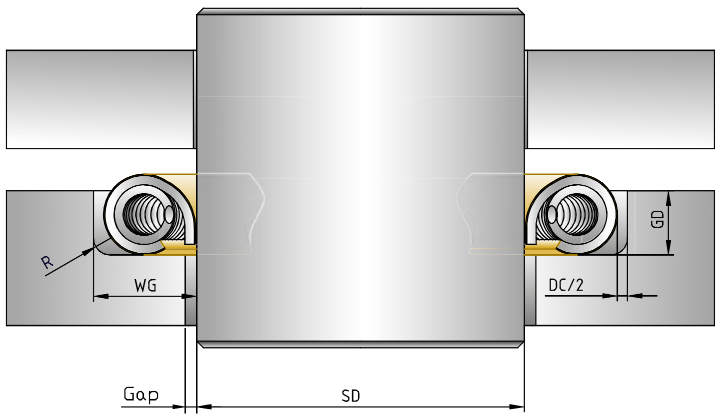
Features / Requirements	Benefits
Axial sealing	Better sealing towards housing compared to CA / CSA
Better controlled seal lip interference	Better control of the seating load, hence better seal performance Increased capabilities to withstand back pressure

Typical Applications

- Piston seal
- Rod seal
- Semi-dynamic applications, rotational and reciprocating

Sizes up to 200 mm





Seal & Groove Dimensions

Be aware that the tolerance on **GD**, the **DC**, different **materials, plating and diameter** can have a huge impact on the actual load and spring back of a seal. Please contact HTMS to evaluate your specific case.

COI

Seal Dimensions							Groove Dimensions						
D	**AS**		**RS**	**MT**		**DC**	**GD**	**WG**	**SD**	**BD**		**R**	**Gap**
Diameter (range)	Axial Section	Tolerance on AS	Radial Section	Material Code	Material Thickness	Diame-trical Clearance	Groove Depth (min/max)	Width Groove (mm)	Tolerance on Shaft Diameter	Bore Diameter	Tolerance on Bore Diameter	Radius (max)	Min / Max
20 - 150	1.57	±0.05	1.79	M	0.15	0.15	1.27 - 1.32	1.86	+0 / -0.03	SD+3.73	-0 / +0.08	0.30	0.20 / 0.30
35 - 200	2.39	±0.05	2.73	M	0.25	0.20	1.91 - 2.01	2.83	+0 / -0.03	SD+5.66	-0 / +0.10	0.50	0.40 / 0.50
45 - 200	3.18	±0.08	3.63	M	0.38	0.30	2.54 - 2.67	3.78	+0 / -0.03	SD+7.56	-0 / +0.12	0.75	0.60 / 0.75
60 - 200	3.96	±0.08	4.52	M	0.41	0.41	3.18 - 3.30	4.72	+0 / -0.05	SD+9.45	-0 / +0.15	1.20	0.70 / 0.80
100 - 200	4.78	±0.10	5.46	M	0.51	0.46	3.84 - 3.99	5.69	+0 / -0.05	SD+11.38	-0 / +0.15	1.20	0.80 / 1.00

Load values comparable to CS-seals

COE

Seal Dimensions							Groove Dimensions						
D	**AS**		**RS**	**MT**		**DC**	**GD**	**WG**	**BD**	**SD**		**R**	**Gap**
Diameter (range)	Axial Section	Tolerance on AS	Radial Section	Material Code	Material Thickness	Diame-trical Clearance	Groove Depth (min/max)	Width Groove (mm)	Tolerance on Bore Diameter	Shaft Diameter	Tolerance on Shaft Diameter	Radius (max)	Min / Max
20 - 150	1.57	±0.05	1.79	M	0.15	0.15	1.27 - 1.32	1.86	-0 / +0.03	BD-3.73	+0 / -0.08	0.30	0.20 / 0.30
35 - 200	2.39	±0.05	2.73	M	0.25	0.20	1.91 - 2.01	2.83	-0 / +0.03	BD-5.66	+0 / -0.10	0.50	0.40 / 0.50
45 - 200	3.18	±0.08	3.63	M	0.38	0.30	2.54 - 2.67	3.78	-0 / +0.03	BD-7.56	+0 / -0.12	0.75	0.60 / 0.75
60 - 200	3.96	±0.08	4.52	M	0.41	0.41	3.18 - 3.30	4.72	-0 / +0.05	BD-9.45	+0 / -0.15	1.20	0.70 / 0.80
100 - 200	4.78	±0.10	5.46	M	0.51	0.46	3.84 - 3.99	5.69	-0 / +0.05	BD-11.38	+0 / -0.15	1.20	0.80 / 1.00

Load values comparable to CS-seals

Most common Materials & Codes

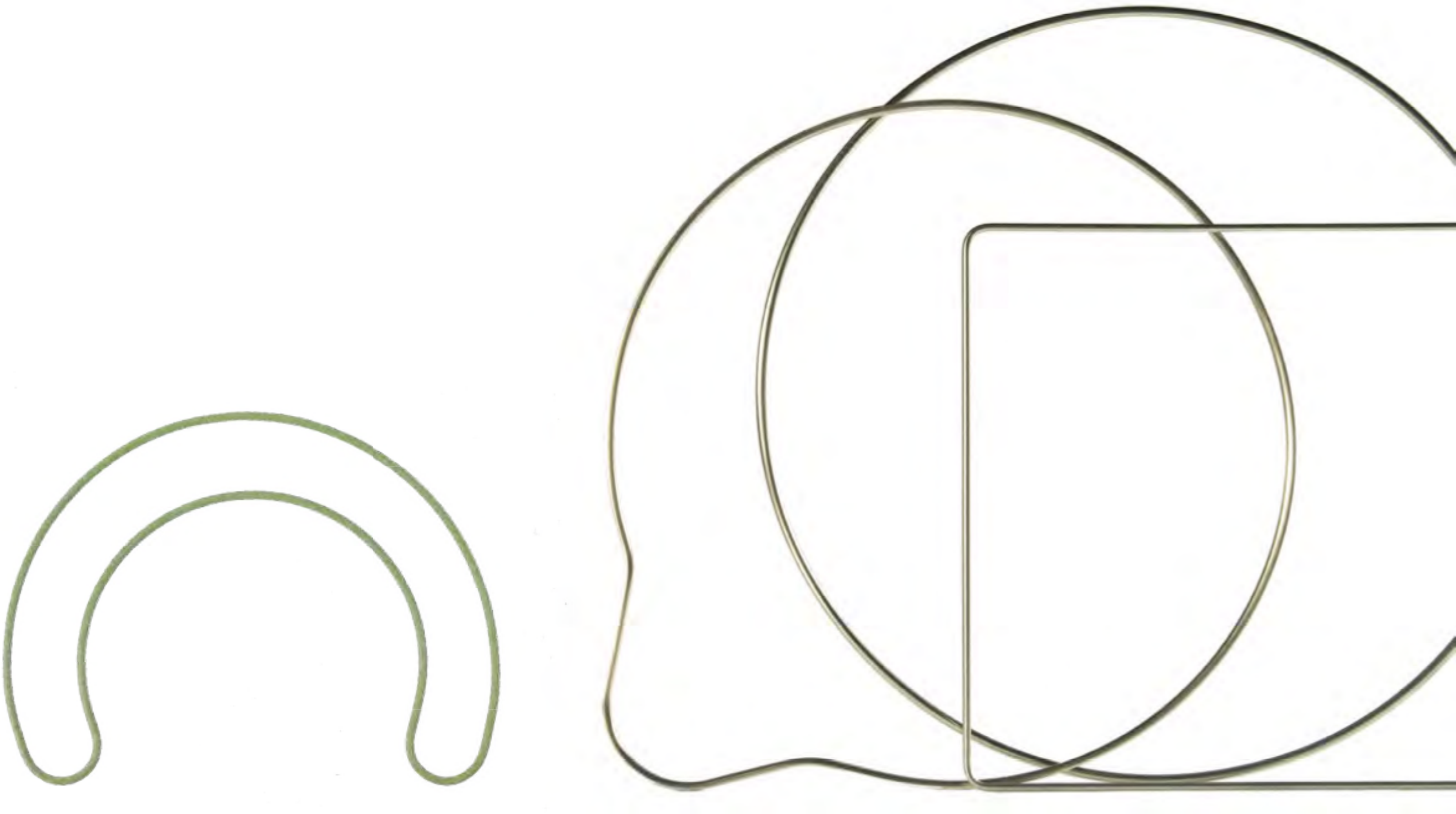
Jacket		Spring	
Code	Material	Code	Material
2	Alloy 718	2	Alloy 718

Other materials on request

Shaped and Custom-made Seals

HTMS has an Engineering Team that focuses on the design of custom-made seals.
Custom-made seals can be seals with a non-standard axial section, base material or spring, or even seals with a retainer to avoid over compression and facilitate the installation, allow the connection with an additional seal and/or facilitate remote handling.

Non-circular seals or so called shaped seals can be manufactured in O-Ring, C-Ring and Spring Energised C-Ring and from cross section 0.89 to 12.70 mm.
The picture below shows a number of examples used in the industry.
The minimum radius for each of the metal ring types is given in the table on the next page.
More than for other metal seals, HTMS asks to complete an application datasheet and to provide a sketch or a drawing.



MINIMUM RADIUS in mm for shaped seals				
TYPE seal				
AS	**O-seal**	**OS-seal**	**C-seal**	**CS-seal**
0.89	5	NA	5	NA
1.57	6	NA	7	7
2.39	12	12	15	15
3.18	20	20	20	20
3.96	40	40	25	25
4.78	60	60	50	50
6.35	100	100	75	75
9.53	200	200	200	200
12.7	300	300	250	250

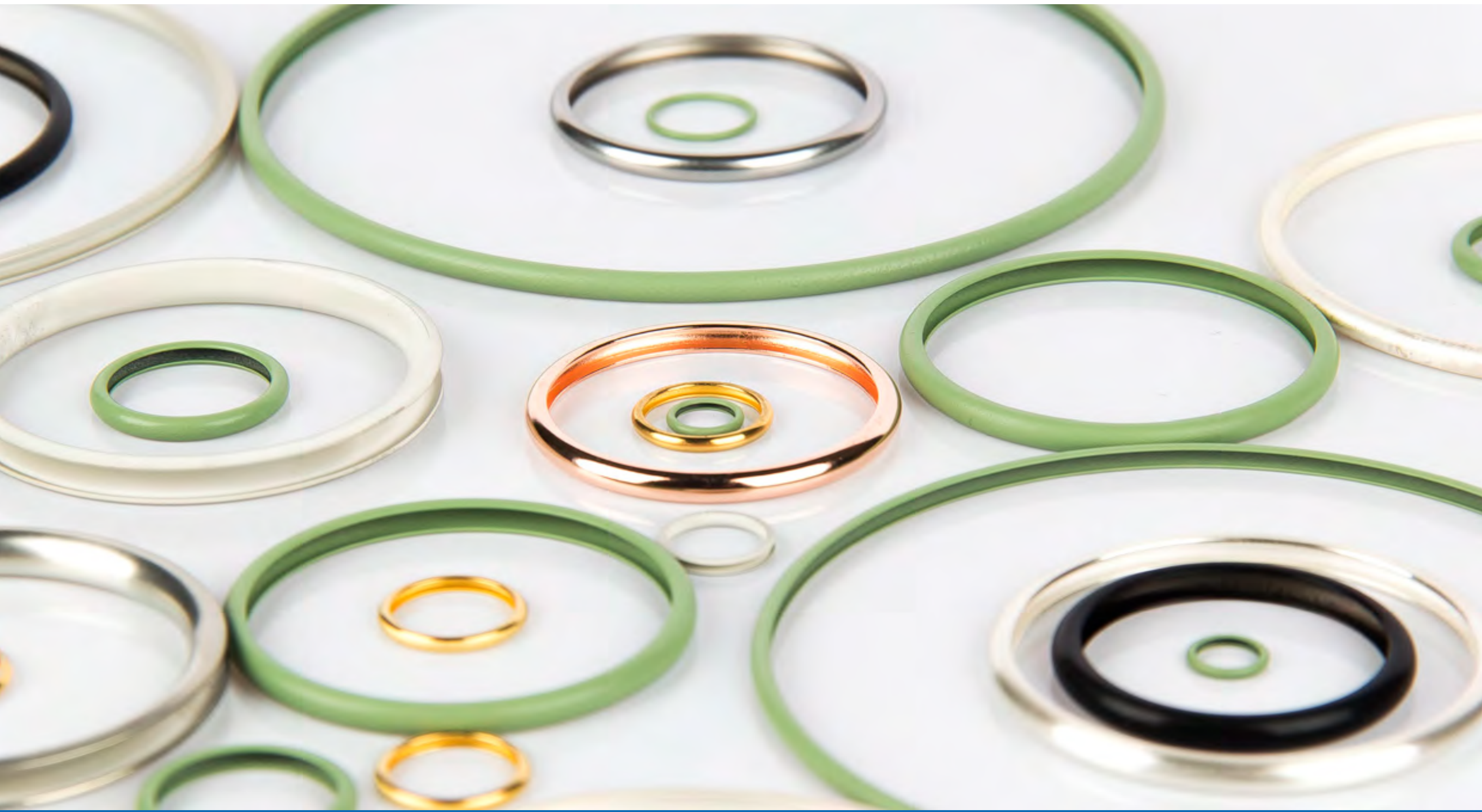
Technical Appendix

Lab

Facilities & Sealing Performance Parameters

The expertise that we build up in the field and in our own lab makes HTMS the partner to set up the qualification program for the seal that you need for your application.

- Check on feasibility
- Fully integrated helium leak test facility (<60 bar)
- Load and spring back test
- Hardness test
- Dynamic leak and load test to determine the useful spring back
- Water pressure tests <1000 bar
- Bubble tests
- 100% LP test on O-ring seal welds
- X-ray of weld area on request
- PMI test with x-ray spectrophotometer



Leak

What leak rate is acceptable for my application? This information is often not available and is most likely the most difficult question at the start of a seal selection. A certain leakage level can be accepted for one customer/application but it could be far away from the acceptance level for another.

Leak rate (mbar*l/s)	Tightness/leak path
10^{0}	water leaking leak path 100 µm
10^{-1}	
10^{-2}	water tight leak path 30 µm
10^{-3}	
10^{-4}	bacteria tight leak path 10 µm
10^{-5}	
10^{-6}	virus tight leak path 3 µm
10^{-7}	
10^{-8}	gas tight leak path 0.8 µm
10^{-9}	
10^{-10}	technically tight leak path 0.1 µm
10^{-11}	
10^{-12}	

To quantify a leak rate several methods can be used; a pressure or bubble test are mostly used to measure larger leak rates while a mass spectrometer is used to quantify a very small leak. Usually helium is used as a tracer gas because of its excellent properties; low atomic mass, easy accessible, easy detectable, safe,...

Leak Conversion Table

Leakage is scaled logarithmic over time. The SI-unit is Pa*m³/s but the most common unit is mbar*l/s (1 Pa*m³/s = 10 mbar*l/s). An overview of the most common units with conversion factors can be found in the following table:

	atm*cm³/s	cc/min	Pa*m³/s	mbar*l/s	torr*l/s
1 atm*cm³/s	1	59.8	0.1013	1.013	0.76
1 cc/min	0.0167	1	1.69E-03	1.69E-02	1.27E-02
1 Pa*m³/s	9.87	592	1	10	7.5
1 mbar*l/s	0.987	59.22	0.1	1	0.75
1 torr*l/s	1.32	79.2	0.133	1.33	1

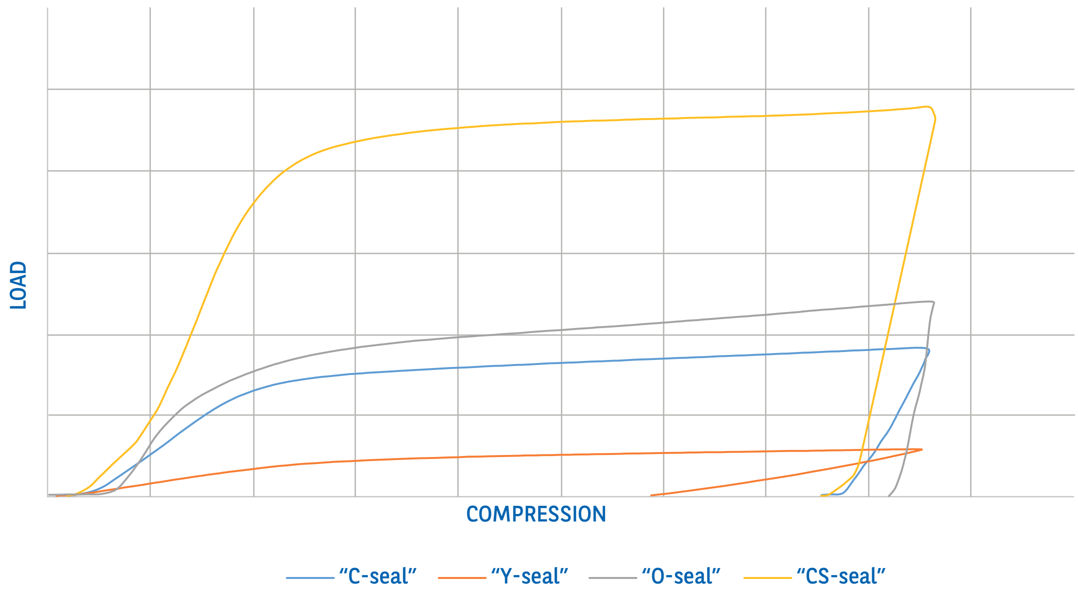
Imagine a helium leak rate of 7*E-7 mbar*l/s, how to interpret this unit/result?

- Every second, a pressure loss of 7*E-7 mbar on a volume of 1 liter helium

or

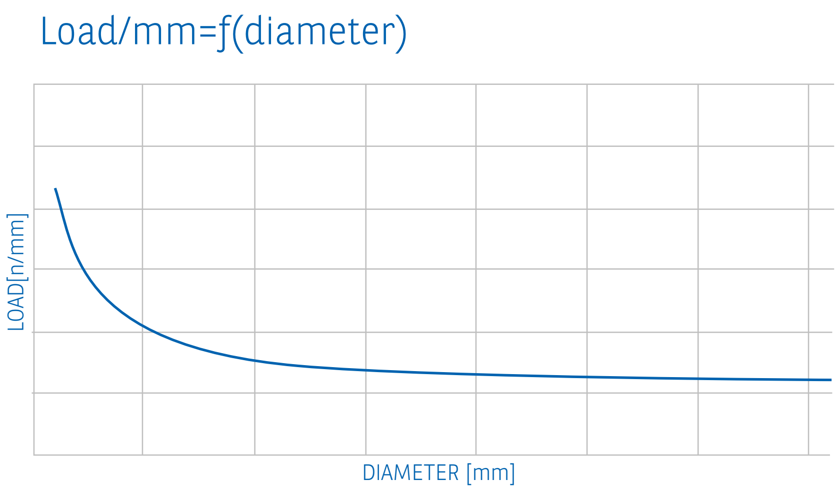
- Every second, a volume loss of 7*E-7 liter helium at atmospheric pressure

As a reaction to the applied displacement during compression, the seal will generate a force which of course is needed to create a seal. This force (seating load or seating stress) is an important design parameter to the hardware of the application.



The compression/decompression graph of an elastic metal seal is established by compressing the seal and plotting the measured load (force) as a function of the displacement. After reaching the maximum compression for a given seal, the seal is unloaded until flange lift-off occurs.

There is a strong relation between the seal diameter and the seating stress/seating load. Due to hoop stresses, seating load can increase > 50% for small diameter seals. The load presented at the seal pages in this catalogue are values for seals where the diameter is no longer significant.



Heat Treatment

	Material Code	HT-1	HT-2	HT-3	HT-4	HT-5	HT-6	HT-7	HT-8
1	Alloy X-750 / Inconel® X-750	X	X		X				
2	Alloy 718 / Inconel® 718	X	X		X	X			X
3	SS 321	X							
4	Alloy 600 / Inconel® 600	X		X					
5	SS 304 L	X							
6	SS 304 high tensile	X							
7	SS 316 Ti	X							
9	SS 302	X							
A	Elgiloy® / Phynox	X	X						
B	Haynes 214	X					X		
C	Aluminum 1050	X		X					
D	Alloy 625 / Inconel® 625	X		X			X	X	
E	Nimonic 90	X	X						
F	Hastelloy C-276	X					X		
G	Haynes 188	X					X		
H	Aluminum 6060	X		X					
I	Tantalum	X							
K	Alloy A-286	X							

HT-1 Work hardened
HT-2 Age hardened
HT-3 Soft annealing
HT-4 Solution annealing + precipitation hardened
HT-5 Solution annealing + precipitation hardened (NACE MR 0175)
HT-6 Solution annealing
HT-7 Stress annealing
HT-8 Solution annealing + short cycle precipitation hardened

Some applications need a little help to reach the required leak tightness or chemical resistance. The right choice of plating / coating must be made based on multiple factors. The medium, flange material, temperature and required leak rate all together determine which plating / coating is most suitable for the system.
HTMS electroplates copper, silver, tin, nickel and gold in-house and is also able to coat seals with PTFE.
Each plating / coating material has its specific pros and cons.

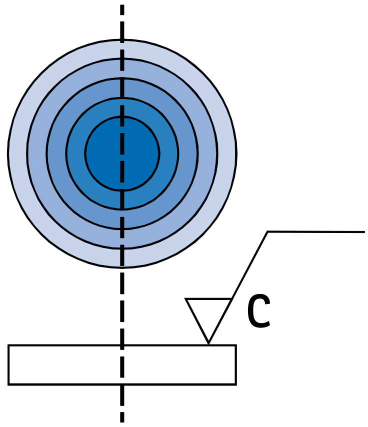
	Pros	Cons
Tin	Excellent for vacuum and cryogenic applications, very soft material	Limited temperature range, low pressure applications, limited seating load
PTFE	Good for cryogenic applications, chemically inert	Limited temperature range, not possible in combination with high load seals, permeable for gases
Gold	relatively soft plating, superb chemical resistance, high temperature range	Expensive
Silver	relatively soft plating, good corrosion resistance and anti-galling properties, wide application range, inexpensive	Not for extremely high temperature applications
Copper	Relatively soft, good for high temperature applications, inexpensive	Oxidises in contact with air
Nickel	Good for extremely high temperature applications, oxidising environments	Extremely hard plating material

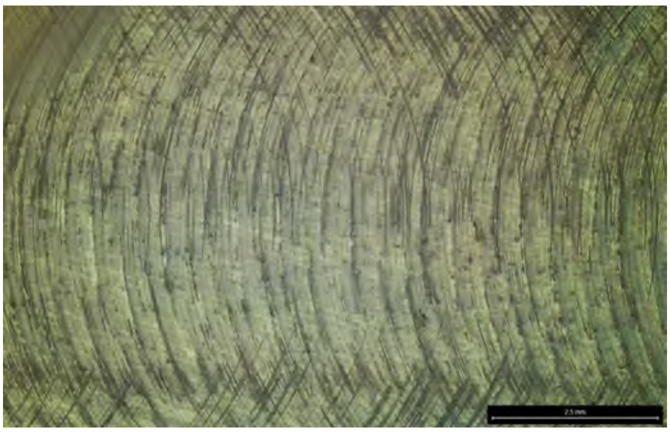
General Surface Finish Requirements

The surface finish of the mating faces is of utmost importance for a leak tight set up. Radial scratches should be avoided at all times because they form the shortest possible leak path. A longer leak path makes it harder for molecules to cross the sealing surface. Hence it is important that the roughness of the groove follows the sealing surface as best as possible. The ideal finish for a standard seal would be concentric circles.

These circles will be imprinted into the plating, forming barriers between the inside and the outside of the seal and thus not creating any leak paths between both sides of the seal at all. To create these barriers it is important that the grooves don't have a mirror-like roughness. The ideal roughness depends on the application medium, the plating and the load of the seal. A soft plating like e.g. tin will easily be imprinted by a higher roughness, while a harder plating could have an impaired sealing capacity if the roughness is too high. Low load seals are prone to leakage if the surface roughness is high. For every single set up it is important that Ra values are taken to heart to ensure a good sealing capacity. For circular seals the desired roughness will be given in Ra-c, 'Ra' standing for the arithmetical mean roughness value and 'c' to make clear the surface grooves should be concentric. On drawings it will be depicted as can be seen beside.

Application Type/ Medium	Surface Finish μm
Water Hydraulic oil sealants	0.4 - 1.6
Light gases	0.2 - 0.4
Heavy gases	0.4 - 0.8





A milled surface finish needs to be polished to minimize the leak paths directly crossing the sealing surface. It is the customer's responsibility to rework the groove in the sealing direction using sandpaper. Start with a rough sandpaper and end with a P320.

HTMS High Tech Metal Seals

Metal Seal Materials			
Material		Similar to W.Nr.	Similar to UNS-Nr.
1	Alloy X-750/Inconel® X-750	2.4669	N07750
2	Alloy 718 / Inconel® 718	2.4668	N07718
3	SS 321	1.4541	S32100
4	Alloy 600 / Inconel® 600	2.4816	N06600
5	SS 304 L	1.4306 / 1.4307	S30403
7	SS 316	1.4401	S31600
9	SS 302	1.4310	S30200
A	Elgiloy® / Phynox	2.4711	R30003
B	Haynes 214	2.4646	N07214
C	Aluminum 1050 (for JCE seals)	EN AW-1050A / 3.0255	-
D	Alloy 625 / Inconel® 625	2.4856	N06625
E	Nimonic 90	2.4632	N07090
F	Hastelloy C-276	2.4819	N10276
G	Haynes 188	2.4683	R30188
H	Aluminum 6060 (for JCE seals)	EN AW-6060 / 3.3206	-
I	Tantalum	-	-
K	Alloy A-286	1.4980	S66286

Common Bolt Grades

Bolt Grade	0.2% Proof Stress (MPa)	Proof Load Stress (MPa)	Max Suggested Bolt Stress (MPa)
ISO 898 Grade 8.8	640	600	510
ISO 898 Grade 10.9	900	830	706
ISO 898 Grade 12.9	1080	970	825
ASTM A193 Gr B7	725	640	540
ASTM A 193 Gr B7M	550	484	340
Stainless steel (Grade A2/50)	210	147	107
Stainless steel (Grade A2/70)	450	315	230

The given values are only indicative and are partially based upon experience

The hereby proposed calculation method is a very simple one, showing the required elements to calculate the bolt-torque.
As there are always many other parameters influencing an assembly and having their importance for a seal tight construction, the customer remains responsible for the flange design and the applied bolt load.

- Calculate the hydrostatic area (biggest diameter of the seal)
  - Ah ⇨ $\pi * D^2 / 4$ |mm²|

    Where D = OD of the seal in mm
- Calculate the hydrostatic force
  - Fh ⇨ Ah * P |N|

    Where P = test pressure in N/mm² = MPa
- Calculate the requested force to compress the seal as prescribed
  - Fr ⇨ π * D * linear load |N|

    Where the linear load is in N/mm and seal specific
- Calculate the total force required
  - Ft ⇨ Fh + Fr |N|
- Calculate the force per bolt
  - Fb ⇨ Ft / number of bolts |N|
- Calculate the bolt stress area
  - Ab ⇨ $(\pi * ((de + dr) / 2)^2 / 4$ |mm²|

    Where de = effective diameter of the thread, dr = root diameter in mm
- Calculate bolt stress
  - Stress ⇨ Fb / Ab |N/mm²|
- Calculate the max allowable force / bolt
  - Fmax ⇨ Max suggested bolt stress * Ab |N|
- Calculate bolt-torque
  - In function of Ft calculated above
    - T ⇨ Coefficient of friction * dn |mm| * Fb |N| / 1000 |Nm|
  - In function of max allowable bolt stress
    - T ⇨ Coefficient of friction * dn |mm| * Fmax bolt |N| / 1000 |Nm|

      Where dn = nominal bolt diameter in mm

Use the highest torque allowed

Tolerances

The seal diameter shall be as close to the groove diameter as possible.
By compressing the seal in the groove, the seal's outside diameter for internal pressure seals will try to grow and the seal's inside diameter for external pressure seals will try to shrink.
This phenomenon is covered by the DC or diametrical clearance. The DC will give allowance for this increase or decrease of the seal's diameter.

Both the seal tolerance and the groove tolerance shall be kept as small as possible. It is better for the seal performance to keep the diametrical clearance as small as possible in compressed condition.

O-Ring Tolerances	
Cross Section	Tolerances on Diameter
0.89 - 4.78	+0.130
4.79 - 9.52	+0.200
9.53 - 12.70	+0.250

Modified tolerance on axial section for CS-types diameter seal > 200 mm	
Axial Section	Additional Tolerance (to be added to standard Tolerance on AS) see pages 20-21 (CSI/CSE)
≤ 3.96	+0.2
> 3.96 ≤ 6.35	+0.3
> 6.35	+0.4

Groove Tolerances		
Nominal Diameter	Cavity ID h10	Cavity OD H 10
0 - 3	0 / -0.040	0 / +0.040
3 - 6	0 / -0.048	0 / +0.048
6 - 10	0 / -0.058	0 / +0.058
10 - 18	0 / -0.070	0 / +0.070
18 - 30	0 / -0.084	0 / +0.084
30 - 50	0 / -0.100	0 / +0.100
50 - 80	0 / -0.120	0 / +0.120
80 - 120	0 / -0.140	0 / +0.140
120 - 180	0 / -0.160	0 / +0.160
180 - 250	0 / -0.185	0 / +0.185
250 - 315	0 / -0.210	0 / +0.210
315 - 400	0 / -0.230	0 / +0.230
400 - 500	0 / -0.250	0 / +0.250
500 - 760	0 / -0.300	0 / +0.300
760 - 1050	0 / -0.400	0 / +0.400
1050 - 1425	0 / -0.500	0 / +0.500
1425 - 1940	0 / -0.630	0 / +0.630

C-Ring Tolerances		
Nominal Diameter	Seal OD h11	Seal ID H11
0 - 3	0 / -0.060	0 / +0.060
3 - 6	0 / -0.075	0 / +0.075
6 - 10	0 / -0.090	0 / +0.090
10 - 18	0 / -0.110	0 / +0.110
18 - 30	0 / -0.130	0 / +0.130
30 - 50	0 / -0.160	0 / +0.160
50 - 80	0 / -0.190	0 / +0.190
80 - 120	0 / -0.220	0 / +0.220
120 - 180	0 / -0.250	0 / +0.250
180 - 250	0 / -0.290	0 / +0.290
250 - 315	0 / -0.320	0 / +0.320
315 - 400	0 / -0.360	0 / +0.360
400 - 500	0 / -0.400	0 / +0.400
500 - 760	0 / -0.500	0 / +0.500
760 - 1050	0 / -0.630	0 / +0.630
1050 - 1425	0 / -0.760	0 / +0.760
1425 - 1940	0 / -1.000	0 / +1.000

Warranty

HTMS is experienced in designing and manufacturing resilient metal seals for extreme environmental service conditions. HTMS' metal seals, O-Rings, C-Rings, spring energised C-Rings and spring energised O-Rings are produced from high quality alloy materials with full lot control, full traceability and inspection procedures at all production steps.

All production procedures starting from purchase to shipment are controlled according to our Q.A. manual. HTMS is an ISO 9001 certified manufacturer of resilient metal seals. Regular internal audits verify that work procedures are maintained and compliant with our Q.A. manual.

HTMS works closely with its customers to analyse sealing problems as correctly as possible and, based on application data, to design and manufacture the best seal for the given application.

We strive to manufacture only correct products and are confident that our seals will be free of all material or manufacturing defects. Should a mistake be made we will replace any defective products with the highest priority free of charge.

Our warranty is limited to the replacement value of the defective seals only and does not include any additional or consequential liabilities.
Resilient metal seals are sensitive seals by design. Nevertheless, depending on the performance requirements, other parameters, such as handling, effective groove sizes and surface roughness, are equally important to achieve the desired results.

The seal being only one part of the sealing solution, HTMS cannot guarantee any leak rate, nor can we accept any liability for costs following poor sealing results. However, should the problem be related to faulty parts, HTMS will replace the parts free of charge.

Except for the general recommendations found in this design manual, we cannot give specific warranties for life expectancy, leak rate or other operational parameters. Customers are always advised to qualify seals, preferably by real life testing, or by similarity, in the exact configuration of their intended use.

These installation instructions will contribute to a proper functioning of the seal. The installation of the seal as well as seal finish, the finish of the mating surfaces, the design of the application etc. will affect the leak tightness.

1 Seal

- To avoid damage seals should remain in the original packaging until they are needed for installation.
- Upon opening of the packaging take care that seals are not damaged due to the use of sharp objects. Even little scratches on the sealing surface can prevent the required tightness from being achieved.
- Before installing the seal the sealing surface of the seal should be inspected for scratches, damages or other imperfections.
- Manipulate the seals only by hand and do not use any tool that touches the sealing surface to inspect or install the seal.
- In applications where high leak tightness is required it is recommended to manipulate the seals with gloves.

2 Groove and Flange

- The finish of the groove, flange or cover must always be in circular direction (except for CA-seals and Commaseals®). Milled grooves can result in leaks.
- The lower the seal load the better the groove surface finish should be.
- The leak rate of an application always depends on the condition of the seal and the groove surface.
- The recommended roughness of the groove, flange or cover depends on the chosen seal
- Make sure that the sealing area is free of dirt, dust or burrs.
- Every scratch on the sealing area can lead to leakage; only scratches in circular direction are allowed.
- Before installing the seal it is recommended that the groove, flange or cover is cleaned with a dust free cloth with IPA (isopropyl alcohol) or acetone to prevent dirt and dust being trapped between seal and flange. The groove should be inspected for scratches, damage or other imperfections.

3 Installing the Seal

- The seal must be installed very carefully into the groove to avoid scratches.
- The cover or flange must be put very carefully into place so that no damage or scratches can occur.
- Try to avoid the use of oil, grease or other products to install the seal.
- If the flange is tightened with bolts, the bolts should be tightened cross wise so that the seal is compressed evenly.

4 Technical Data

For technical information, e.g. pressure, temperature range and finish of construction, please contact HTMS.

Resilient Metal Seals Application Data Sheet

HTMS High Tech Metal Seals

Company	Data
Address	Phone
Zip	Fax
City	Email
Contact	Title

Application and/or Equipment			
Current seal			
Customer Item Number			
Clamping Load available	Bolt size:	Bolt quantity:	Bolt quality:
Surface Finish	Production details:		
Flange Materials			
Flange Hardness			
Static Pressure	Cyclic		
Internal Pressure	Frequency		
External Pressure	Amplitude		
Fluid Medium	Max. Leak		
Leak Test Procedure	Max. Leak		
Additional Info			

(Add Units)	At Test		Minimum		Maximum		Operating	
Temperature								
Pressure								
Groove Depth (GD)								
Groove Width (GW)								
Groove OD (DG) for Internal Pressure								
Groove ID (DG) for External Pressure								
Yearly Quantities								
Lot Sizes								
Sample Size								

Sketch

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Plating code	Plating / Coating
S	Silver - max. 430°C
G	Gold - max. 930°C
C	Copper max. 930°C
N	Nickel - max. 1200°C
T	PTFE - max. 290°C
Sn	Tin - max. 200°C

Thickness code	Plating thickness in μ
30	10 - 30
50	30 - 50
70	50 - 70

Temper code	Temper Description
1	Work hardened
2	Age hardened
3	Soft annealing
4	Solution annealing + precipitation hardened
5	Solution annealing + precipitation hardened (NACE MR 0175)
6	Solution annealing
7	Stress annealing
8	Solution annealing + short cycle precipitation hardened