ET 527E0930

Flexible graphite

CEFIGRAF® SEALS

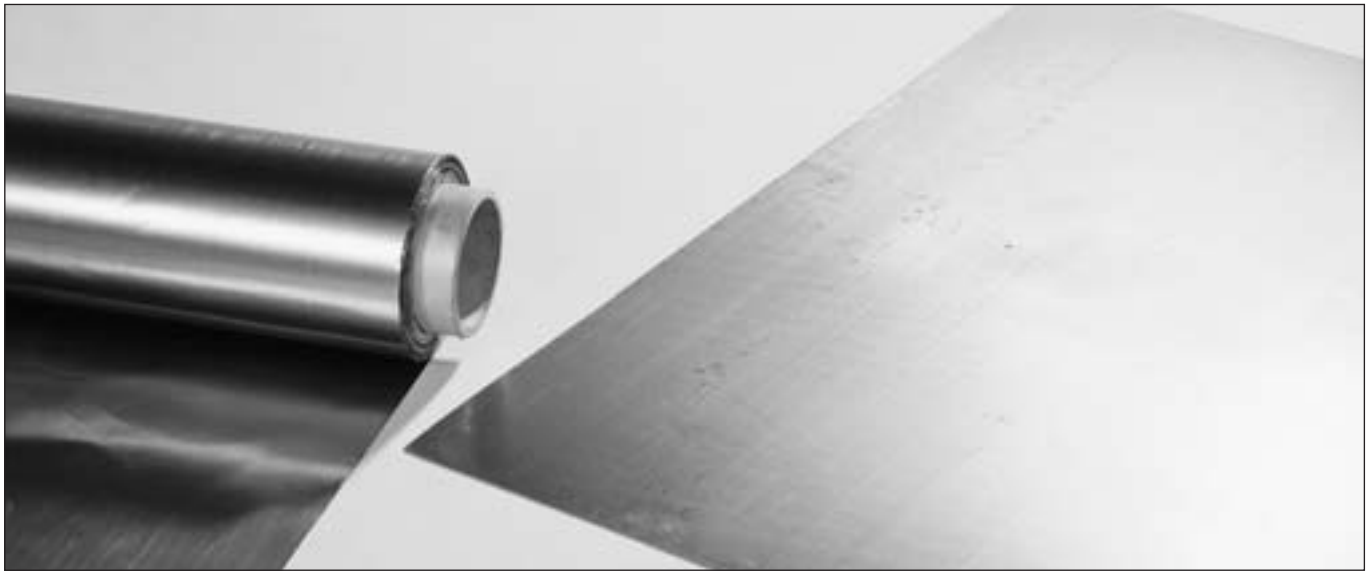
ORIGRAF® SEALS

FARGRAF® RINGS

Garlock
Sealing Technologies
CEFILAC

CONTENTS

Flexible graphite is produced worldwide by companies specialized in fine-grain graphites and carbons.
The main uses of this material are in sealing. With its remarkable properties, flexible graphite, which is harmless to the environment, is one of the best replacements for asbestos-based materials.



ELEVEN REASONS TO USE FLEXIBLE GRAPHITE

The original structure of flexible graphite gives it remarkable properties :

Compressibility : Flexible graphite is compressible up to a maximum density of 2.25. The choice of initial density is a big factor in optimizing the characteristics of the finished product.

Elastic recovery : Flexible graphite has a capacity for elastic recovery of about 10% in volume, making it possible to maintain compressibility and tightness over a broad temperature range.

Creep/relaxation : Flexible graphite has a very low creep rate in its service temperature range and holds up to high seating pressures.

Lubrication : Flexible graphite is self-lubricating and has a low coefficient of friction (less than 0.10 with steel).

Processing : Flexible graphite is easy to cut using conventional manufacturing equipment.

Ageing : Flexible graphite is one of the non-metallic materials least affected by ageing. This property is not influenced by temperature.

Chemical inertness : Flexible graphite, which contains no binders, withstands most chemicals : mineral acids and solvents (see documentation and corrosion table of carbons and graphites).

Temperature resistance : In a reducing or inert atmosphere, flexible graphite retains its characteristics over a broad range of temperatures, from - 196° C to + 2500° C (sublimation temperature 3500° C).

In the presence of oxygen, graphite forms CO or CO^2 from 450°C (550°C for the grade with passive inhibitor). The rate of oxidation depends on the area in contact with the oxidizing medium.

Anisotropy : Flexible graphite is anisotropic.
Its mechanical properties and conductivity are very different between the directions parallel and perpendicular to the flakes.

Radiation performance : Flexible graphite resists ageing from high levels of radiation : no visible effect at 10^{22} neutron/cm^2.

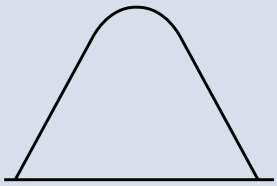
Removability : Flexible graphite adheres very little to the surfaces in contact with it.

PREPARATION

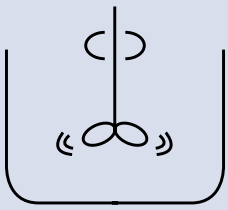
Flexible graphite is prepared from flakes of purified natural graphite. This allotropic variety of carbon has the property of forming lamellar compounds by the insertion of certain atoms or molecules in the crystalline structure of the graphite. This property is used in the preparation of flexible graphite, by the insertion of an acid.

The insertion compound thus formed undergoes a thermal shock at very high temperature that regenerates the graphite, in a highly-expanded form, by the sudden departure of the inserted element.

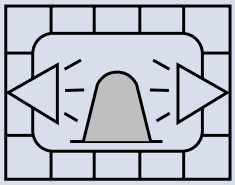
This expanded graphite, which has a very low specific gravity (a few grams per litre), self-agglomerates, without any binder, by a simple mechanical action. Rolling or pressing produces a flexible or semi-rigid material in roll or sheet form. It is also possible, during preparation, through careful selection of raw materials and processes and the insertion of certain additives, to adapt flexible graphite to the needs of specific applications.



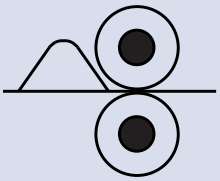
1 - Raw material
Natural graphite



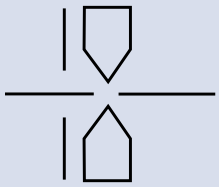
2 - Chemical attack
Insertion



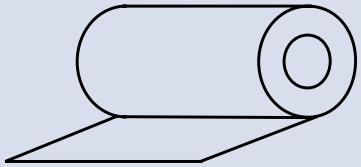
3 - Expansion
Heat treatment



4 - Rolling



5 - Gauging



6 - End product
Sheets, rolls - Inspections

Optical microscope

QUALITY ASSURANCE

Our business, SEALING, can be carried out correctly only with the backing of rigorously managed QUALITY ASSURANCE.

- Our quality manual defines various QUALITY LEVELS according to the product and the customer's need. The QUALITY ASSURANCE engineer, who reports to general management, is responsible for managing quality.
- The QUALITY CONTROL department is charged with applying the various inspection operations, with the help of the most modern resources available in the field.

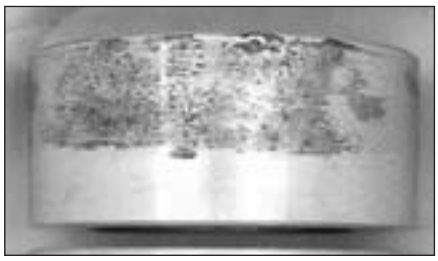
SPECIFICATIONS

Our flexible graphite suppliers have developed different grades of material to meet the needs of various applications.

	Basic materials			Materials with inhibitor				PMUC Materials
	N 998	**I 980**	**A 950**	**NZ 998**	**IZ 980**	**NP 998**	**IP 980**	**NS 200**
Typical applications	High purity material for special applications	Standard grade for industrial applications	Automotive grade (head gasket applications)	Grade with active corrosion inhibitor to be used for all corrosion problems, according to the type of industry		Grade with passive corrosion and oxidation inhibitor		EDF PMUC Qualified grade for nuclear applications
Carbon content	>99,8	> 98	> 95	> 93,8	> 98	> 99,8	> 95	> 99,8
Ash content	< 0,2	< 2	< 5	< 0,2	< 2	< 0,2	< 5	< 0,2
Inhibitor content (%)	0	0	0	2 to 6	2 to 6	1 to 3	1 to 3 included in ash content	0
Chlorine content (ppm)	≤ 30	≤ 50	≤ 100	≤ 30	≤ 50	≤ 30	≤ 50	Sulfur ≤ 200 Chlorine ≤ 30 Halogen ≤ 80
Tensile strength (DIN 50210) (MPa)	4,5 ±1,5			4,5 ±1,5				
Compressibility (%) (ASTM F36-66 Method A)	45 to 53			45 to 59				
Elastic recovery (%) ASTM F36-66	10 to 15			10 to 15				
Temperature resistance in oxidizing atmosphere (° C)	500	450	450	500	550	450	550	500

Certification : on request, any of our products can be delivered with a certificate guaranteeing compliance with NF L 00-015 and DIN 54922 standards.

Example of corrosion test on packing :
Comparison of type I 980, IZ 980, and IP 980 products on Z30 C 13 stainless steel ring.



I 980

IZ 980

IP 980

PRODUCTS

ROLLS - Available in the following grades, thicknesses, formats, and densities :

Grade		N 998	I 980	A 950	NZ 998	IZ 980
Dimensions W (mm) x L (m)	**th. (mm)**					
500 x 46 (or 50)	**0,2**	1,1	1,1			
500 x 46 (or 50)	**0,38**	1,1	1,1			
500 X 50 (or 100)	**0,5**	0,7	0,7 and 1,1	0,7	0,9	0,9
1000 x 50	**0,75**		1 and 1,1	1,1		
1000 x 50	**1**		1			
500 x 50	**1,35**		0,7			

Note : Other possibilities on request.
The maximum width is 1000 mm.

SHEETS

Sheets are made from the various grades already described, with or without reinforcement.
The reinforcement makes them easier to handle.

Types of reinforcement :

* **SR** = No reinforcement. N988 grade without glue. Other grades with thickness > 0.8 mm, assembled by gluing.
* **RI** = Reinforced by 316 stainless steel (50 µm) with glue.
* **RN** = Reinforced by nickel sheet (13 µm) with glue.
* **PI** = Reinforced by perforated 316 stainless steel sheet (100 µm) without glue.
* **GI** = Reinforced by 316 stainless steel wire mesh without glue.

Standard products as per table below (STANDARD DENSITY = 1)

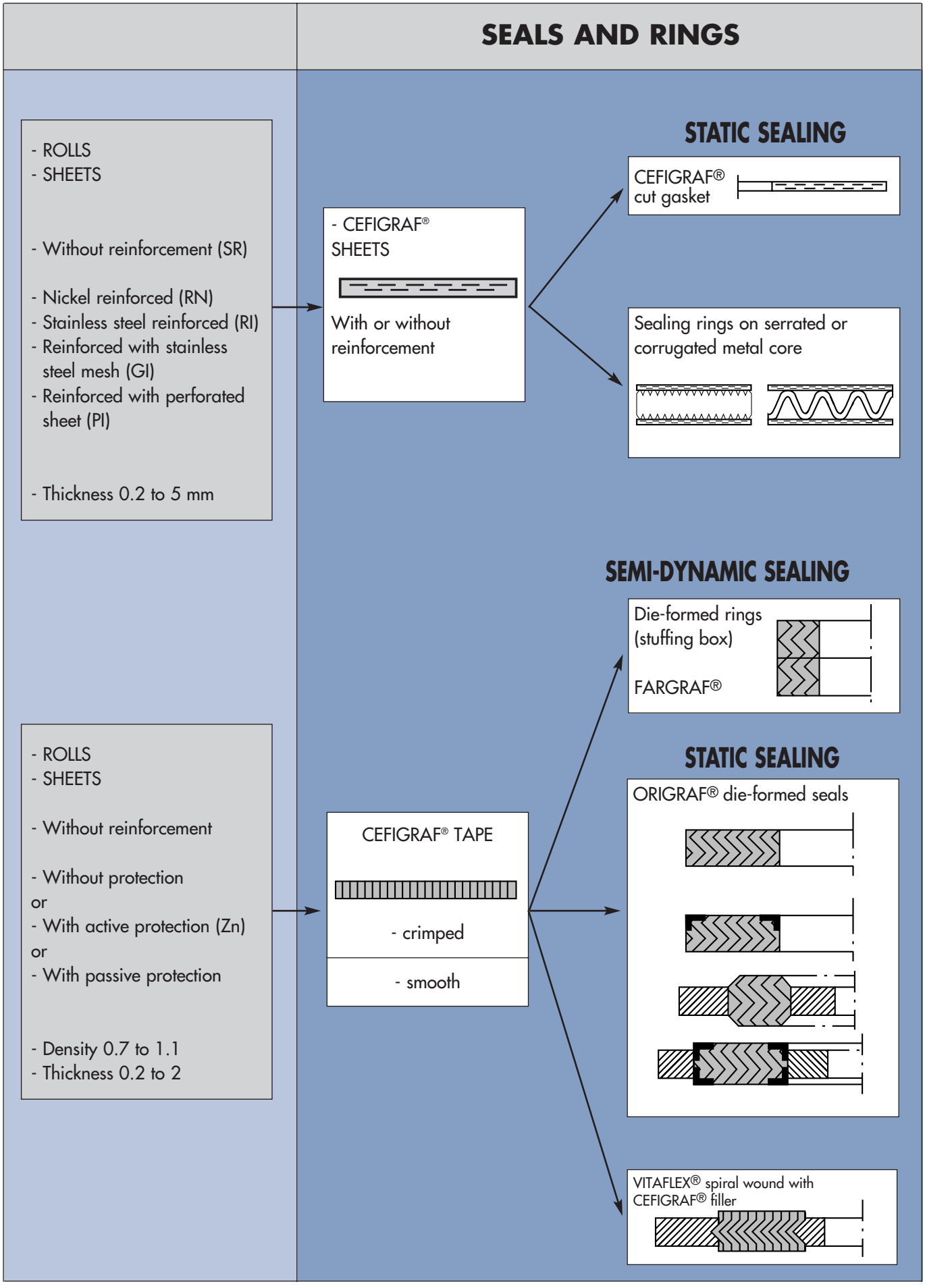
grade / thickness	N 998 SR	I 980 SR	I 980 RI	I 980 RN	I 980 PI	N 998 GI
0,2	500 X 1000	—	—	—	—	—
0,38	500 X 1000	500 X 1000	—	—	—	—
	1000 X 1000	—	—	—	—	—
0,5	500 X 1000*	500 X 1000*	—	—	—	—
0,8	1000X 1000	—	—	—	—	—
1	1000 X 1000	1000 X 1000	1000 X 1000	500 X 1000[1]	—	700 X 1000
1,5	700 X 1000	1000 X 1000	1000 X 1000	500 X 1000[1]	1000 X 1000	700 X 1000
2	700 X 1000	1000 X 1000	1000 X 1000	500 X 1000[1]	1000 X 1000	700 X 1000
3	700 X 1000	1000 X 1000	1000 X 1000	—	—	—
5	700 X 1000	—	—	—	—	—

Note : Other formats, densities, and grades can be produced on request ; ask us.
Product hot in stock * Density = 0,7 [1] Possible other format 1000 x 1000

NOTE : ● EDF PMUC approved NS 200-SR and NS 200 PI are also available in sheets.
● The following with corrosion inhibitor are also available in sheets :
NP 998 (without reinforcement) and NP 998-PI-AS 2 (with reinforcement and 2 faces anti-sticking treatment).

PROCESSING OF FLEXIBLE GRAPHITE INTO SEALS AND RINGS

Flexible graphites presented in the previous pages are processed into seals and rings, can be classified by function as indicated in the table below.



Grades of graphite

The round or shaped gaskets sold under the CEFIGRAF® name as indicated by the table below are cut from flexible graphite materials :

	GASKETS WITHOUT REINFORCEMENT		GASKETS WITH REINFORCEMENT					
Type of Reinforcement	None	None	Stainless steel sheet	Nickel sheet	Stainless steel mesh	Perforated stainless steel sheet		
Flexible graphite material	**N 998**	**I 980**	**I 980 RI**	**I 980 RN**	**N 998 GI**	**I 980 PI**	**NP 998-PI-AS2**	**NS 200 PI**
CEFIGRAF® (gasket)	**NAN**	**NAI**	**ATI**	**ATN**	**AGI**	**ATP**	**NP.ATP.AS2**	**ATP.NS200[1]**

For gaskets with inhibitor, whether reinforced or not, contact us.
[1] EDF PMUC approved

Production possibilities

- Size limits
  We can produce all sizes, in simple or complex shapes, to seal flanges, cases, etc.
  For sizes larger than raw material sheets or rolls, the gaskets can be made in sectors.
- Special products :
  A metal protecting base can be crimped onto the CEFIGRAF® cut flexible graphite gasket.
  A CEFIGRAF® flexible graphite cut gasket can be bonded to a metal support (even if the shape is special).

Examples and fields of application

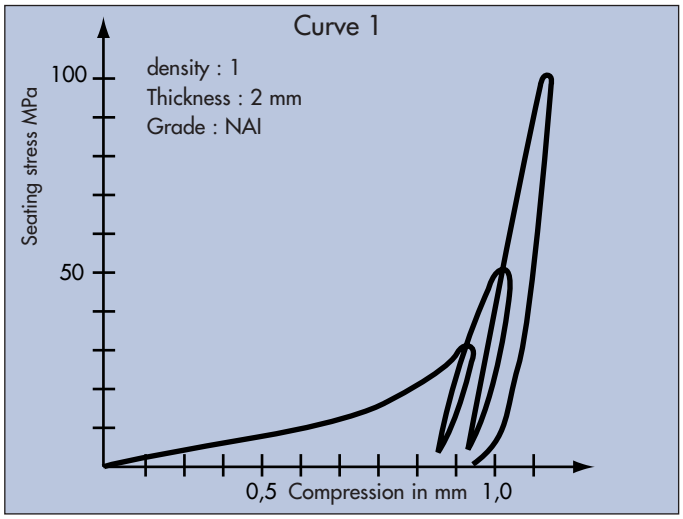
- Standardized assembly from PN 10 and up for steam, heat-transfer or corrosive fluids, food products, and other lines.
- Body/bonnet joints on small equipment (gate and relief-valves) for low-pressure applications
- Sealing of fume ducts
- Sealing on glass for windows and portholes
- etc…

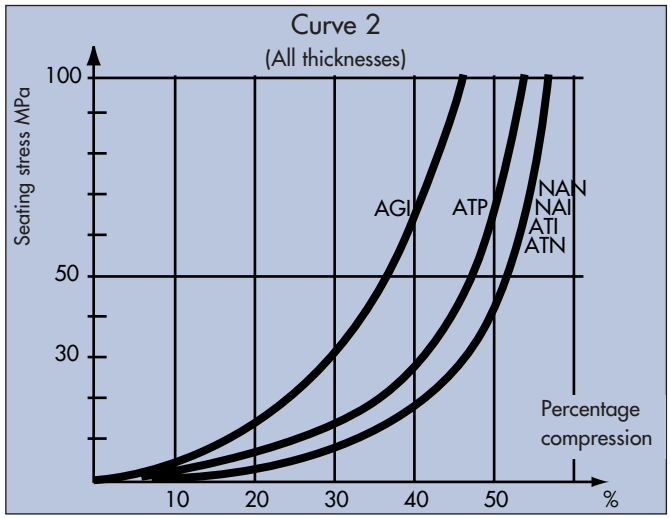
Technical characteristics

• **Compression curve**

Curve 1 shows evolution of seating stress versus compression on a 2 mm thick CEFIGRAF® NAI gasket.

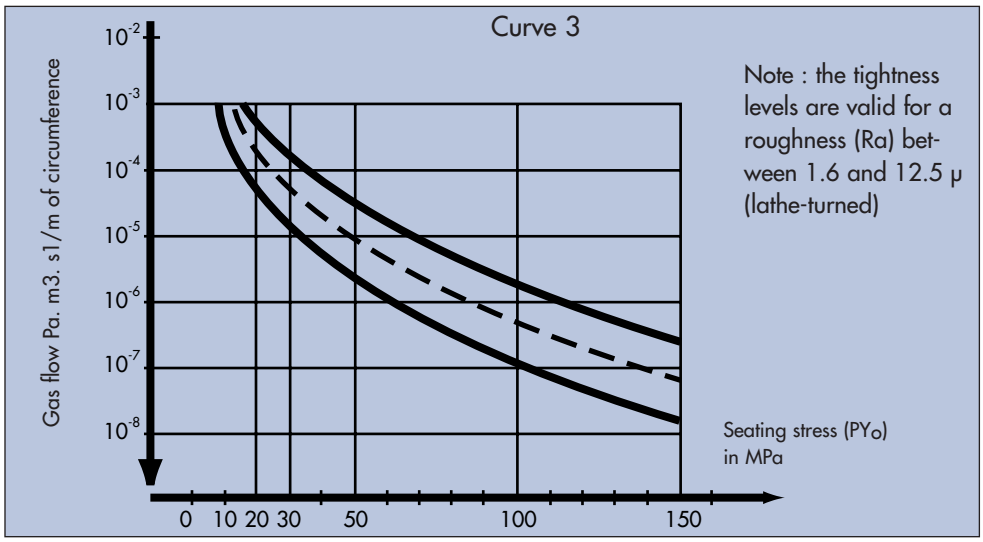
Curve 2 shows seating stress versus compression rate for the various grades of CEFIGRAF® for any thickness.





• **Gas tightness curve**

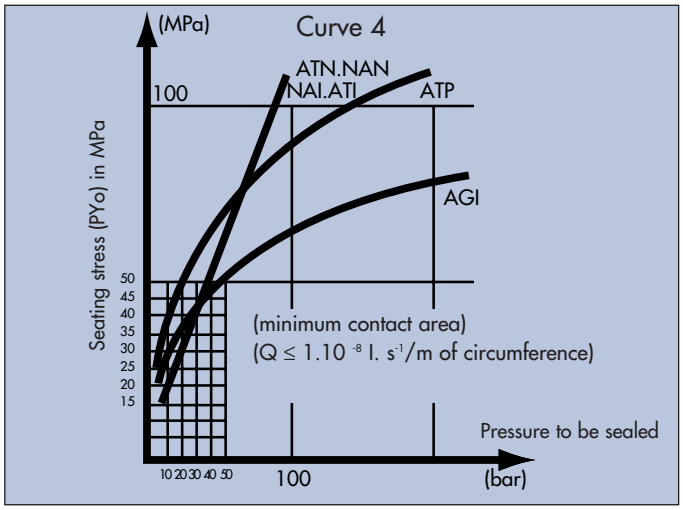
Curve 3 shows evolution of helium gas flow at a ΔP of 1 bar versus seating stress PY_o, in compression and decompression (this curve applies to all types of CEFIGRAF® gasket).

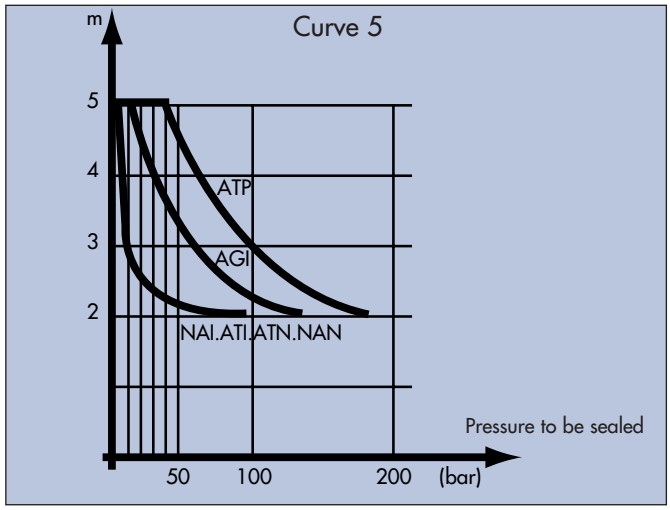


• **Liquid tightness curve**

Curve 4 shows seating stress to be applied to a gasket (contact pressure) = PY_o versus pressure to be sealed.

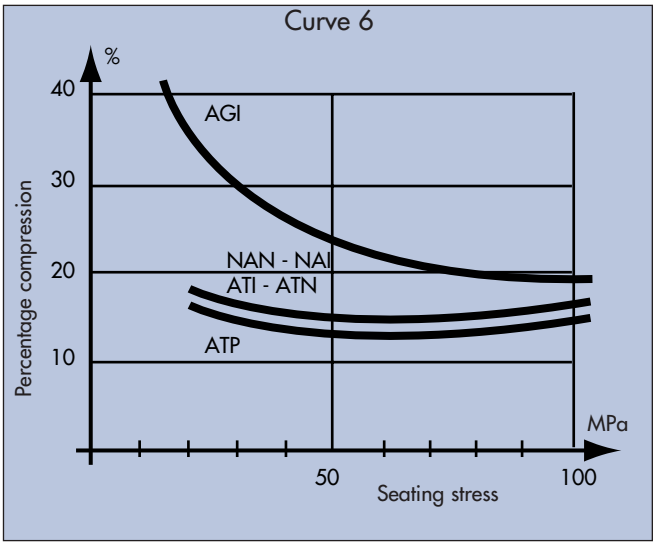
Curve 5 shows gasket factor «m» versus pressure to be sealed.

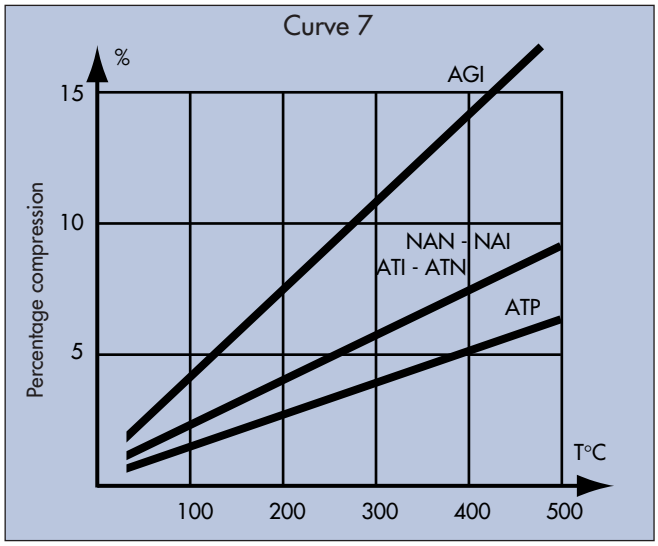




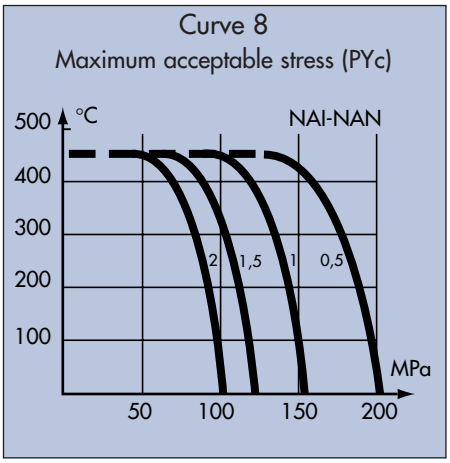
- **Elastic recovery curve**
  Curve 6 shows elastic recovery as a percentage of compression versus seating stress, at room temperature.

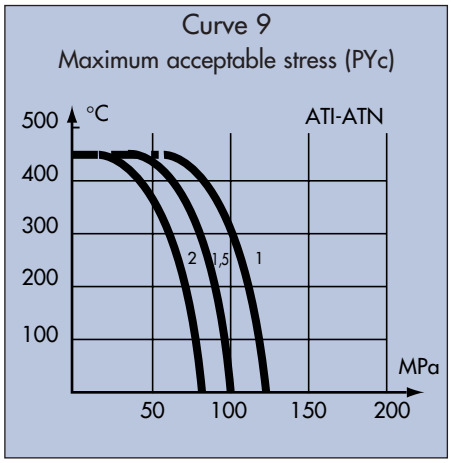
- **Creep curve**
  Curve 7 shows creep as a percentage of compression versus temperature at a constant seating stress of 50 MPa.

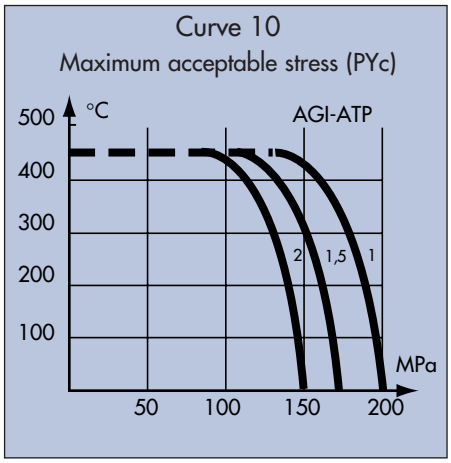




- **Maximum acceptable stress (PYc) curves, nos. 8, 9, and 10**
  The curves below show maximum acceptable stresses versus temperature for various types and thicknesses of CEFIGRAF® gaskets.

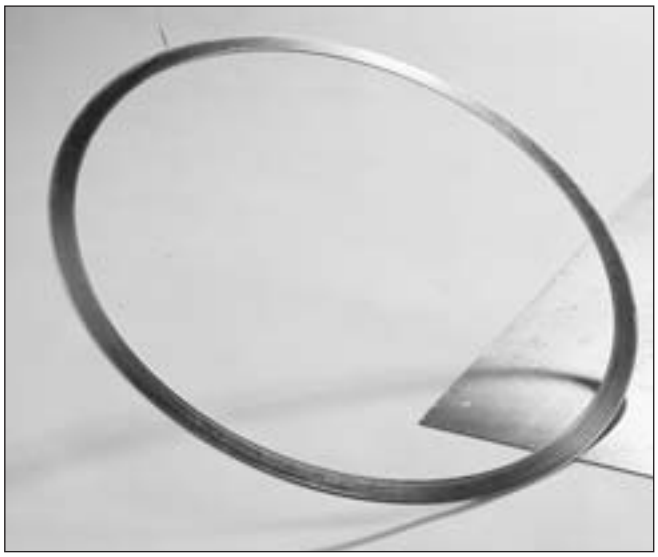






Advantages over conventional gaskets

CEFIGRAF® flexible graphite gaskets :
- fit in place of standardized gaskets made of conventional materials
- have very good resistance to extreme temperature (from cryogenic levels to + 450°C)
- have good chemical inertness
- stand up very well at extreme pressures
- withstand ionizing radiation
- remain tight at fire test conditions

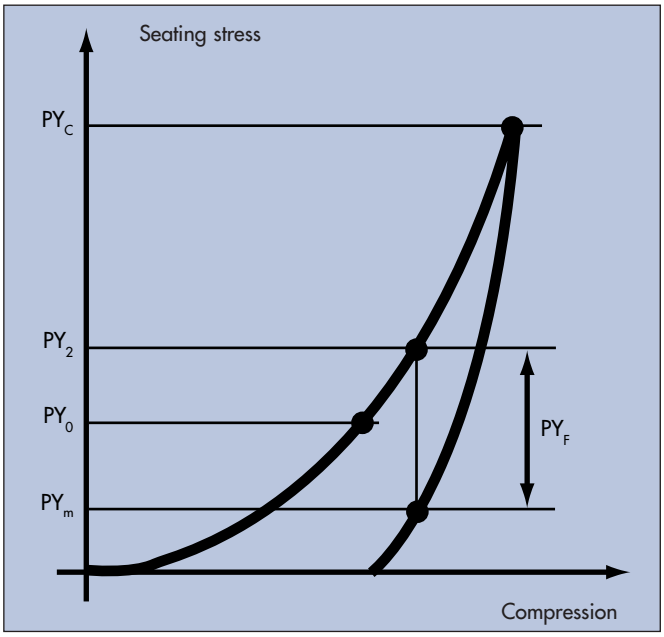


Standardization

Flexible graphite cut gaskets can fit standardized flanges with flat or raised faces, and narrow or wide tongue and groove faces (see standard NF E 29-900-2, Gaskets).

GASKET CALCULATIONS

Determination of seating stress



• Minimum seating stress PY_o

The minimum seating stress to be exerted on the gasket serves to densify the graphite and mould it to surface irregularities. It is a minimum, applicable where the internal pressure is low. Curve 3 is for gases and curve 4 is for liquids.

• Maximum seating stress : PY_C

The maximum acceptable stress that must not be exceeded in operation is a key characteristic value. It depends on the grade and thickness of the seal, but most of all on the service temperature. It is a maximum and applies even when the internal pressure is high. It is given by curves no. 8, 9, and 10.

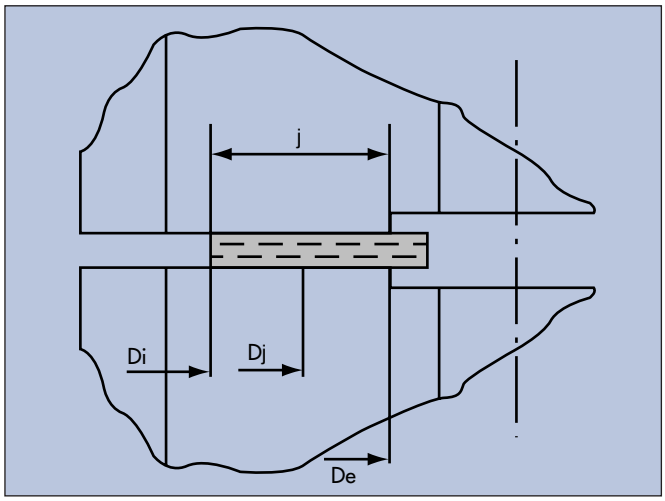
• Optimal seating stress PY_2

The calculated optimal seating stress $PY_2 = (PY_m + PY_F)$ must, naturally, lie between PY_o and PY_C.

PY_F is the stress resulting from fluid end-load, which tends to lift the gasket in operation.

$PY_F = \frac{P.Dj}{4j}$ (j : actual width of gasket ; P = service pressure)
(Dj : mean diameter of gasket)

PYm is the minimum acceptable stress, taking lift-off into account ; it must in all cases be greater than "m" times the internal pressure (PY_m = mP). The coefficient is given by curve 5 for liquids and by the ratio PY_o/P for gases.



• Recommended seating stress

If ⟶ $PY_2 < PY_o$: PY_o
If PY0 < $PY_2 < PY_C$: PY_2
If ⟶ $PY_2 > PY_C$: review seal design, including the following options :

- reduce thickness
- increase width j
- change grade of graphite
- change type of seal : replace gasket by a VITAFLEX® spiral-wound gasket or an ORIGRAF® die-formed graphite seal.

CALCULATION PROCEDURE :

GASKET							
Di	= Inside diameter of active part	mm	**Di**	**Fa**	= Seating load	N	**S x PY_o**
De	= Outside diameter of active part	mm	**De**				
Dj	= Mean diameter	mm	**(De + Di) / 2**				
j	= Width of active part of gasket	mm	**(De - Di) /2**	**Ff**	= Fluid end-load	N	**π x Dj x P / 4 (=S x PY_F)**
S	= Surface area of gasket	mm^2	π x D_j x j	**Fm**	= Minimum load to be maintained	N	**S x m x P (=S x PY_m)**
				Fs	= Load required at 20°C	N	**Ff + Fm (=S x PY_2)**
PY_o	= Seating stress	MPa	Liquids : see curve 4 Gases : see curve 3	**Fs***	= Load required at Ts	N	**Fs x E t20 / E ts**
m	= Gasket factor		Liquids : see curve 5				
			Gases : m = PY_o / P	**Fb**	= Corrected bolt load to be applied to the gasket	N	**y x Fa si y x Fa > Fs*** **Fs* si y x Fa ≤ Fs***
PY_c	= Maximum seating stresss on gasket at high temperature	MPa	cf. curves 8, 9 and 10				
y	= Elasticity coefficient of the assembly		1.1				
				Sigma b	= Stress in bolting	N	**Fb / (Nb x S)**
P	= Fluid pressure	MPa					
E t20	= Young's modulus of bolting at T = 20°C	MPa		**PY min**	= Min. resulting stress on gasket	MPa	**Fb / S**
E ts	= Young's modulus of bolting at service temperature	MPa		**PY max**	= Max. resulting stress on gasket at T s	MPa	**(Fb x E ts / E t20) / S**
Nb	= Number of bolts						**Check : PYmax < PY_C**
Sb	= Load-bearing section of one bolt	mm^2	

Note : The calculations do not take the creep of the gasket into account, because it can be regarded as negligible - less than 1% of the compression at 20°C and 50 MPa and less than 10% at 450°C under the same conditions.

DIE-FORMED FLEXIBLE GRAPHITE SEALS

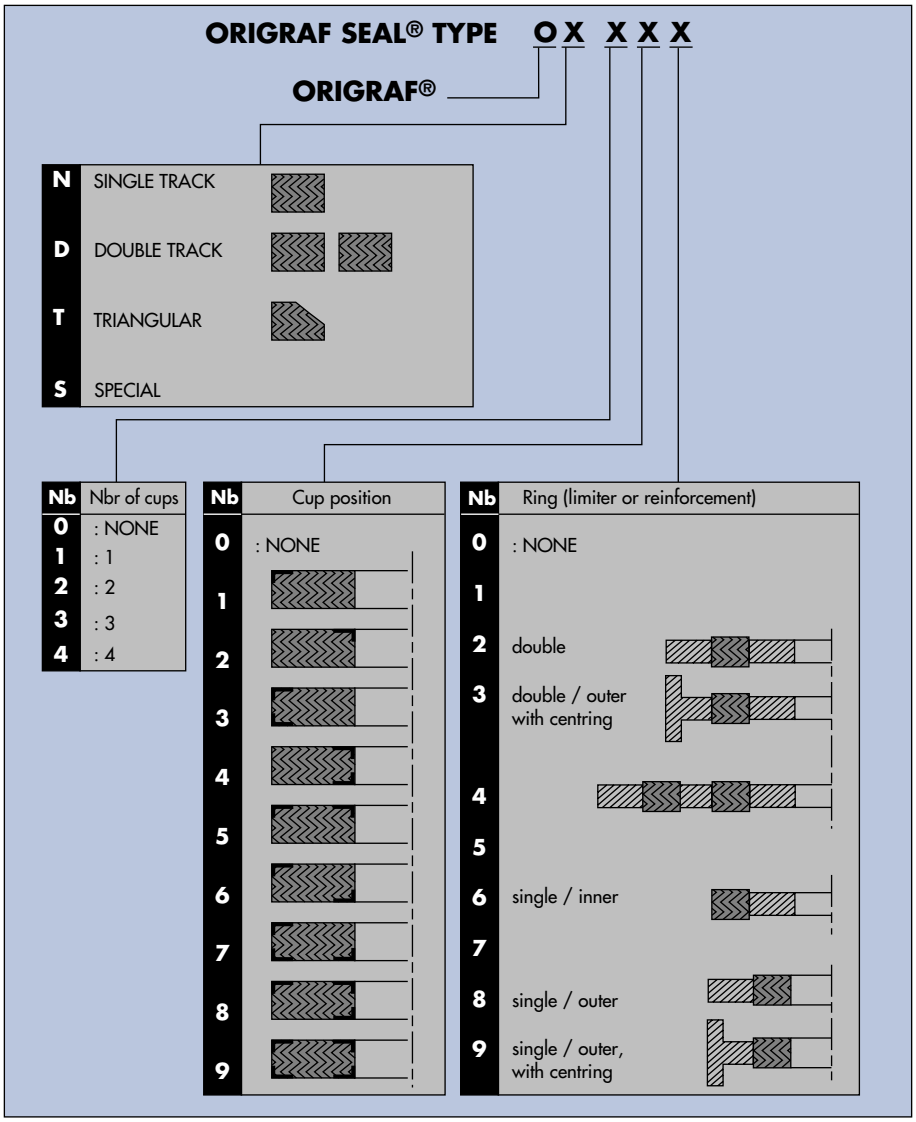
Grades of graphite

ORIGRAF® seals are made of CEFIGRAF® material as indicated below.

Flexible graphite	N 998	I 980	NZ 998	IZ 980	NP 998	IP 980	NS 200
CEFIGRAF (seals)	N	I	NAC	IAC	NP	IP	NS 200[1]

[1] EDF PMUC approved.

Type of seals*



ORIGRAF® with anti-extrusion cups :

This patented system is recommended for the following cases :

- High pressure.
- Absolute necessity of avoiding extrusion.
- Fluids containing impurities or highly corrosive (to protect the core of the seal).

The plates are made of stainless steel (316L, 304L, etc...) or on request of Arcap, Monel, Inconel, silver, etc.

* Other shapes or sections can be considered on request.

Production possibilities

ORIGRAF® SEALS WHITOUT CUPS (type ON 000)
Minimum possible thickness 2 mm
ø mini ID 2 mm
ø OD up to 1000 mm
Section according to pressures to be sealed.

ORIGRAF® SEALS WITH PLATE (S)
Examples : Type ON 110; ON 120; ON 250

ø in mm	Min. th. in mm	Min. section in mm
20 to 75	4,00	5,00
75,1 to 125	4,50	6,00
125,1 to 200	5,00	7,50
200,1 to 300	5,50	8,75
300,1 to 450	6,00	10,50
450,1 to 600	6,50	12,50

For other dimensions and types, contact us.

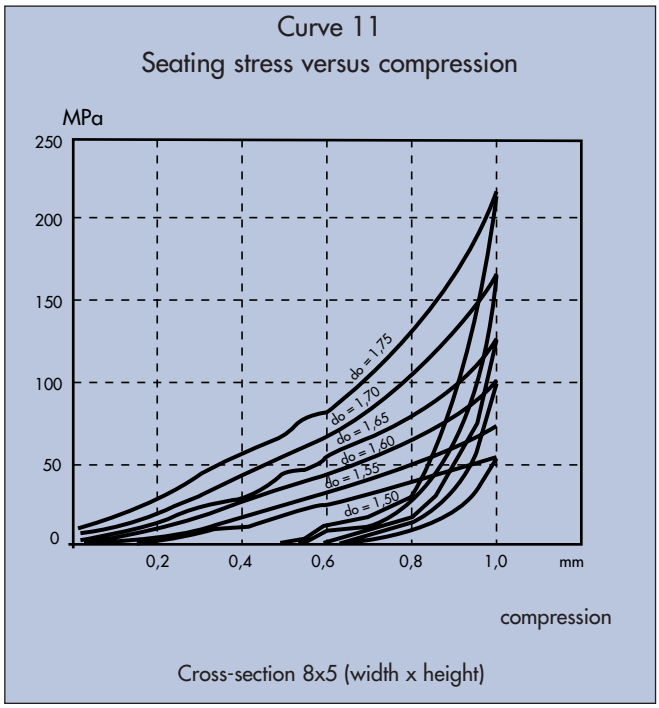
Technical characteristics

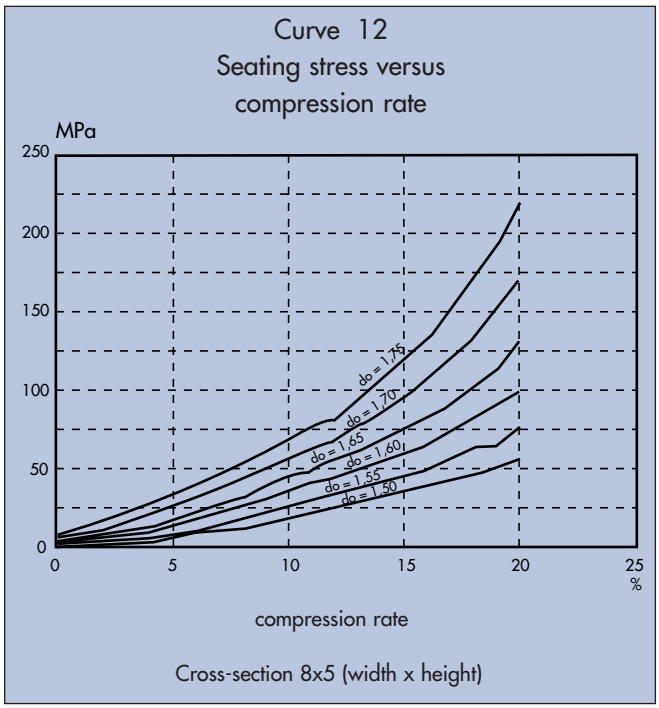
• Operating mode

Unlike flexible graphite cut gaskets, the compression of the ORIGRAF® die-formed seal is limited by a mechanical stop : groove or inner and/or outer ring. In the case of assemblies subject to extreme pressure and/or temperature this design prevents application of an excessive seating stress on the seal during transients.

• Compression curve

Curve 11 shows seating stress versus compression on an ORIGRAF® seal with 8 x 5 cross-section at initial density "do".
This parameter serves to modulate seating stress at point of contact with the mechanical stop.
Curve 12 shows seating stress versus compression rate at initial density "do".



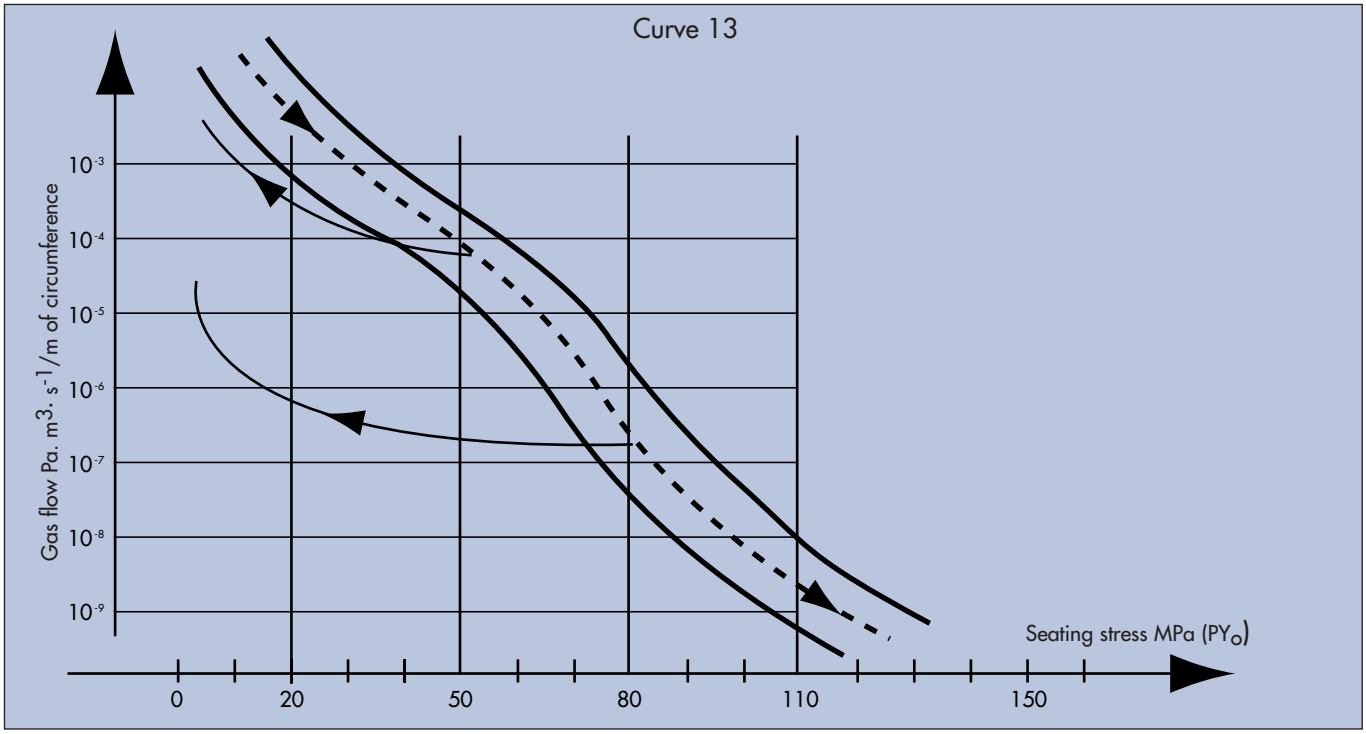


Backed by substantial Research and Development support, several tests to characterize ORIGRAF seals have made it possible to control the key parameters in seal performance.

These parameters allow us to use a nominal contact pressure of **35 to 50 MPa** in most applications.

• **Gas tightness curve**

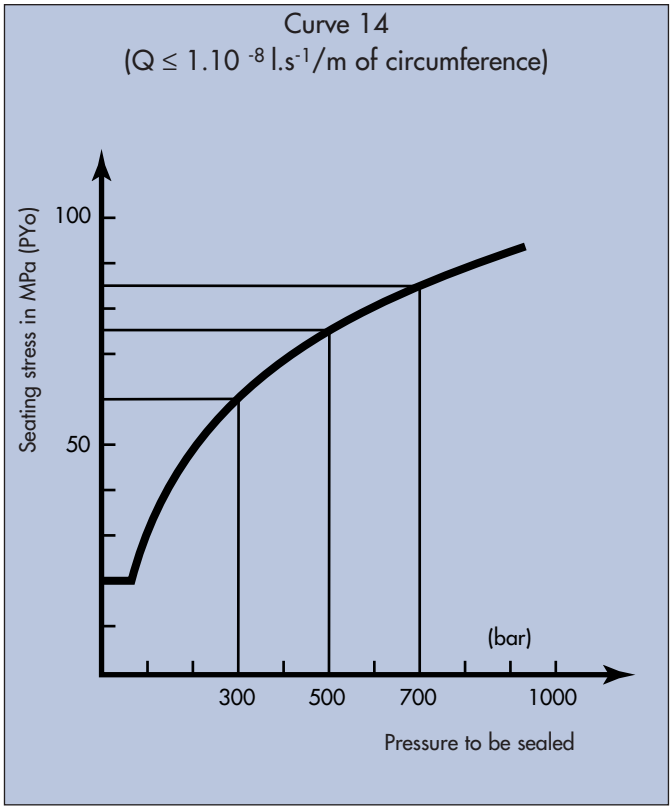
Curve 13 shows helium leak rate at a ΔP of 1 bar versus seating stress, in compression and decompression.

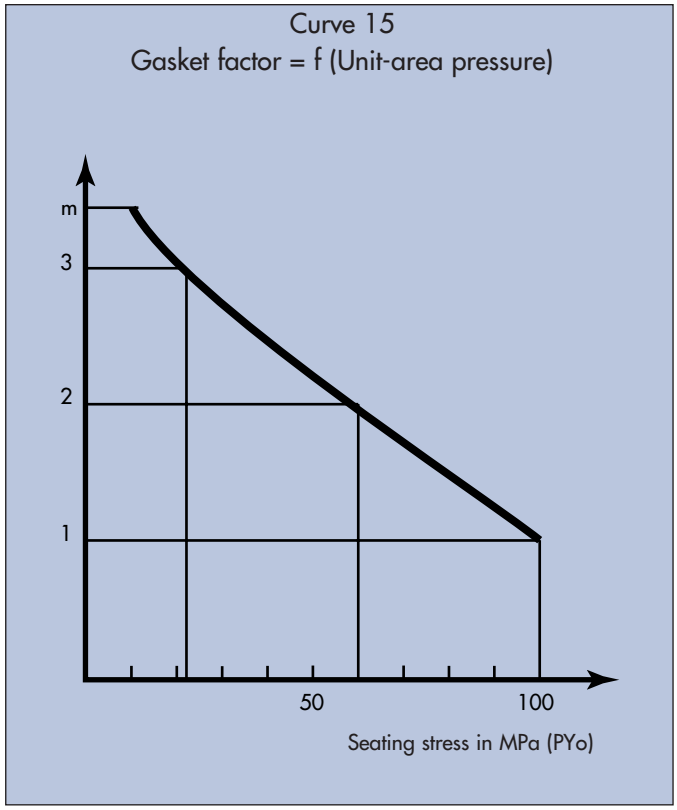


• **Liquid tightness curve**

Curve 14 shows seating stress to be applied to the seal (at metal/metal contact) versus pressure to be sealed.

Curve 15 shows gasket factor "m" versus seating stress.





Note : These values are constant over the whole service temperature range of the material.

Recommendations for use

• Surface conditions :

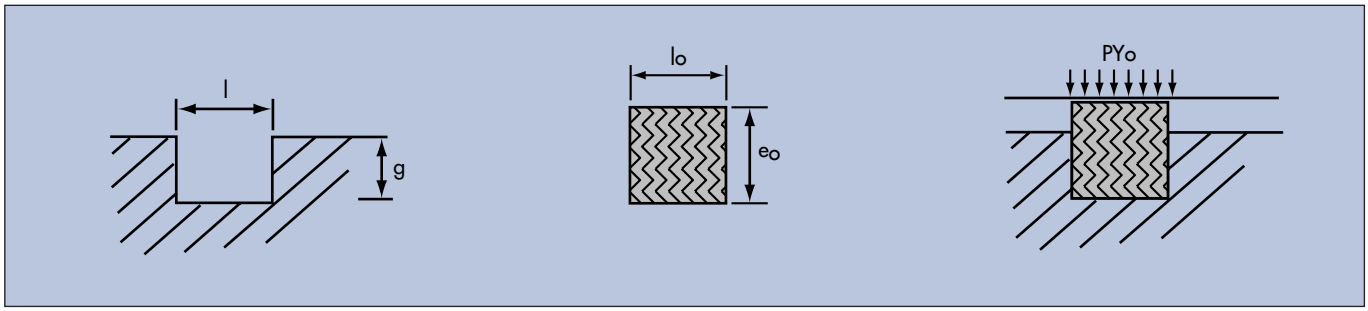
The surface conditions of the contact areas should be :
Ra = 0.8 to 12.5 µ for circular seals
(recommended Ra = 1.6 to 6.3 µ)
Ra = 0.4 to 1.6 µ for shaped seals
(recommended Ra = 0.8 µ)

• Compression rate :

ORIGRAF® seals are designed to be compressed 15 to 20%.

• Groove size :

The groove size has a direct effect on seating stress to be applied to the seal to ensure metal/metal contact.
The table below shows influence of groove tolerances on the accuracy of contact pressure (PYo) specified for a seal having initial section of lo x e_o.



GROOVE		Section lo x e_o (mm^2)		
g	l	25	50	100
± 0,05	+ 0,05 + 0	PYo ± 20 %	PYo ± 15 %	PYo ± 10 %
± 0,05	+ 0,10 + 0	PYo ± 25 %	PYo ± 20 %	PYo ± 15 %
± 0,10	+ 0,20 + 0	PYo ± 50 %	PYo ± 30 %	PYo ± 25 %

• Installation / removal

For ORIGRAF® seals installed in grooves, it is recommended that precautions be taken during removal, to extract the seal without damaging the groove bottom (for example, with the ON 250 type, pay attention to the direction of installation - cup on open angle side).

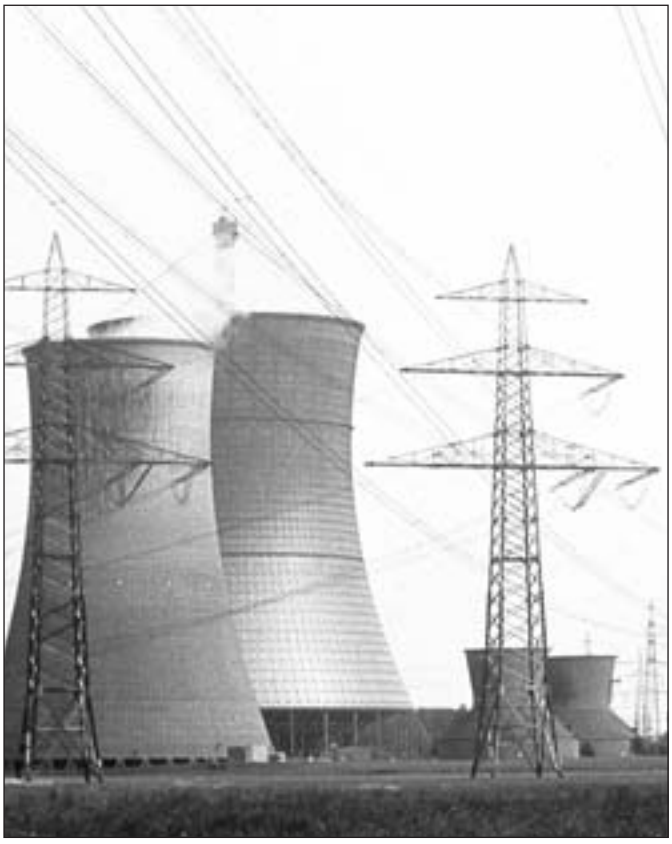
For ORIGRAF® seals with limiters, no special precautions are required during installation, except, in all cases, to avoid any risk of damaging the sealing area, such as dents, scratches, foreign bodies, and deformation.

Main advantages of the ORIGRAF® seal

- Overall performance is better than that of cut gaskets because of the special orientation of the raw material and the design of the seal.
- Excellent elastic recovery - up to 50% of compression.
- Improved seal in service with lower stresses on bolting.
- Improved ability to withstand temperature transients.
- Less corrosion of sealing contact areas, making maintenance easier when the junction is opened and the seal replaced.
- Good ability to take up relative movement between the sealing contact areas.
- Excellent ability to withstand a broad range of temperatures, from - 196 to + 2500°C* (* depending on type and grade of graphite - see table on page 3 - and environmental and installation conditions).
- Tightness maintained after fire tests.
- The seating pressure applied during installation is maintained over time because of the very low level of relaxation, in the order of 6 to 8% at most.

Fields of application

- Replacement of elastomer O-rings for the following static applications :
  high and low temperatures,
  highly corrosive fluids,
  radioactive environnement.
- Nuclear applications : steam generator, heat-exchanger, all types of valve.
  Navy : ships and submarines.
- Chemical and petrochemical industry, valves, autoclaves, piping, heat exchangers, corrosive circuit, cryogenics, heat-transfer fluid, high- and low-pressure steam.
- Installation on enamelled sealing contact areas and on technical polymers.
- Blocks and plates for handling pieces of molten glass.

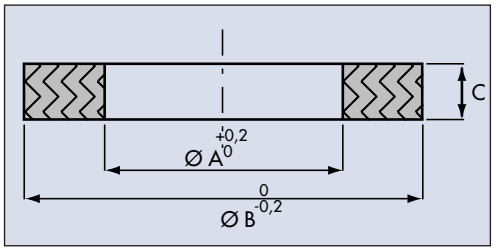


Standardization

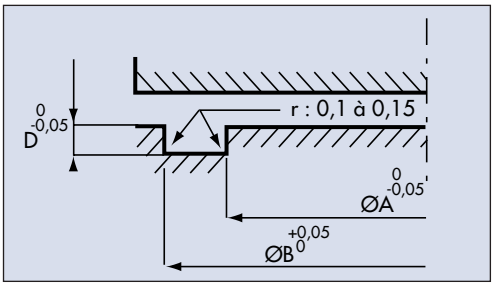
Installation in groove - Series 15 000 - French standard

REF	A x B x C	REF	A x B x C	REF	A x B x C
20008	9 X 15,5 - 2,4	**20038**	67,1 X 79,5 - 4,9	**20068**	169,5 X 186,2 - 6
20009	9,5 X 16 - 2,4	**20039**	70 X 83,5 - 4,9	**20069**	175 X 192 - 6
20010	12 X 19 - 2,4	**20040**	73 X 87 - 4,9	**20070**	182 X 199 - 6
20011	14 X 21 - 2,4	**20041**	78 X 92 - 4,9	**20071**	187 X 204 - 6
20012	15 X 22,5 - 2,4	**20042**	80 X 93 - 4,9	**20072**	195 X 212 - 6
20013	16 X 23 - 2,4	**20043**	84 X 97 - 4,9	**20073**	200 X 217 - 6
20014	18 X 25 - 2,4	**20044**	87 X 100 - 4,9	**20074**	215 X 232 - 6
20015	18 X 26 - 3,4	**20045**	90 X 103 - 4,9	**20075**	225 X 242 - 6
20016	20 X 28 - 3,4	**20046**	95 X 107 - 4,9	**20076**	238 X 255 - 6
20017	21 X 31 - 3,4	**20047**	96 X 109 - 4,9	**20077**	251 X 268 - 6
20018	22 X 31 - 3,4	**20048**	100 X 113 - 4,9	**20078**	265 X 282 - 6
20019	24 X 33 - 3,4	**20049**	103 X 116 - 4,9	**20079**	277 X 294 - 6
20020	25 X 34 - 3,4	**20050**	106 X 120 - 4,9	**20080**	290 X 307 - 6
20021	27 X 37 - 3,4	**20051**	110 X 123 - 4,9	**20081**	303 X 320 - 6
20022	28,6 X 38,1 - 3,4	**20052**	112 X 125 - 4,9	**20082**	316 X 333 - 6
20023	30 X 39 - 3,4	**20053**	112 X 129 - 6	**20083**	328 X 345 - 6
20024	31,5 X 41,3 - 3,4	**20054**	115 X 132 - 6	**20084**	340 X 357 - 6
20025	34 X 42 - 3,4	**20055**	120 X 136 - 6	**20085**	353 X 370 - 6
20026	34 X 43,6 - 3,4	**20056**	122 X 139 - 6	**20086**	365 X 382 - 6
20027	36 X 44 - 3,4	**20057**	125 X 142 - 6	**20087**	378 X 395 - 6
20028	36 X 50 - 4,9	**20058**	127 X 145 - 6	**20088**	394 X 410,6 - 6
20029	40 X 53 - 4,9	**20059**	131 X 148 - 6		
20030	42 X 55 - 4,9	**20060**	134 X 151 - 6		
20031	45 X 58,6 - 4,9	**20061**	138 X 155 - 6		
20032	50 X 63 - 4,9	**20062**	140 X 157 - 6		
20033	53 X 66 - 4,9	**20063**	144 X 161 - 6		
20034	55 X 68,4 - 4,9	**20064**	146 X 163 - 6		
20035	58,5 X 71,3 - 4,9	**20065**	150 X 167 - 6		
20036	62 X 75 - 4,9	**20066**	155 X 172 - 6		
20037	65,42X 77,42 - 4,9	**20067**	163 X 180 - 6		

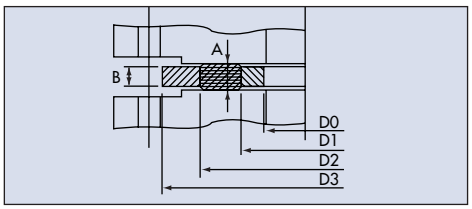
DIMENSIONS OF ORIGRAF® SEALS



DIMENSIONS OF GROOVES FOR ORIGRAF® SEALS



O-ring number French standard	Torus Ø of O-ring to be replaced	Groove depth D
N° 7 to 14	2,7	2
N° 15 to 27	3,6	2,9
N° 28 to 52	5,33	4,2
N° 53 to 88	6,99	5,2



For flanges as per NF E 29-203 (july 1989 rev) or ASME/ANSI B 16.5 of May 1988 with ISO bolting.
For sizes corresponding to MSS SP 44 and NF E 29 209 with ISO or UNC bolting flange standards, seals can be produced on request.

ISO PN 20

DN	D0	D1	D2	D3	B	A
15	14,2	22	30	46,5	3	3,7
20	23	32	40	56	3	3,7
25	27	38	46	65,5	3	3,7
32	38,1	48	58	75	3	3,7
40	44,5	56	66	84,5	3	3,7
50	55,6	70	80	104,5	3	3,7
65	66,5	84	94	123,5	3	3,7
80	81	96	108	136,5	3	3,7
100	104,8	122	134	161,5	4	4,8
125	135,7	152	164	196	4	4,8
150	162,6	176	192	221,5	4	4,8
200	213,4	230	246	278,5	4	4,8
250	267,3	286	302	338	4	4,8
300	319,9	342	362	408	5	5,9
350	351,6	374	394	449	5	5,9
400	402,4	432	452	513	5	5,9
450	454,7	476	500	548	5	5,9
500	505,5	526	550	605	5	5,9
600	668,7	630	654	716,5	5	5,9

ISO PN 50

DN	D0	D1	D2	D3	B	A
15	14,2	22	30	52,5	3	3,7
20	14,2	24	32	66,5	3	3,7
25	26,9	38	46	73	3	3,7
32	38,1	48	58	82,5	3	3,7
40	44,5	56	66	94,5	3	3,7
50	55,6	70	80	111	3	3,7
65	66,5	90	100	129	3	3,7
80	81	104	116	148,5	3	3,7
100	104,8	138	150	180	4	4,8
125	135,7	164	176	215	4	4,8
150	162,6	186	202	250	4	4,8
200	213,4	242	258	306	4	4,8
250	267,3	286	302	360,5	5	5,9
300	319,9	342	362	421	5	5,9
350	351,6	380	400	484,5	5	5,9
400	402,4	434	454	538,5	5	5,9
450	454,7	492	516	595,5	5	5,9
500	505,5	540	564	653	5	5,9
600	608,7	648	672	774	5	5,9

ISO PN 100

DN	D0	D1	D2	D3	B	A
15	14,2	22	30	52,5	3	3,7
20	14,2	24	32	66,5	3	3,7
25	26,9	38	46	73	3	3,7
32	38,1	48	58	82,5	3	3,7
40	44,5	56	66	94,5	3	3,7
50	55,6	70	80	111	3	3,7
65	66,5	90	100	129	3	3,7
80	81	104	116	148,5	3	3,7
100	106,4	134	150	192	4	4,8
125	131,8	160	176	240	4	4,8
150	154,8	182	202	265	4	4,8
200	205,6	238	258	319	4	4,8
250	254,6	290	310	399	4	4,8
300	307,2	346	370	456	5	5,9
350	349,3	376	400	491	5	5,9
400	400,1	434	458	564	5	5,9
450	449,9	488	516	612	5	5,9
500	500,7	538	566	682	5	5,9
600	608,7	646	674	790	5	5,9

ISO PN 150

DN	D0	D1	D2	D3	B	A
15	14,2	22	30	62,5	3	3,7
25	27	38	46	77,5	3	3,7
32	34,9	46	58	87	3	3,7
40	41,4	54	66	97	3	3,7
50	52,4	70	86	141	3	3,7
65	63,5	82	98	163,5	3	3,7
80	81	100	116	166,5	4	4,8
100	106,4	134	150	205	4	4,8
125	131,8	160	176	246,5	4	4,8
150	154,8	182	202	287,5	4	4,8
200	209,6	238	258	357,5	4	4,8
250	256,4	290	310	434	4	4,8
300	303,9	346	370	497,5	5	5,9
350	345,6	376	400	520	5	5,9
400	402,8	434	458	574	5	5,9
450	453,6	488	516	638	5	5,9
500	500,7	538	566	697,5	5	5,9
600	608,7	646	674	837,5	5	5,9

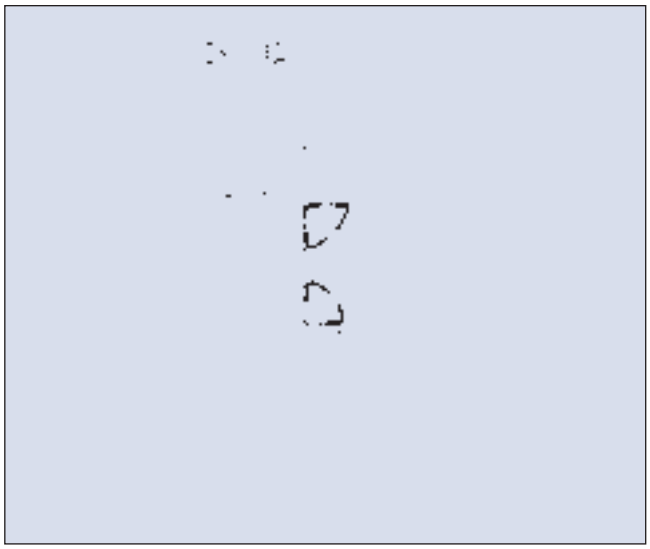
ISO PN 250

DN	D0	D1	D2	D3	B	A
15	14,2	22	30	62,5	3	3,7
20	20,6	32	40	69	3	3,7
25	27	38	46	77,5	3	3,7
32	34,9	46	58	87	3	3,7
40	41,4	54	66	97	3	3,7
50	52,4	70	86	141	3	3,7
65	63,5	82	98	163,5	3	3,7
80	81	100	116	173	4	4,8
100	106,4	130	150	208,5	4	4,8
125	131,8	156	176	253	4	4,8
150	157,2	182	202	281,5	4	4,8
200	206,2	234	258	351,5	4	4,8
250	257,8	286	310	434,5	4	4,8
300	314,5	346	370	519,5	5	5,9
350	342,9	376	400	579	5	5,9
400	396,4	434	458	641	5	5,9
450	444,5	488	516	704	5	5,9
500	495,3	538	566	756	5	5,9
600	596,9	646	674	900,5	5	5,9

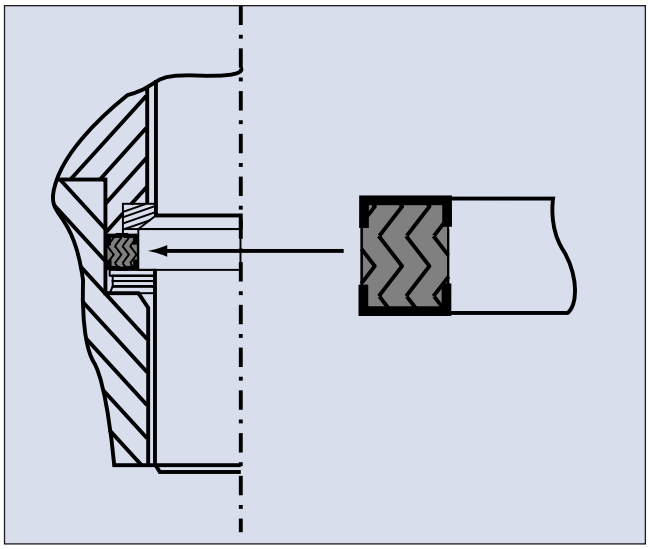
ISO PN 420

DN	D0	D1	D2	D3	B	A
15	14,2	22	30	69	3	3,7
20	20,6	32	40	75	3	3,7
25	27	38	46	84	3	3,7
32	34,9	46	58	103	3	3,7
40	41,4	54	66	116	3	3,7
50	52,4	70	86	144,5	3	3,7
65	63,5	82	98	167	3	3,7
80	81	100	116	195,5	3	3,7
100	106,4	130	150	234	4	4,8
125	131,8	156	176	279	4	4,8
150	157,2	182	202	316,5	4	4,8
200	205,9	234	258	386	4	4,8
250	260	286	310	475,5	4	4,8
300	307,5	346	370	549	5	5,9

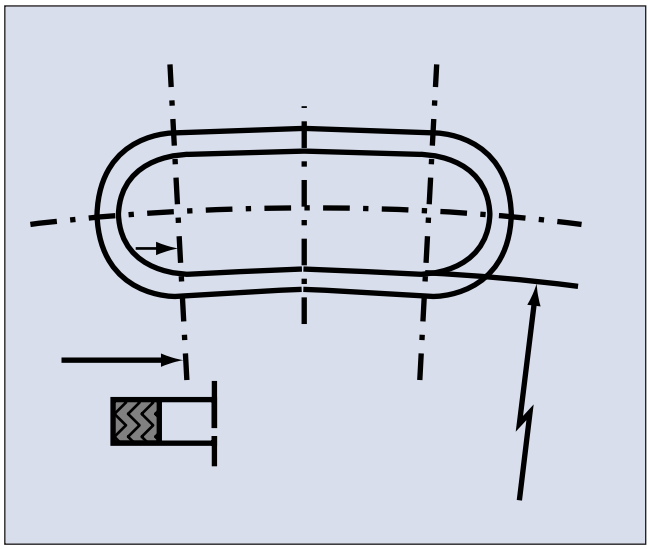
Other types of ORIGRAF® seals



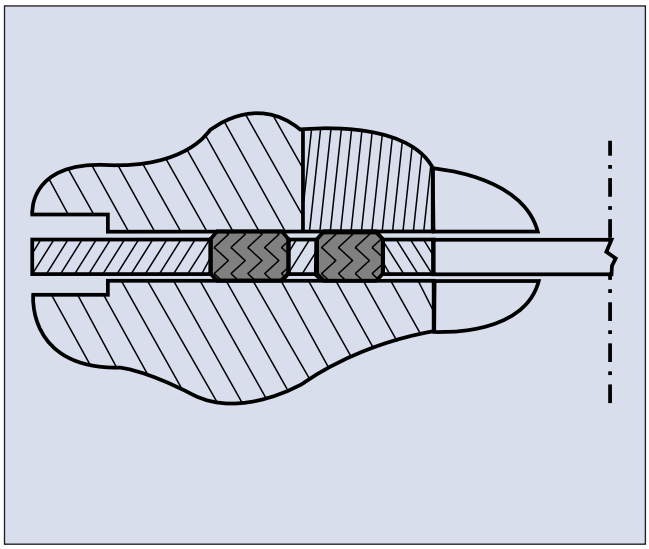
Sealing on electric boiler



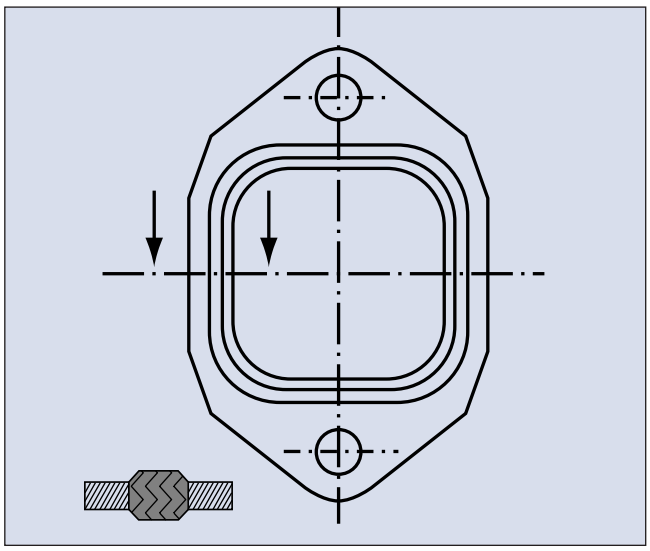
Sealing and centering of valve stem



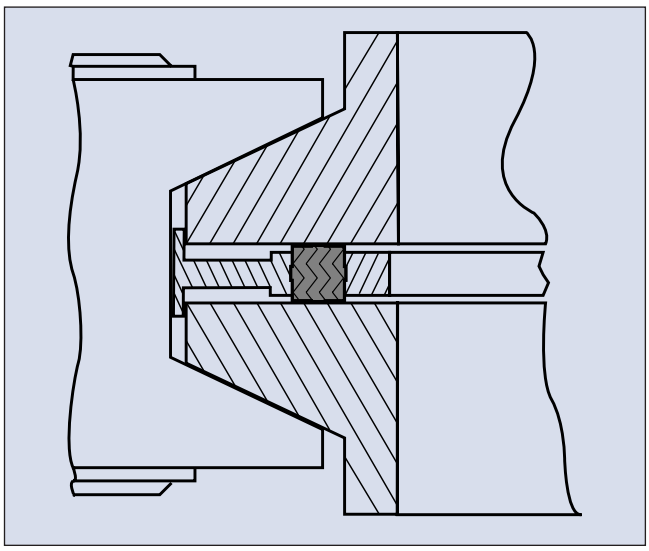
Special "BEAN" shapes



Installation with double sealing track



Installation on exhaust flange



Installation on "Quick - disconnect" flanges

ORIGRAF® CALCULATION

Determination of seating stress

• Minimum seating stress PYo

The minimum seating stress to be exerted on the seal serves to densify the flexible graphite and mould it to surface irregularities. It is a minimum, applicable even where internal pressure is low. Curve 13 is for gases and curve 14 is for liquids. It corresponds to metal/metal contact.

• Optimal seating stress PY_2

The calculated optimal seating stress $PY_2 = PY_m + PY_F$.

PY_F is the stress resulting from the fluid end-load, which tends to lift the seal in operation.

$$PY_F = \frac{PDj}{4j}$$ (j : actual width of seal - P : service pressure) (Dj : mean diameter of seal)

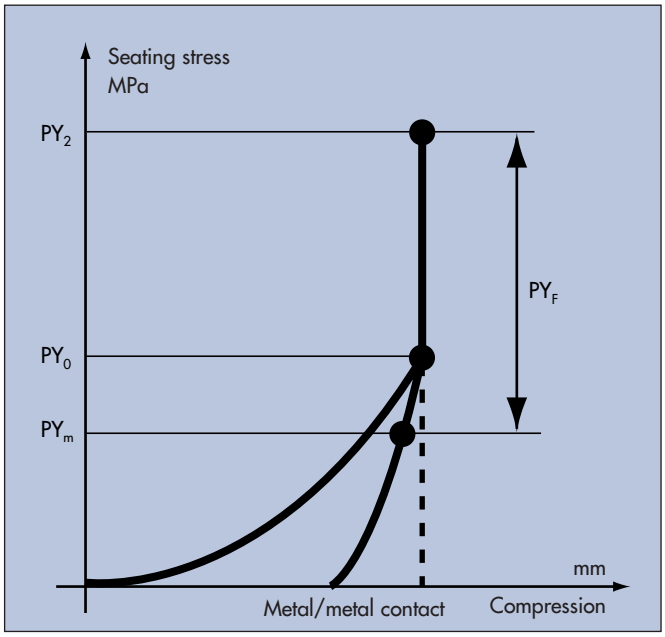
PYm is the minimum acceptable stress, taking lift-off into account ; it must in all cases be greater than «m» times the internal pressure ($PY_m = mP$)

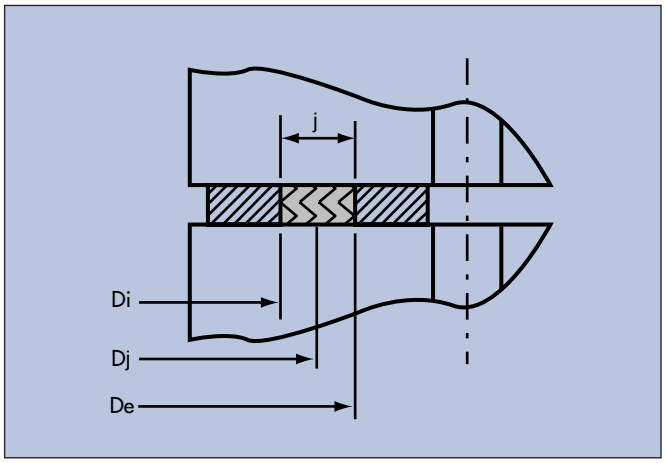
The coefficient m is given by curve 15 for liquids and by the ratio PYo/P for gases.

• Recommended seating stress

If ⟶ $PY_2 < PY_o$: PY_o

If ⟶ $PY_2 > PY_o$: PY_2





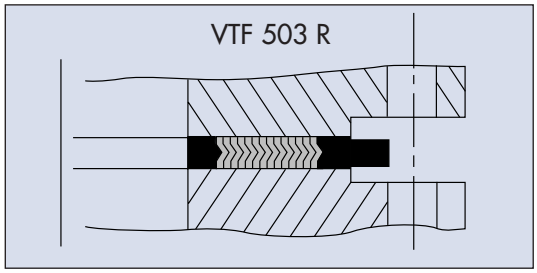
CALCULATION

ORIGRAF							
Di	= Inside diameter of active part	mm	**Di**	**Fa**	= Seating load	N	**S x PY_o**
De	= Outside diameter of active part	mm	**De**				
Dj	= Mean diameter	mm	**(De + Di) / 2**				
j	= Width of active part of seal	mm	**(De - Di) /2**	**Ff**	= Fluid end-load	N	**π Dj^2 x P / 4 (=S x PY_F)**
S	= Surface area of seal	mm^2	π x Dj x j	**Fm**	= Minimum load to be maintained	N	**S x m x P (=S x PY_m)**
				Fs	= Load required at 20°C	N	**Ff + Fm (=S x PY_2)**
PY_o	= Seating stress	MPa	Liquids : see curve 14	**Fs***	= Load required at Ts	N	**Fs x E t20 / E ts**
			Gases : see curve 13				
m	= Gasket factor		Liquids : see curve 15				
			Gases : m = PY_o / P	**Fb**	= Bold load to be applied to the seal	N	**Fa si Fa > Fs*** **Fs* si Fa <= Fs***
P	= Fluid pressure	MPa					
				Sigma b	= Stress in bolting	N	**Fb / (Nb x S)**
Sb	= Load-bearing section of one bolt	mm^2					

OTHER TYPES OF FLEXIBLE GRAPHITE SEALS

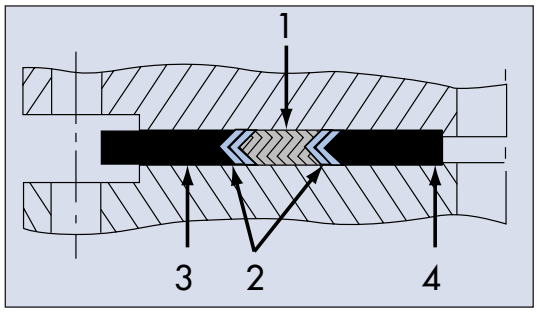
VITAFLEX® spiral wound gasket :

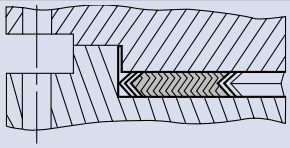
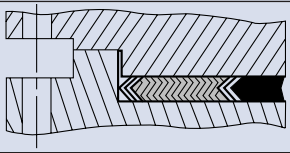
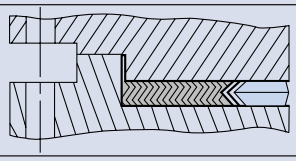
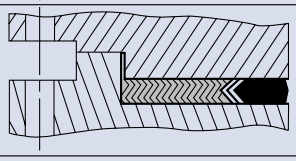
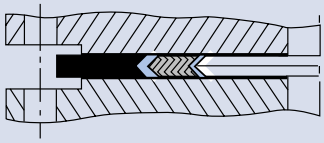
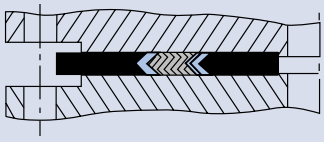
Flexible graphite as a strip of filler material is combined with a metal strip in a winding of a given width and thickness, including or not other and/or inner rings.



RADIAGRAF® : patented system

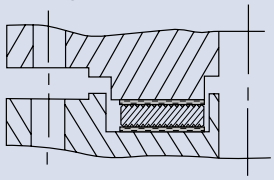
Concept :
- Pre-compressed CEFIGRAF® seal (1).
- Stainless steel, Monel, Inconel, or Arcap ring to prevent extrusion (2).
- If the assembly requires, inner and/or outer locating/limiting device (3 and 4) can be added.



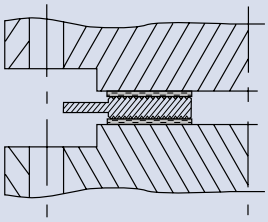
STANDARD TYPE		TYPE WITH INTERNAL REINFORCEMENT	
2001		**2001 RT**	
2002		**2002 RT**	
2003		**2003 RT**	

SERRATED METAL RING WITH CEFIGRAF® FLEXIBLE GRAPHITE LAYERS

Tongue and groove

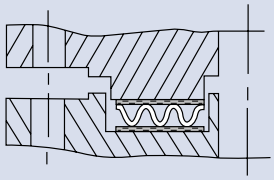


Flat or raised face

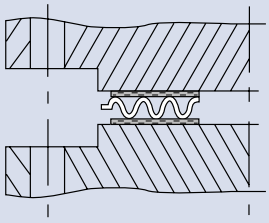


CORRUGATED METAL WITH CEFIGRAF® FLEXIBLE GRAPHITE LAYERS

Tongue and groove

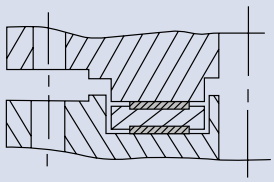


Flat or raised face

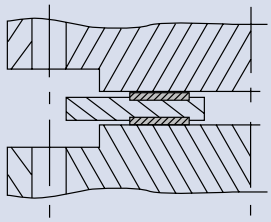


GROOVED METALLIC RING WITH CEFIGRAF® FLEXIBLE GRAPHITE LAYERS

Tongue and groove



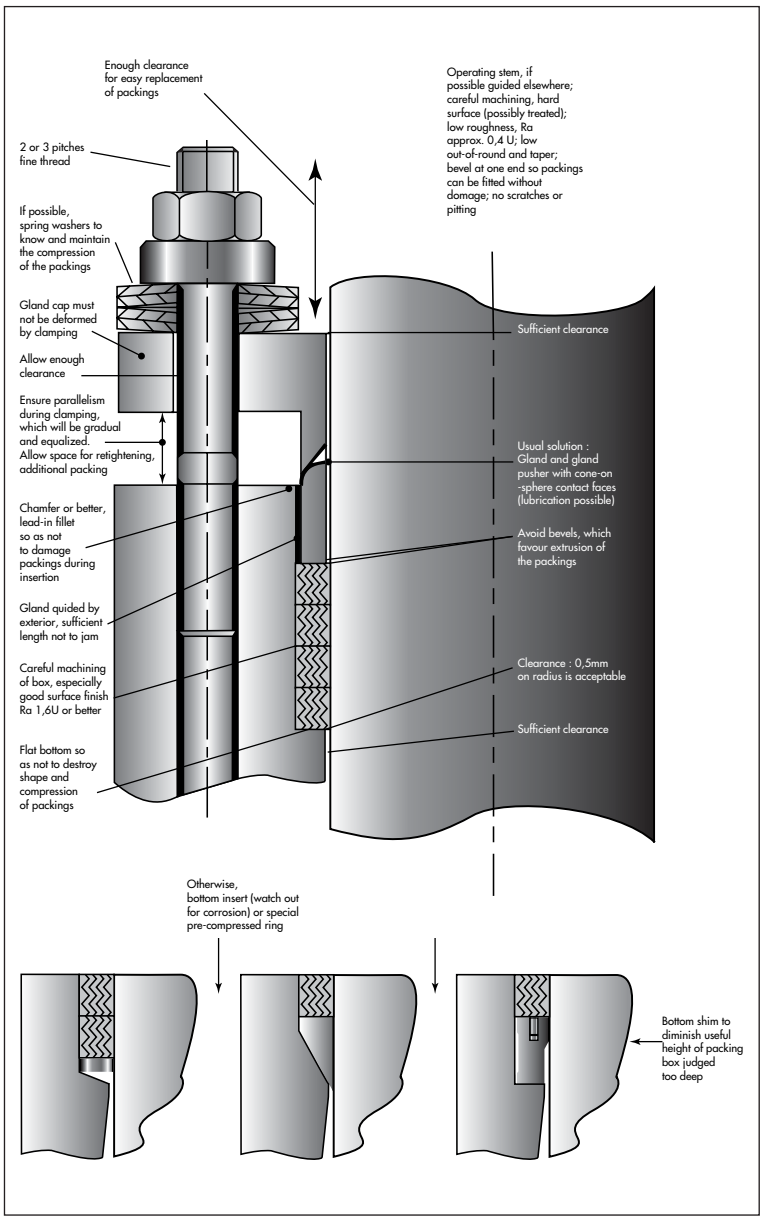
Flat or raised face

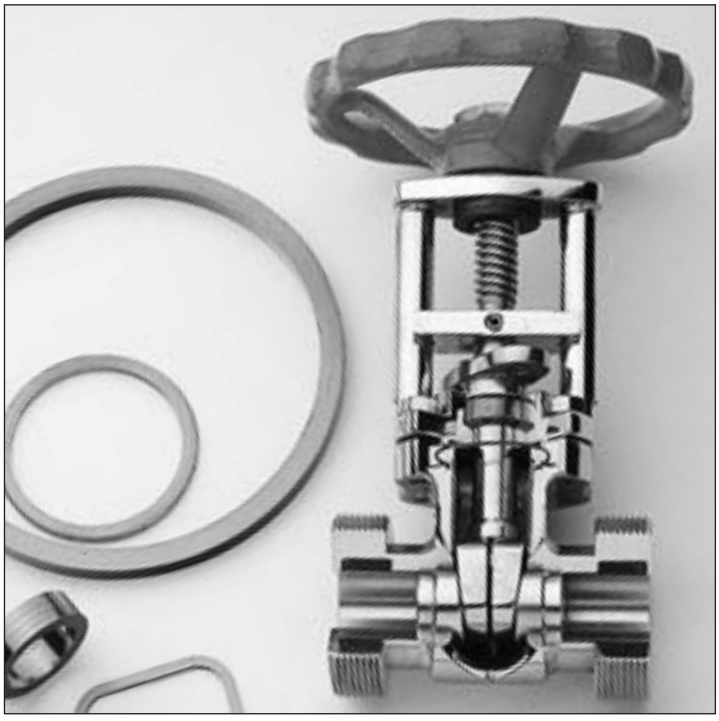


General comments :

- A RADIAGRAF® seal can be regarded as a special ORIGRAF® version (used in particular when anti-extrusion rings are required and seal has to have limited thickness).
- As For the last three types having CEFIGRAF® flexible graphite layers, they function like cut gaskets, and their characteristics are therefore significantly inferior to those of ORIGRAF® die-formed seals.

CARACTERISTICS OF A PACKING BOX





The stuffing box

The box should have a flat bottom. If not, make a ring of metal, hard graphite, bronze, etc. Maximum clearance between stem and box should not exceed 0.5 mm on the radius when there is no anti-extrusion ring. If the clearance is larger, top and bottom spacers are essential. A surface condition Ra ≤ 1.6 µ is recommended to facilitate the sliding of the rings.

The stem

The stem must be big enough not to buckle. Take care to clear the threads and to bevel the top of the stem so as not to damage the rings during installation. The surface condition of the stem should be Ra ≤ 0.4 µ to keep the operating force to a minimum and avoid ring wear.

The gland

The gland has a flat contact surface for the same reasons as the bottom of the box.
Avoid bevels, which could favour ring creep.
Guidance must be on its outer diameter and will extend over a sufficient height to avoid jamming.
The maximum clearance between the inside diameter of the box and the outside diameter of the gland will be 0.3 mm on the radius. The maximum clearance between the inside diameter of the gland and the diameter of the stem will be 0.5 mm on the radius. If the clearance is larger, top and bottom shims will be essential.

Recommended grades of steel

The use of certain stainless steels that are particularly compatible with FARGRAF® rings is recommended, to avoid corrosion problems :

Z5 CNUNb 170404	(17-4 P4)
Z6 CNUD 15-04	(F 14 P4)
Z2 CND 17-13	(316 L)
Z6 CND 17-05	(APX 4)
Z6 CN 18-10	(304)

With other grades of steel, the use of FARGRAF® flexible graphite rings with NAC, IAC, NP, and IP type corrosion inhibitor is recommended.

ADVANTAGES OF FARGRAF® RINGS

The properties of CEFIGRAF flexible graphite make it possible to produce packings perfectly suited to the complete and permanent sealing of stuffing boxes.

Coefficient of friction

Due to their coefficient of friction and their self-lubricating feature, FARGRAF® rings can both hold the stem firmly and allow it to move easily. These packings must be used dry, so there must be no leaks. Unlike conventional asbestos-based packings, the ring that provides the primary seal is at the bottom of the packing box and not under the gland. This keeps the fluid from getting between the stem and the packings.

Temperature

CEFIGRAF® expanded graphite retains all of its physical and mechanical properties, and all of its elasticity, from cryogenic temperatures up to very high temperature.
It has an expansion coefficient very close to that of steels, and so expands and contracts in the same proportions as the assembly holding it.
This property ensures a constant volume of packing in the box, thus eliminating any need for retightening the gland.

Heat dissipation

Thermal conductivity of CEFIGRAF® expanded graphite makes it possible to direct heat dissipation, lowering stuffing box temperature and avoiding loss of shaft mechanical properties.

Fire-resistance

Seal performance is maintained after fire tests. Valves with FARGRAF® rings have been approved by the following organizations : A.P.I., Aramco Overseas Company, Belgian Royal Gas Association, Bureau Véritas, C.N.P.P., Lloyd's Register of Shipping, S.N.E.A., etc.

Life duration

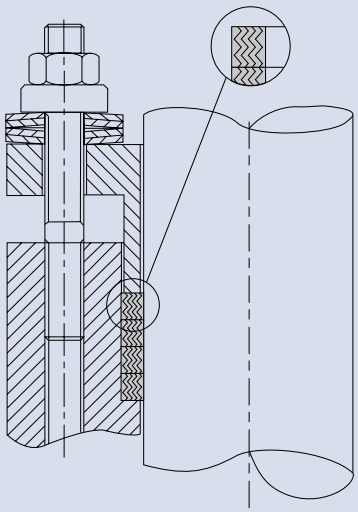
The life of packings made of CEFIGRAF® expanded graphite is much longer than that of braided packing. Tests on valves with sliding stems show that it is possible to exceed 50 000 cycles :

- Without leaks
- Without retightening

The field of application of FARGRAF® pre-compressed rings is therefore very large, and the cost of using them very low.

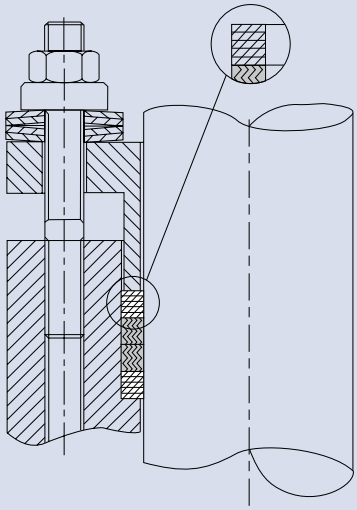
RECOMMENDED INSTALLATION AND RING TYPES

FARGRAF® BASIC RING



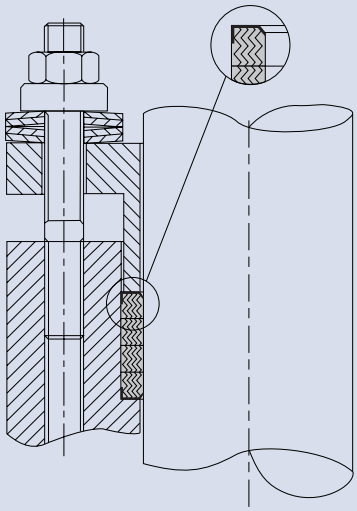
Assembly with minimum clearance, no anti-extrusion system needed

FARGRAF® RING with top and bottom spacers



Assembly with large clearance, requiring top and bottom spacers made of :
a) graphite braid
b) hard graphite (polycrystalline)
c) metal washer

FARGRAF® RING with metal cup



Assembly with large clearance and circularity defect, requiring heat-treated metal cups.

SIZE LIMITS

Our extensive tooling and long experience enable us to meet almost any requirement. FARGRAF® pre-compressed rings can be cut straight or at 45° angle, in two parts, with special shapes and sections.

RECOMMENDATIONS FOR USE

- **Determining the stuffing-box height with FARGRAF® rings :**
  Up to a maximum pressure of 300 bar, the height of the packing is calculated using the following formula : height = stem ø + 15 mm

- **Ideal cross-section :**
  For maximum effectiveness and to optimize the packing, the ring should have a square cross-section.

- **Installing FARGRAF® rings :**
  Insert the packing set composed of FARGRAF rings, with or without anti-extrusion cups or spacers, in the packing box.

  Apply a seating load to the gland equal to 1.5 to 1.8 times the system pressure (Pa min. = 10 PMa). In tricky cases, to ensure uniform compression of all rings, it is recommended that this operation be performed ring by ring.

- **Using an elastic system to ensure consistent loading**
  It is important to bear in mind that the precision of the tightening torque applied to the studs of the gland is key to the proper functioning of the packing.
  This precision depends on many parameters such as :
  - Thread pitch.
  - Depth, shape, and surface condition of threads.
  - Stud and nut material.
  - Type of lubrication.
  - Torquing tool.

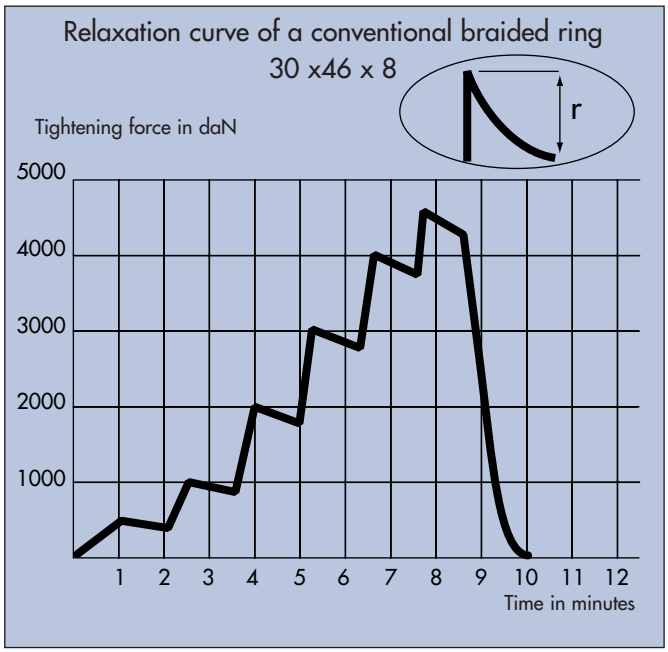
In addition, the limited efficiency of certain tightening systems leads us to recommend using an elastic system, such as :
- Spring washers
- Dynamo elastic ring
  (see Specific CEFILAC literature)
- etc…

These elastic systems have two advantages :
- Control of the load applied to the gland ;
- Long-term stability of this load.

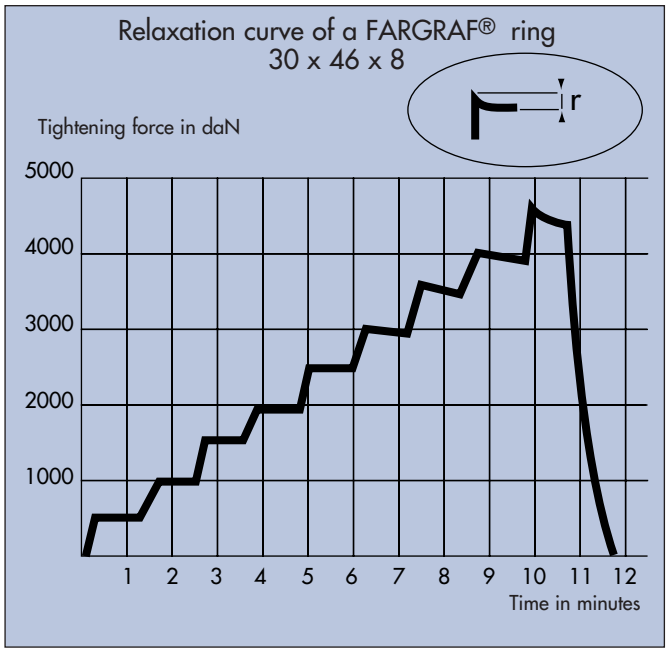
The use of an elastic system in conjunction with FARGRAF® rings makes it unnecessary to retighten the gland.

RELAXATION CURVES

a) Conventional braid system



b) FARGRAF® ring system



These comparative curves show the difference in relaxation between a FARGRAF® ring and a conventional braided ring in the tightening range from 10 to 50 MPa. It can be seen that the relaxation level with the FARGRAF® ring is only one fifth of that in the other case, ensuring a constant packing volume in the box and long-term sealing without retightening.

REFERENCES AND FIELDS OF APPLICATION

STUFFING BOXES ON FOLLOWING TYPES OF VALVE :

- Regulation
- Full-flow
- Butterfly
- Thermostat
- Chamber
- Ball

TO SEAL :

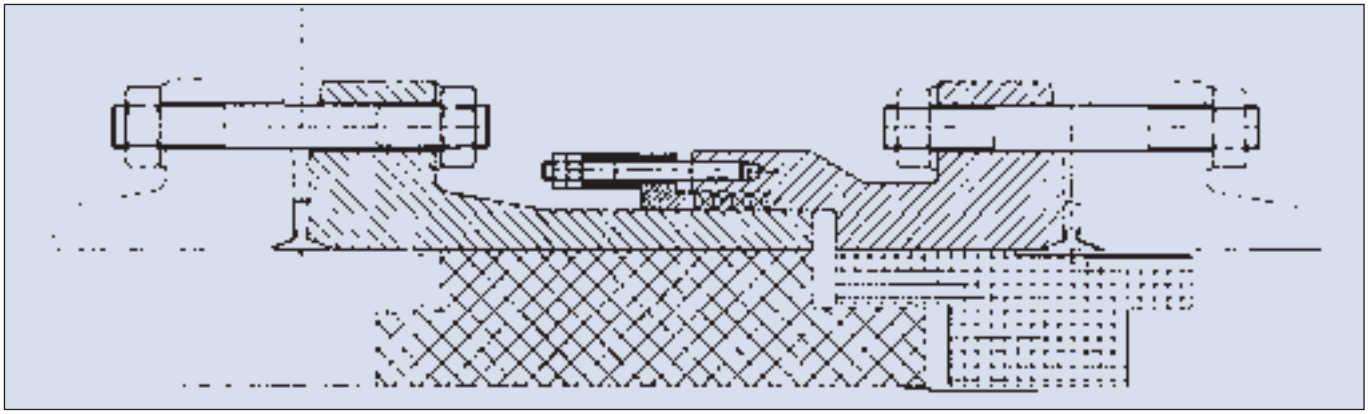
- High-pressure and high-temperature steam
- Heat-transfer fluid
- Water containing impurities, at high pressure and/or temperature
- Corrosive fluids
- Cryogenic applications
- Oil
- Fuel oil
- Hydrocarbons
- Gases
- Nuclear power plant primary circuits
- Nuclear power plant secondary circuits
- Hydrogen
- Oxygen
- Ethylene
- Food products (wine, oil, etc...)
- Etc...

IN THE FOLLOWING SECTORS :

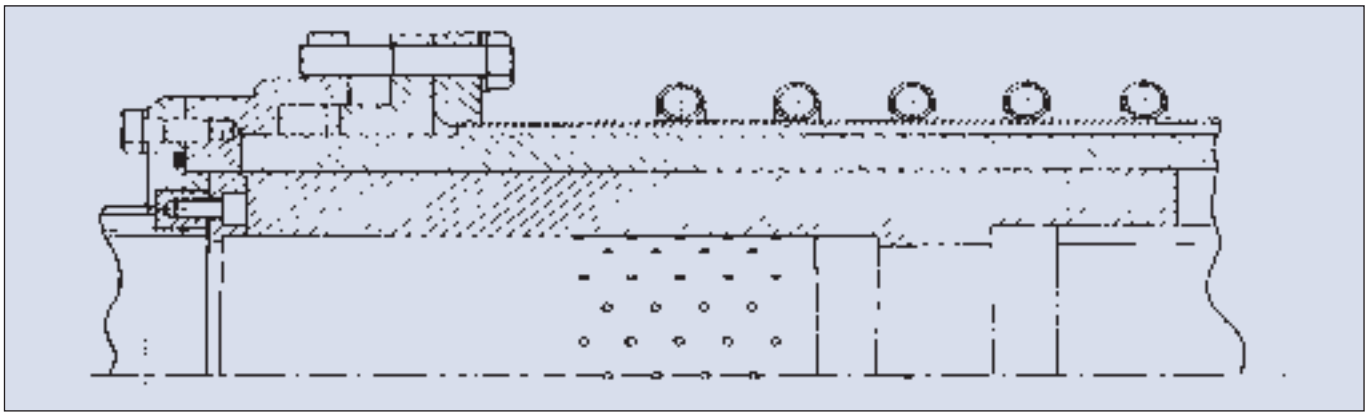
- Conventional and nuclear thermal power plants
- Boiler plants
- Chemicals
- Petrochemicals
- Refineries
- Gas pipelines
- Oil pipelines
- Paper mills
- Blast furnaces
- Navy, surface vessels, submarines
- Etc...

OTHER INSTALLATION PRINCIPLES :

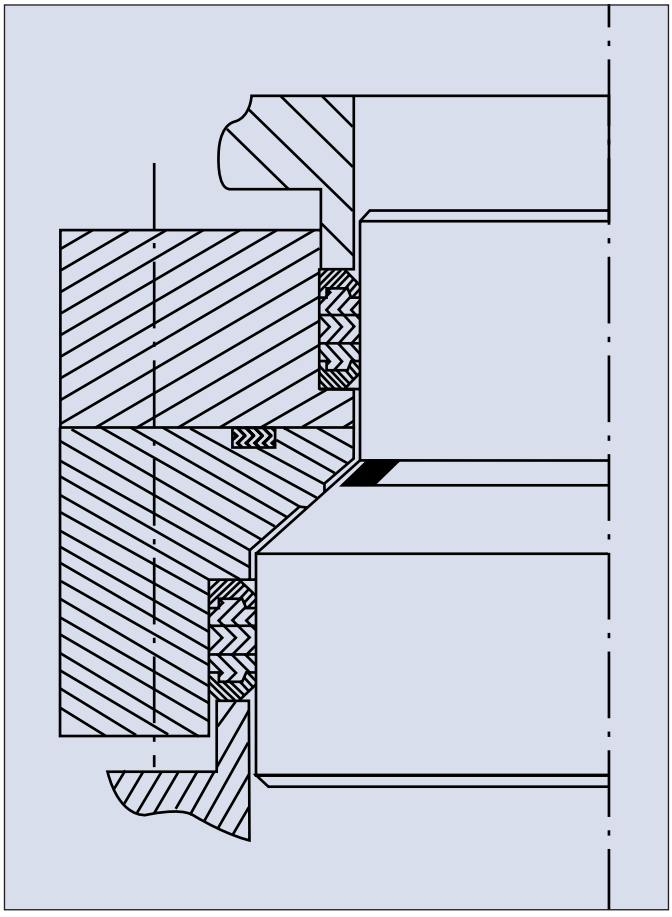
EXPANSION JOINT replacing bellows on a hot-air pipe at more than 600°C



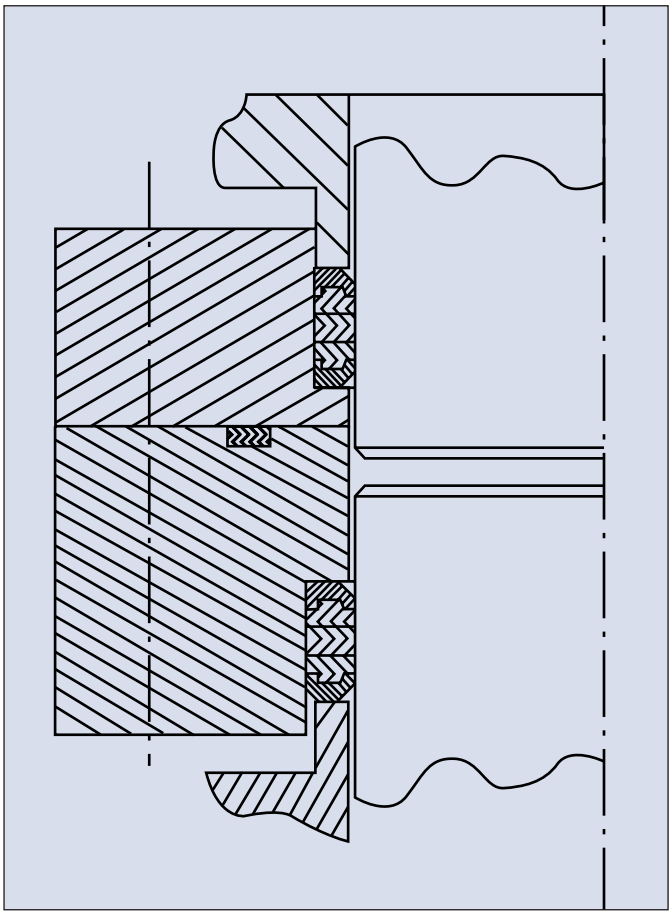
SLIDING SEAL between a ceramic tube and a metallic jacket



SEALING SYSTEM on defective weld



CONNECTING SYSTEM for piping



PRODUCTS KEPT IN STOCK

The following products are kept in stock at all times, in the form of :

- Reinforced and unreinforced sheets
- Rolls of raw material
- Crimped or smooth tape.

For more details, refer to our catalogue and price list.

TECHNICAL INFORMATION

Backed by our extensive research and development department, which enables us to create and develop new products, and our computing capacity, for checking and calculating assemblies, we are in a position to recommend the product best suited to you needs. For this, please send us the necessary information.

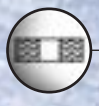
The most complete line of

SHEETS
And cut gaskets

CONVENTIONAL
Gaskets

RESILIENT METAL
Seals

SEALING SYSTEMS
And assemblies



GRAPHITE
Seals and rings

BRAIDS
And compression packings

LIP SEALS AND O'RINGS

KLOZURE
Oil seals

GPA - GULLIVER
Mechanical seals

ELASTOMER
Seals

HYDRAULIC AND PNEUMATIC
Components

OTHER SEALING PRODUCTS

AUTHORIZED DISTRIBUTOR

P. Guichard & Associés 04 77 80 42 14

ET 527 E 9930

Garlock GmbH
Postfach 21 04 64 . Falkenweg 1
D-41468 Neuss
Tel. 49-21 31/34 9-0
Fax : 49-21 31/349-222
e-mail: garlock-gmbh@t-online.de

Cefilac
90, rue de la Roche du Geai
42029 SAINT-ETIENNE Cédex 1
France
Tél. 33-4 77 43 51 00
Fax : 33-4 77 43 51 51
http://www.helicoflex.com

Garlock (GB) Limited
Hambridge Road, Newbury
Berkshire RG 14 5 TG
England
Tel. 44-1635-38668
Fax : 44-1635-49586

Garlock Inc
1666 Division Street
Palmyra, New York 14522
Tel. 1-315/597-4811
Fax : 1-315/597-3339
http://www.garlock-inc.com

Garlock
Sealing Technologies
CEFILAC