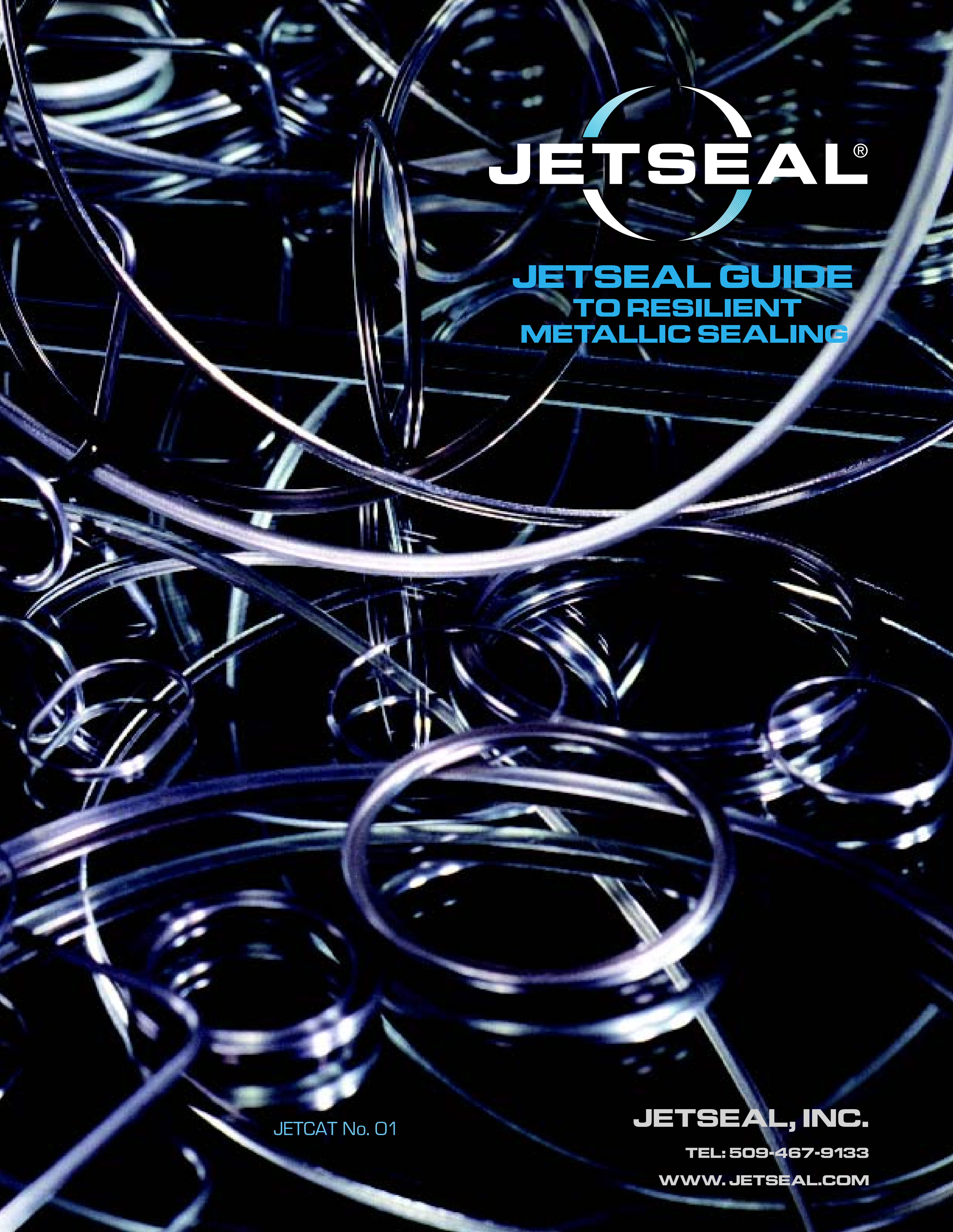


JETSEAL GUIDE TO RESILIENT METALLIC SEALING

JETCAT No. 01

JETSEAL, INC.

TEL: 509-467-9133

WWW. JETSEAL.COM

JETSEAL GUIDE TO RESILIENT METALLIC SEALING

JETSEAL Mission Statement:

JETSEAL's mission is to have delighted customers, enthusiastic, knowledgeable employees and stockholders, and informed world-class suppliers, all engaged in teamwork to create the most efficient and cost effective metal sealing devices and applications.

A delighted customer is one who is satisfied by our performance, excited by our innovative products and business methodology, and wishes all suppliers were like JETSEAL.

An enthusiastic employee or stockholder is one who is fairly rewarded and fully supportive of all company initiatives and goals. This mandates their fullest involvement and the sharing of corporate knowledge.

An informed world-class supplier is integrated into the JETSEAL team and has a clear understanding of the benefits of product improvements and the minimization of variability on the well-being of both companies.

JETSEAL Quality Statement:

JETSEAL is proud of our ISO 9001: 2000 and AS9100 certification, which extends to every facet of the business, as an endorsement of the company's quality system. We are committed to total conformance to requirements, both internally and externally imposed, and to the reduction of variability.

JETSEAL welcomes criticism and suggestions for improvement and regards customer quality visits as indispensable to a complete and continuously updated understanding of requirements.

Other JETSEAL products:

This JETSEAL guide contains general information (Jetcat. 01). See back cover for a synopsis of other JETSEAL products (Jetcat. 02 – 05).

AN INTRODUCTION TO JETSEAL RESILIENT METALLIC SEALS

JETSEAL resilient metallic seals comprise a complete selection of cross-sections, capable of satisfying a vast variety of applications. Whether your project needs seals for high pressure or hard vacuum, cryogenics or extremely high temperatures, large deflections or light loadings, you will find the right product here.

We will help you to make the optimum product selection and will analyze your requirements to ensure satisfaction. Our knowledge of metal seals and their applications makes JETSEAL a valuable addition to your engineering team—at no additional cost.

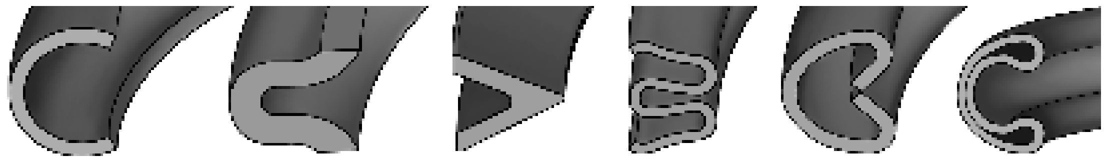
You begin by following the selection procedure to find a standard product to suit your needs, then, if necessary, contact us at the Telephone/Fax numbers (shown on the Manual's cover) for further explanation or custom designs. We are at your service.

A description of our standard products begins in the next section of this manual. Each of the designs shown has its own niche in sealing applications. In many cases two or more of the products will satisfy your requirements and the decision will reduce to a question of economics, in which case you will be guided towards the most cost-effective solution.

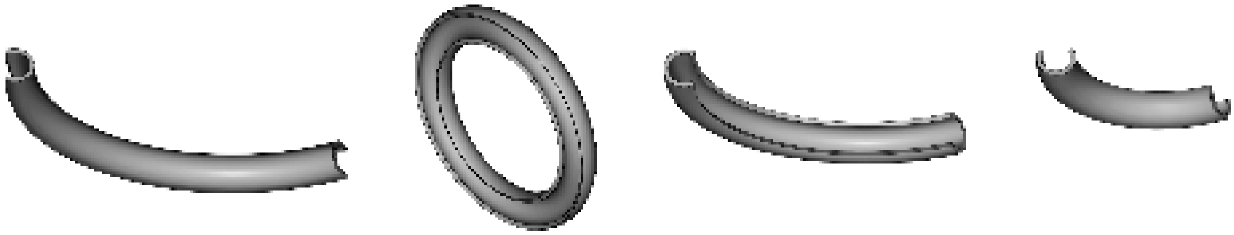
The product decriptions on the following pages define briefly each of our current products and are followed by a glossary explaining some of the special terminology and nomenclature employed throughout our literature.

JETSEAL 1024 N. Ralph St Spokane, Washington 99202

JETSEAL METAL SEALING RING SELECTION



The C-Seal:



The C-Seal is the most cost-effective solution for a wide variety of applications. It has a very high pressure-containment rating, as high as 50,000 psi and a moderate-to-good deflection capability. Higher pressure ratings are possible; please consult us.

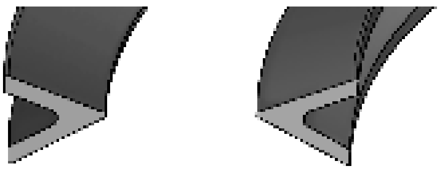
C-Seals are available in a wide range of cross-sections and virtually any diameter. They can be produced in any material which has an elongation of at least ten per cent. For the most cost-effective C-Seals, however, it is necessary to stay within the formability properties of Alloy 718, Alloy X-750 and 300 series stainless steel, which are JETSEAL standard materials. Selecting sizes from the data tables in this manual minimizes set-up costs and delivery lead times.

The C-Seal is employed in the elastic-plastic deformation range of currently available materials. It does not fully recover its original dimensions when installation forces are removed or reduced. It is therefore unsuitable for use where significant separation of the cavity sealing surfaces occurs cyclically or at low pressure. At high pressures, pressure-energization supplements the seal's inherent spring force in maintaining the required contact stress at the sealing interfaces.

Alloy 718 and X-750 C-Seals are commonly employed up to 1050˚F (566˚C) and make adequate air seals up to 1150˚F (621˚C). Waspaloy C-Seals are effective to 1250˚F (677˚C). High temperature soft platings are available to enhance sealing at these regimes.

Because of its arcuate sealing contact surfaces and relatively wide contact areas, the C-Seal causes very little disturbance of the mating cavity component sealing surface texture. It is therefore suitable for installations in which the joint is subject to multiple disconnection/reconnection cycles; provided that flatness and parallelism tolerances are not greater than thirty percent of the seal's springback. See C-Seal Design Manual.

The V-Seal:



While generally more expensive than the C-Seal, the V-Seal is capable of attaining tighter sealing in many cases. This seal has flat-lapped faces which, when they are deflected at installation, present wide-angle knife-edges to the sealing surfaces of the mating, cavity components. If the latter have surface finishes of 16 micro-inches (0.4 microns) or better, and soft coatings such as silver plating are applied to the seal, excellent sealing results ($1•10^{-9}$ mbl/s) may be obtained.

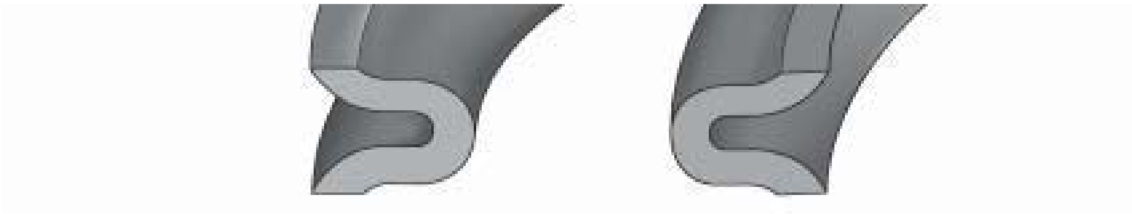
WWW.JETSEAL.COM TEL: 509-467-9133 FAX: 509-467-9028

The V-Seal (continued):
Because it generates high contact stress, the V-Seal is best used in very demanding, low leakage rate applications, where the joint will remain undisturbed for long periods. If the mating sealing surfaces are hard (Rc40 min.) frequent joint disconnections can be made without fear of significant sealing surface texture deterioration.

The V-Seal is rated for over 36,000 psi (01 and 03 sections) for both pneumatic and hydraulic pressure applications. It is also suitable for use in vacuum systems. JETSEAL V-Seals are available in Alloys 718, X-750, Elgiloy, Waspaloy, Hastelloy X and stainless steels. They may be plated with silver, gold, soft nickel, or copper.

Effective sealing is maintained at temperatures up to 1350˚F (732˚C) when the V-Seal is produced in Waspaloy or René 41. Long term operating deflections at high temperatures are limited by the stress-relaxation characteristics of the alloy selected. Please consult JETSEAL's technical staff for further information.

The Omega Seal:



Like the V-Seal, the Omega seal attains extremely tight sealing by virtue of its flat-lapped, knife-edge sealing features. In low to moderate temperature applications, heavy wall thicknesses may be employed. The resulting product achieves excellent sealing efficiency, while providing high springback.

These roll-formed seals out-perform many more complex seals, without resorting to the use of spring-energizers or machined features. They are equally capable in high vacuum or in sealing deep well drilling pressures.

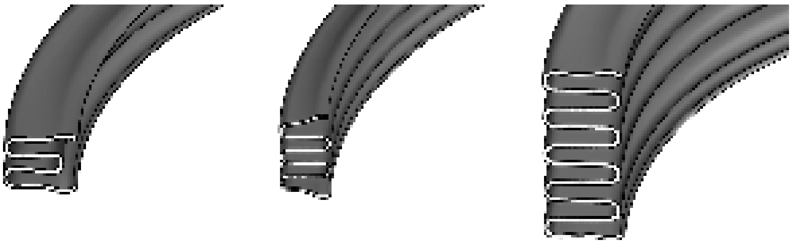
Also available, thin-wall, low-load versions of the Omega seal are ideal in many applications formerly reserved for E-Seals. At the low end of the high-deflection sealing spectrum, Omega seals are competitive in price and superior in performance.

JETSEAL is the world's leading manufacturer of Omega seals. Current production includes seals in Alloy 718 and Waspaloy in a wide range of sizes. Soft platings are available to fill minor toolmarks and asperities in mating component sealing surfaces.

The Omega seal is superior to all other types for vacuum and high pressure gas sealing. It is a clean, single-piece seal, not requiring spring-energizers to assist in effective sealing when pressure-assistance is negligible.

When employed in 'L'-shaped cavities, as shown below, the Omega seal provides maximum access for system cleaning during media changes and for the elimination of contaminants in vacuum equipment pump down cycles.

The E-Seal:



The JETSEAL standard E-Seal is a refined and improved version of this “industry standard” product for high cyclic deflections and high temperature and pressure impulses. AS1895 Engineered for improved performance by the inventor of the first successful aircraft-pneumatic duct joint and turbine E-Section seals, JETSEAL E-Seals are produced on innovative new tooling; designed to enhance elastic deflection capability and to reduce long-term stress relaxation at the maximum operating temperature of AS1895 and above.

These seals, including both single and multiple convolution types are produced in Alloy 718 and Waspaloy and may be manufactured in other suitable materials for custom applications. They are generally not plated but may be furnished with tribological, anti-wear coatings, such as Tribaloy T-800®, applied by HVOF thermal spray and superfinished.

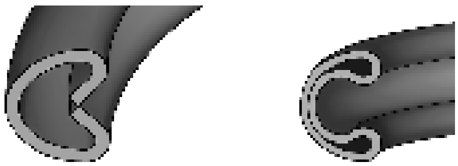
In addition to the standard parts shown in our JEI, JEE, JWI and JWE data sheets, JETSEAL E-Seals are custom engineered for more demanding applications. JETSEAL employs virtual engineering with F.E.A. to eliminate nearly all risk from new designs and new applications.

E-Seals for higher pressure regimes are included in JETSEAL’s JHI/JHE Series. These seals have somewhat less deflection capability than our JEI/JEE Series but may be plated for tighter sealing.

Application data sheets are located at the back of the manual. Responding to all relevant questions helps to define our task, so that we may provide you with a fully engineered proposal as rapidly as possible. After you have evaluated our proposal we are available for concurrent engineering in which the design is refined until *you are satisfied* that it is the optimum solution to your sealing problem. We will never be satisfied until you are satisfied!

EXCLUSIVE JETSEAL PRODUCTS
THAT REVOLUTIONIZE METALLIC SEALING TECHNOLOGY

The Super C-Seal:



A JETSEAL first. This new seal can be used in any application designed for the C-Seal where *enhanced springback* is needed. This one-piece design combines greatly increased springback with *higher load* for tighter sealing.

Available to fit any manufacturer’s C-Seal cavity, JETSEAL’s Super C-Seal comes in all common C-Seal materials, including alloys 718, X-750, Elgiloy and Waspaloy. The new seal’s cost is only marginally higher than that of standard C-Seals, considerably lower than that of any other highly resilient seal available.

A two-ply Super C-Seal variant may also be specified to exclude system media from the inside of the seal, to avoid carry-over at media changes. Both types may also be substituted for metal 0-Rings wherever low springback or weld neck-down leakage is causing failures or poor performance (Super C-Seals are produced from cold-forged TIG-welded bands and do not require a local sanding operation during finishing).

Multiple-Ply E-Type Seals:

JETSEAL is the first manufacturer to offer all convolution-type seals in multiple-ply configurations, without circumferential welding. These seals have the highest deflection capability of all resilient metallic seals for a given envelope size. A two-ply seal can literally double the deflection capability in the same space as the seal you are using, or contemplating using now.

If you have an application where a single-ply seal is just not making it, leading to performance deterioration in your system or engine, JETSEAL is working on just what you need. If you are designing a seal into your application now and the single-ply seal looks marginal, let us propose an alternative; which you can keep up your sleeve until the need is confirmed by test, or specify now.

JETSEAL Two-Ply seals cost approximately twice as much as our single-ply seals. Yet their comparatively miniscule price can save hundreds of expensive overhaul hours and many thousands of dollars in lost service revenues and/or extra fuel burn. If your application is for a new engine or system, they can also reduce the risk of qualification test interruptions and save valuable points towards specific fuel consumption guarantees. Two-Ply coated seal costs do not entail as great a premium compared to those of their single-ply counterparts because of the common and important contribution of the coating to the cost of each type.

JX Series

Lever Seal-The Answer to Advanced Sealing Requirements:

Jetseal is on the cutting edge of sealing technology with the uniquely designed and patented Lever Seal. This seal can be used in any application where enhanced springback and excessive flange movement or flange distortion handling is needed. Regardless the requirement, the Lever Seal will out perform any other seal at a competitive cost.

The Lever Seal is superior to other “high deflection” seals available. Due to its unique stress-distributing design, the Lever Seal can handle three times the flange movement of a single-ply standard E-seal with the same sealing capability. This makes it a good choice where thermal relaxation is a factor. Additionally, the Lever Seal meets both AS1895/7 and AS1895/23 E-Seal standards requirements.

Featuring 100% springback, the Lever Seal’s allowable deflection is almost double the industry’s next best seal. Why settle for a seal that starts with a free height of 0.121” and compresses to 0.088” when for less cost you can install a Lever Seal with a free height of 0.145” in the same cavity. A two-ply Lever Seal design will allow for substantially greater deflection handling capabilities, and is available for even more demanding applications.

Available to fit any manufacturer’s E-Seal cavity, JETSEAL’s Lever Seal comes in all common materials, including alloys 718, X-750, Elgiloy and Waspaloy. The Lever Seal’s cost is only marginally higher than that of standard E-Seals, and considerably lower than that of any other highly resilient seal.

A GLOSSARY OF RESILIENT METALLIC SEAL TERMINOLOGY

Deflection Capability:
A portion of the springback of a seal which undergoes elastic or elastic-plastic strain during the compression of its section at installation and during in-service deflections. This is the “safe” recovery of the seal, which is sufficient to ensure continued sealing.

Springback:
The recovery of the free height dimension of a seal which has been compressed and released. If the seal remains in the fully elastic state, its springback is equal to the initial compression. If partial plasticity occurs during installation or in operation, the seal does not fully return to its initial dimension but, instead, takes a permanent set. The difference between the permanent set dimension and the fully-compressed dimension is the springback of the seal.

Free Height:
The initial height of the seal, lying on a flat, horizontal, planar surface. The equivalent term for a gasket is thickness, a term which is not employed in the same way for resilient metallic seals, since for these hollow, shell-like structures it refers to material thickness.

Strain Energy:
The energy stored in a structure when it is deflected or deformed by external (extraneous) forces. It is this energy which causes the full or partial recovery of the structure when the loads deflecting or deforming it are removed. Think of springs released from their compressed positions (elastic recovery) or an unbent paper-clip that springs back a little each time it is bent to a new permanent set position and released (elastic-plastic recovery).

Face Type Seal:
A seal that functions when compressed between two flat plate (planar) surfaces; such as the faces and groove bottoms of pipe flanges.

Coaxial Type Seal:
A seal the functional surfaces of which engage and are deflected by cylindrical walls. Sometimes known as Radial Seals, because their displacement is radially inward and outward, they are more generally called axial seals because their engagement surfaces are coaxial.

Compression:
Sometimes known as “squeeze” or “pinch”, this is the reduction in dimension of a resilient metallic seal structure, which creates the strain energy to produce a reaction force for sealing.

Sealing Force:
A force developed by the deflected/compressed seal, distributed along a contact line; usually expressed as force per unit circumference. (lbf/in;kN/M)

Sealing Contact Line:
The line (usually narrow) at which the seal contacts the faying, or sealing, surfaces of the bodies forming the joint to be sealed. There are usually two contact lines per seal; one engaging each of the joined bodies.

Sealing Contact Stress:
The stress at the interface between the seal and the bodies contacted. A critical determinant of leakage. If the seal edge is a sharp corner, the contact stress is theoretically infinite, regardless of the magnitude of the contact force. In reality, local compressive deflection ensures that the line has width. The softer the contacting materials, the wider the contact line width, for a given contact force.

Soft Coatings:
Soft coatings; metals such as silver, gold, lead and copper; plastics, such as polytetrafluoroethylene, Teflon®. When applied to seals, they extrude to fill surface asperities, voids and toolmarks and scratches in the mating component sealing surfaces at installation. Soft coatings also widen the sealing line, to ensure sealing against turned (phonograph grooved) surfaces, when they extrude into micron-level “valleys” and form around peaks. Annealed soft nickel coatings are effective in high temperature air sealing.

WWW.JETSEAL.COM TEL: 509-467-9133 FAX: 509-467-9028

A GLOSSARY OF RESILIENT METALLIC SEAL TERMINOLOGY *(continued)*

Tribological Coatings:
At very high temperatures, in applications where sliding occurs due to relative thermal movements, these metallurgically-sophisticated coatings reduce wear and prevent galling, which would otherwise lead to early leakage and possibly structural failure. The most popular coating material for seals is Tribaloy® T-800, an intermetallic alloy powder comprising Cobalt, Molybdenum and Chromium. Coatings are usually applied by thermal spray, using special Hyper-Velocity Oxy-Fuel equipment (HVOF).

Diametral Change:
Change in a seal diameter in proportion to axial compression; of variable magnitude depending upon the seal cross-section configuration. C and V seal diameters tend to change significantly, whereas those of E and Omega seals change little. The direction of change is opposite for internally-pressurized (opening towards center) and externally-pressurized (opening facing radially outward) seals. Internally-pressurized seal inside diameters grow whereas the inside diameters of externally-pressurized seals reduce.

Cavity Support (Pros):
At very high pressures, resilient metallic seals sometimes benefit from radial support from the grooves or plates in which they are installed. If the radial force due to pressure is sufficient to overcome the sum of the hoop resistance of the seal and the friction forces arising from the face contact loads, then clearance between the cavity walls and the seal must be minimized to avoid excessive radial excursions. Large radial movements may cause galling and wear, which result in increased leakage rates.

Cavity Support (Cons):
Excessive radial contact between metallic face seals and their cavities may result in *increased* leakage rates. Attempts to ensure that compression will cause engagement between groove walls and seals under minimum metal tolerance conditions also ensure that heavy interference is produced when tolerances approach the maximum metal condition. Heavy interference causes binding between the diameters of seals and cavities; which results, because of friction, in reduced sealing interface loads at the bottoms of grooves and higher leakage. Binding also reduces operating springback in some cases, because it prevents the release of the bottom half of the seal, which is stuck in the groove. A stuck seal also has to be pried out of its groove when it has to be replaced; this often results in cavity sealing surface damage, requiring rework.

Surface Finish:
a) Seal Cavities/Faces:
Components interfacing with plated seals should have a surface texture of 32 microinches to 16 microinches (0,8 micrometers to 0,4 micrometers(microns) with a “concentric” lay (a fine-turned finish). Unplated seals work best against a 16 microinch or better finish, turned or lapped but will work well against 32 microinch surface textures.

b) Seal Contact Surfaces:
Seal substrate surface finishes are applied to contact surfaces only. These surface finishes are obtained by a generating process, which removes material to a uniform depth from the theoretical surface profile, as the sealing ring is revolved about its axis. The removal of material from other locations is unnecessary and may be undesirable. The C-Seal for example should not have material removed at the mid-point of the C, opposite the opening, since thinning in this area tends to weaken the seal and cause local strain concentrations in meridional bending at which circumferential cracks can be initiated.

Zero Leakage:
A meaningless term, unless accompanied by a qualifying definition. For gases, “zero leakage” is sometimes defined as $1{\cdot}10^{-9}$ mb.l/s (millibar liters per second). In the case of air seals, zero leakage is often defined as 1.10^{-5} mb.l/s (See leakage equivalence chart in this guide.)

Safe Operating Temperature:
Seal performance is sensitive to changes of temperature, especially at elevated temperatures close to or within the creep and relaxation ranges of the material from which they are constructed. *The critical temperature is the seal metal temperature and not that of the sealed medium or media.*

In most high temperature gas flow applications, the metal temperature in the most highly stressed locations of the seal geometry is often considerably lower than the gas path temperature. This results primarily from the fact that the medium outside the sealed area may be at a lower temperature than the contained gas, tending to cool the seal and secondly, from the insulation of the seal from the main flow by a stagnant boundary layer.

Since the seal’s metal temperature may be two hundred or more degrees lower than the gas temperature, safe and effective sealing can be achieved where “operating” temperatures are considerably higher than the limits of elevated temperature above which the material properties are no longer sufficient for satisfactory seal performance.

A General Introduction to the JETSEAL Intelligent Part Numbering System for Standard Seals.
(Non-standard seals are described by numerical part numbers with non-significant digits.)

Example of Intelligent P/N (part number whose characters signify discrete properties of the product).

J CI 02707 – 08 – 01 – 01 – SSA

1. JETSEAL Signifier
2. Seal Section Geometry
3. Diameter Pages – to –
4. Cross-Section Page 10
5. Material Page 10
6. Heat Treatment Page 10
7. Plating/Coating Page 11

1. J Prefix indicates seal P/N defines seal in English units.
I prefix indicates ISO metric system units (see separate catalog section).

2. Seal section geometry:

CI	=	C-Seal, Internal Pressure
CE	=	C-Seal, External Pressure
CA	=	C-Seal, Coaxial (Radial Interference.)
EI	=	E-Seal, High Deflection, Internal
EE	=	E-Seal, High Deflection, External
HI	=	E-Seal, High Pressure, Internal
HE	=	E-Seal, High Pressure, External
MI	=	Omega Seal, High Performance, Internal
ME	=	Omega Seal, High Performance, External
VI	=	V-Seal, Internal
VE	=	V-Seal, External
SI	=	Super C-Seal, Internal
SE	=	Super C-Seal, External
TI	=	Super C-Seal, Two-ply, Internal
TE	=	Super C-Seal, Two-ply, External
WI	=	Two-convolution, E-Seal, Internal
WE	=	Two-convolution, E-Seal, External
XI	=	Two-ply E-Seal, Internal
XE	=	Two-ply E-Seal, External
ZI	=	Two convolution, Two-ply E-Seal, Internal
ZE	=	Two convolution, Two-ply E-Seal, External
LE	=	Lever Seal, External
LI	=	Lever Seal, Internal

3. Diameter code: Expressed in one-thousandths of an inch, *e.g.*

02707	=	2.707 inches
99500	=	99.500 inches

For internal pressure seals, the maximum external diameter is encoded. For all others, the minimum internal diameter is used.

Example P/N JCI 02707-08-01-01-SSA, above, defines an internal pressure C-Seal, 2.707 outside diameter, .125 free height, material thickness .015, Alloy 718, solution and precipitation heat treated and plated with silver .0005 - .0010 thick.

WWW.JETSEAL.COM TEL: 509-467-9133 FAX: 509-467-9028

4. **Cross-section codes: Example only. See relevant design manual section for seal type.**

Code	Nominal Section	Free Height	Material Thickness	Cavity Depth	Cavity Corner Rad. (Max)
01	3/64	.046 - .048	.005	.036 - .038	.015
02	3/64	.046 - .048	.007	.036 - .038	.015
03	1/16	.062 - .064	.007	.049 - .051	.020
04	1/16	.062 - .064	.010*	.049 - .051	.020
05	3/32	.093 - .095	.008	.073 - .077	.030
06	3/32	.093 - .095	.012	.073 - .077	.030
07	1/8	.124 - .127	.010	.098 - .102	.045
08	1/8	.124 - .127	.015	.098 - .102	.045
09	3/16	.186 - .190	.015	.149 - .153	.070
10	3/16	.186 - .190	.020	.149 - .153	.070
11	1/4	.248 - .252	.020	.198 - .202	.090
12	1/4	.248 - .252	.025	.198 - .202	.090

* Not available for seals less than .625 nominal diameter.

5. **Material codes:**

Code	Material	Specification	Temperature Limit (°F)[1]	Remarks
01	Alloy 718	AMS 5596 AMS 5589	1200	Superior performance (NACE approved H.T. available)
02	Alloy X-750	AMS 5598 AMS 5582	1100	Excellent performance Lower load/Springback
03	Waspaloy	AMS 5544	1350	Superior creep, stress relaxation above 1200°F
04	Cres 304	AMS 5511 AMS 5560	800	Effective within reduced temp. range. Low springback
05	Elgiloy	AMS 5786	900	Excellent H_2 embrittlement resistance
06	Incoloy 909®	AMS 5892	1200	Low expansion alloy
07	Hastelloy X	AMS 5754 AMS 5587 AMS 5530	1500	High temperature oxidation Resistance.

[1] Temperatures may be exceeded for certain applications; especially short duration.

6. **Heat treatment codes for all seals:**

Codes	Heat Treatment	Remarks
00	None	Strain hardened - not generally recommended
01	Solution & Precipitation	Alloy 718: General applications
03	Solution & Precipitation (NACE)	Special H.T. for sour gas (Hydrogen Sulfide) service
04	Solution, Stabilization & Precipitation	Waspaloy: Creep & Relaxation resistance.
05	Solution & Precipitation(H_2)	Alloy 718: High temperature H_2 gas service.
06	Precipitation only.	Interstage annealing may be employed

7. **Plating and coating codes for all seals:**

Note: All JETSEAL seals have rotationally generated or lapped substrate surface profiles.

Code	Plating/Coating	Thickness, inch	Remarks
– – –	None		
S S A	Silver	.0005 – .0010	Inert gas annealed @ 950° F
S S B	Silver	.0010 – .0015	Inert gas annealed @ 950° F
S S C	Silver	.0015 – .0020	Inert gas annealed @ 950° F
S S D	Silver	.0020 – .0025	Inert gas annealed @ 950° F
S A A	Silver w/gold u/lay	.0005 – .0010	Inert gas annealed @ 950° F (Thickness does not incl.u/lay)
S A B	Silver w/gold u/lay	.0010 – .0015	Inert gas annealed @ 950° F (Thickness does not incl.u/lay)
S A C	Silver w/gold u/lay	.0015 – .0020	Inert gas annealed @ 950° F (Thickness does not incl.u/lay)
N I A	Soft nickel	.0005 – .0010	Inert gas annealed @ 1200° F
N I B	Soft nickel	.0010 – .0015	Inert gas annealed @ 1200° F
N I C	Soft nickel	.0015 – .0020	Inert gas annealed @ 1200° F
N A A	Soft nickel w/gold u/lay	.0005 – .0010	Inert gas annealed @ 1200° F
N A B	Soft nickel w/gold u/lay	.0010 – .0015	Inert gas annealed @ 1200° F
N A C	Soft nickel w/gold u/lay	.0015 – .0020	Inert gas annealed @ 1200° F
A A A	Gold	.0005 – .0010	Inert gas annealed @ 1200° F
A A B	Gold	.0010 – .0015	Inert gas annealed @ 1200° F
C U A	Copper	.0005 – .0010	Inert gas annealed @ 1200° F
C U B	Copper	.0010 – .0015	Inert gas annealed @ 1200° F
C U C	Copper	.0015 – .0020	Inert gas annealed @ 1200° F
C A A	Copper w/gold u/lay	.0005 – .0010	Inert gas annealed @ 1200° F
C A B	Copper w/gold u/lay	.0010 – .0015	Inert gas annealed @ 1200° F
C A C	Copper w/gold u/lay	.0015 – .0020	Inert gas annealed @ 1200° F
P B C	Lead	.0015 - .0020	
P B D	Lead	.0020 - .0025	
T F B	Teflon®	.0010 - .0015	
T F D	Teflon®	.0020 - .0025	

WWW.JETSEAL.COM TEL: 509-467-9133 FAX: 509-467-9028

Selection of plating & coating materials:

Platings and coatings are applied to the contact surfaces of metal seals in order to provide them with the ability to extrude into mating surface imperfections to block leakage paths. The materials employed and their standard thicknesses are tabulated in Chart 7.

Electrodeposited metallic coatings such as silver, gold, soft nickel, copper and lead are metallurgically bonded to nickel and cobalt alloy substrate materials in thicknesses proportional to the surface roughness of the mating surfaces. The following limitations should be noted:

- Plating bond strength is inversely proportional to its thickness. For example, thicknesses of silver plating greater than .004 inches are prone to have weakly bonded areas which may allow peeling, blistering or rucking.

- Platings are permeable to various degrees. The temperature limitation of 800˚F on the use of silver, which has a melting temperature of 1761˚F, in air, is due to oxidation at the plating-to-substrate interface caused by the permeation of an oxidizing agent, in this case air, through the silver plating.

Plating/coating material	Applications/limitations.	Load limit lb_f/in. circ.	Temperature limit°F
Unplated	Pneumatic applications. Leakage not critical.	Depending on substrate and mating materials	Substrate/mating material use limitations.
Silver	General use up to 800°F. Good corrosion resistance. Relatively inexpensive. Soft.	Depending on seal design usually unlimited.	800°F oxidizing atmosphere.
Silver w/gold underlay	General use up to 1300°F. Good corrosion resistance. Moderate cost. Soft.	Depending on seal design usually unlimited.	1300°F
Gold	Excellent corrosion resistance and temperature capability. Expensive when thick &/or applied to large parts.	Depending on seal design usually unlimited.	1500°F*
Soft nickel (annealed)	Replaces silver for very high temps. but is harder. Sealing efficiency not as high.	Depending on seal design usually unlimited.	1500°F*
Copper	Softness between that of silver and soft nickel. Inexpensive. Effective.	Depending on seal design usually unlimited.	1500°F*
Lead	Ideal plating where temperature permits its use. Very soft. Most effective sealing.	300 lbf/in. circ.	400°F
Teflon®	Chemically inert. OK for low load seals. Not for use in fire hazard applications.	250 lb_f/in. circ.	400°F

Drawing note required: Plating optional and may be incomplete inside seal section and on inward folds (non-sealing contact areas), except where specified as corrosion barrier.

* Consult JETSEAL's technical support staff for higher temperature exceptions.
Teflon® is a registered trademark of Dupont Nemours.

Surface roughness (micro-inches)	Recommended plating thickness(inches)
32 or better	.0005 - .0010
64 or better	.0010 - .0015
125 or better	.0015 - .0020
250 or better	.0025 - .0030
500 or better	.0035 - .0040

Performance data for each seal series must be corrected by multiplying by the factors in the table below, when specifying alloys other than Alloy 718 or for service at elevated operating temperatures.

CORRECTION FACTORS FOR MATERIALS & TEMPERATURES

Temp °F	Alloy 718	Alloy X-750	Waspaloy	Incoloy 909	Cres 304	Elgiloy	Hastelloy X
70	1.00	.67	.73	1.00	.62	1.00	.30
200	.97	.64	.71	.98	.57	-	.29
300	.96	.63	.70	.97	.55	-	.28
400	.95	.61	.69	.97	.53	.93	.27
500	.94	.59	.68	.97	.53	-	.27
600	.93	.58	.66	.95	.52	.90	.26
700	.92	.56	.65	.93	.51	-	.26
800	.91	.55	.64	.93	.50	.87	.25
900	.90	.54	.63	.92	.47	-	.25
1000	.89	.53	.62	.91	.43*	.80	.24
1100	.86	.50	.60	.88	.38*	-	.22
1200	.81	.46*	.59	.83*	.31*	-	.20
1300	.72*	.41*	.57	.72*	-	-	.17
1400	.55*	.35*	.54*	.50*	-	-	.15
1500	.39*	.28*	.50*	-	-	-	.11

*At these temperatures, only short term exposure is recommended. Longer exposures require full analysis, involving concurrent application engineering. Consult JETSEAL's technical support staff. Not all products are available as standard parts in all materials listed. Refer to relevant design manual section for available standard materials.

Incoloy 909 is a registered trade mark of Inco Alloys International, Inc.
Elgiloy is a registered trade mark of Elgiloy Limited Partnership, Inc.
Waspaloy is a registered trade mark of United Technologies Corp.
Hastelloy is a registered trademark of Haynes International.

COEFFICIENT OF THERMAL EXPANSION DATA FOR SEAL & CAVITY MATERIALS

Temp °F	Alloy 718	Alloy X- 750	Alloy 625	Waspaloy	Incoloy 909	Cres 300	Alloy 286	Titanium 6-4	Hastelloy X
200	7.10	7.40	7.10	6.80	4.40	8.95	9.20	5.00	7.50
300	7.25	7.60	7.15	7.00	4.50	9.20	9.27	5.10	7.70
400	7.40	7.78	7.20	7.20	4.50	9.43	9.32	5.20	7.80
500	7.58	7.85	7.30	7.38	4.38	9.63	9.40	5.27	8.00
600	7.65	7.95	7.40	7.50	4.30	9.80	9.45	5.35	8.07
700	7.80	8.00	7.50	7.65	4.20	9.97	9.55	5.45	8.20
800	7.85	8.00	7.60	7.78	4.30	10.10	9.62	5.52	8.25
900	7.95	8.05	7.70	7.82	4.63	10.25	9.70	5.58	8.35
1000	8.05	8.10	7.83	7.90	5.11	10.38	9.80	5.62	8.45
1100	8.20	8.20	7.97	8.00	5.38	10.50	9.92	-	8.60
1200	8.30	8.40	8.10	8.10	5.70	10.60	10.05	-	8.70
1300	8.45	8.60	8.25	8.30	-	-	-	-	8.80
1400	8.75	8.80	8.40	8.50	-	-	-	-	8.90
1500	9.00	9.05	8.60	8.80	-	-	-	-	9.00

C.O.E., α: 1E-6 in./in./°F, between 70°F and temperature shown.

Differential thermal expansion between seal and cavity may result in excessive radial interference, giving rise to higher leakage rates. Please advise JETSEAL's technical support staff if this may occur in your application.

WWW.JETSEAL.COM TEL: 509-467-9133 FAX: 509-467-9028

CONVERSION / EQUIVALENCY CHARTS

Pressure conversion:

To obtain / Multiply by	P.S.I.	Pa	KPa	MPa	Bar	Torr	Inches of Mercury	Inches of Water	Atmosphere	K.S.I.
Pounds per square inch	1	6.8948E+3	6.8948E+0	6.8948E-3	6.8948E-2	5.1714E+1	2.0360E+0	2.7681E+1	6.8046E-2	1.000E-3
Pa	1.4504E-4	I	1.0000E-3	1.0000E-6	1.0000E-5	7.5006E-3	2.9530E-4	4.0146E-3	9.8692E-6	1.4504E-7
KPa	1.4504E-1	1.0000E+3	1	1.0000E-3	1.0000E-2	7.5006E+0	2.9530E-1	4.0146E+0	9.8692E-3	1.4504E-4
MPa	1.4054E+2	1.0000E+6	1.0000E+3	1	1.0000E+1	7.5006E+3	2.9530E+2	4.0146E+3	9.8692E+0	1.4504E-1
Bar	1.4504E+1	1.0000E+5	1.0000E+2	1.0000E-1	I	7.5006E+2	2.9530E+1	4.0146E+2	9.8692E-1	1.4504E-2
Torr	1.9337E-2	1.3332E+2	1.3332E-1	1.3332E-4	1.3332E-3	1	3.9370E-2	5.3520E-1	1.3158E-3	1.9337E-5
Inches of Mercury	4.9116E-1	3.3864E+3	3.3864E+0	3.3864E-3	3.3864E-2	2.5400E+1	1	1.3595E+1	3.3421E-2	4.9116E-4
Inches of Water	3.6128E-2	2.4910E+2	2.4910E-1	2.4910E-4	2.4840E-3	1.8685E+0	7.3556E-2	I	2.4584E-3	3.6128E-5
Atmosphere	1.4696E+1	1.0133E+5	1.0133E+2	1.0133E-1	1.0133E+0	7.6000E+2	2.9921E+1	4.0678E+2	I	1.4696E-2
K.S.I.	1.0000E+3	6.8948E+6	6.8948E+3	6.8948E+0	6.8948E+I	5.1717E+4	2.0360E+3	2.7681E+4	6.8046E+1	I

Leakage rates:

SCCS	SCFM	Torr 1/s	Mb-l/s	Approximate Equivalent	Bubbles Observed in Air U/Water Test
1.0E+2	2.12E-1	7.6E-3	1.01E+2	6 liters/minute	Strong flow - water turbulent
1.0E+1	2.12E-2	7.6E-2	1.01E+1	0.6 liters/minute	Strong continuous stream
1.0E+0	2.12E-3	7.6E-1	1.0IE+0	60 ccs/minute	Intermittent strong stream
1.0E-1	2.12E-4	7.6E-2	1.01E-1	6 ccs/minute	Fine stream
1.0E-2	2.12E-5	7.6E-3	1.01E-2	36 ccs/hour	10 small bubbles per second
1.0E-3	2.12E-6	7.6E-4	1.01E-3	3.6 ccs/hour	1 per second
1.0E-4	2.12E-7	7.6E-5	1.01E-4	1 cc in 3 hours	1 in 10 seconds
1.0E-5	2.12E-8	7.6E-6	1.01E-5	1 cc in 30 hours	1 in 100 seconds
1.0E-6	2.12E-9	7.6E-7	1.01E-6	1 cc in 2 weeks	3 in one hour
1.0E-7	2.12E-10	7.6E-8	1.01E-7	3 ccs in 1 year	
1.0E-8	2.12E-11	7.6E-9	1.01E-8	1 cc in 3 years	
1.0E-9	2.12E-12	7.6E-10	1.01E-9	1 cc in 30 years	Observation impractical
1.0E-10	2.12E-13	7.6E-11	1.01E-10	1 cc in 300 years	
1.0E-11	2.12E-14	7.6E-12	1.01E-11	1 cc in 3000 years	

Temperature:

$T_F = 1.8T_C + 32$; $T_R = T_F + 460$; $T_C = (T_F - 32)/1.8$; $T_K = T_C + 273$; $T_R = 1.8\ T_K$
Where F = °Fahrenheit; R = °Rankine; C =°Celcius (Centigrade); K = °Kelvin.

Force:

$1\ lb_f = 4.448N$; Distributed force: $1\ lb_f/in = 175\ N/M = .175N/mm$

Moment & Torque:

$1\ in - lb_f = .113\ N\text{-}M$

Typical Leakage Rates:

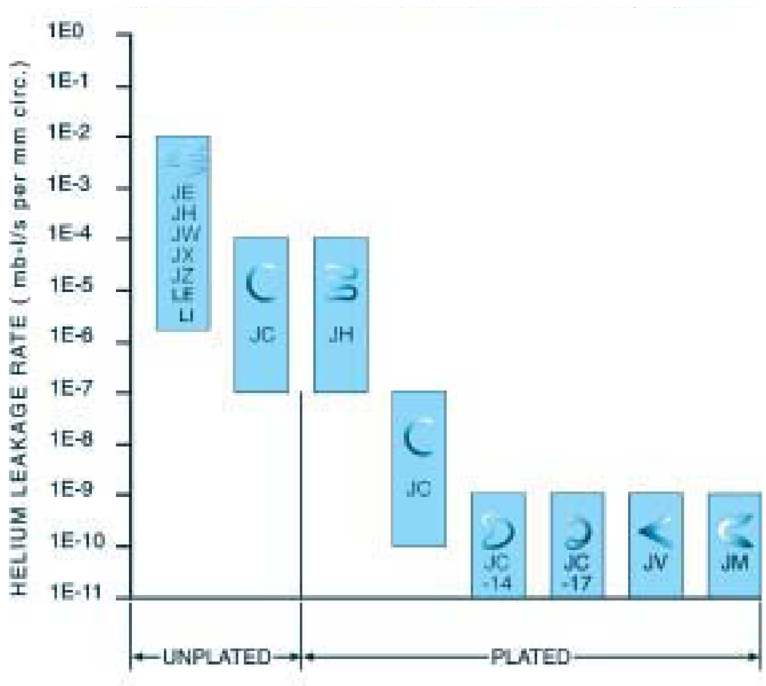


Fig. 1. Typical Leakage Rates

Typical ranges of leakage rates, measured by helium mass spectroscopy, are shown in the bar chart at left. These ranges are obtained using test flanges with surface finishes and cavity dimensions in accordance with the recommendations in each relevant seal design manual section.

In order for each sealing system or joint to attain its maximum sealing efficiency, it is essential that the compressive force applied to the seal, through threaded fasteners or other means, exceed the sum of the seal reaction force at full compression and the product of the system pressure and the projected area enclosed.

$$\Sigma F > P_{max} (\pi D_s^2/4) + \pi D_s F_s$$

Where ΣF is the total joint closing force, P is the differential pressure across the joint, D_s is the effective sealing diameter

and F_s is the reaction force of the seal, per unit length of sealing line.

If bending moments and/or axial loads are applied to the joint, their effects must be computed and added to the right-hand side of the equation; the required closing force then becomes,

$$\Sigma F > \frac{\pi P D_s^2}{4} + \frac{4 M D_s}{D_{bc}^2} + F_A + \pi D_s F_s$$

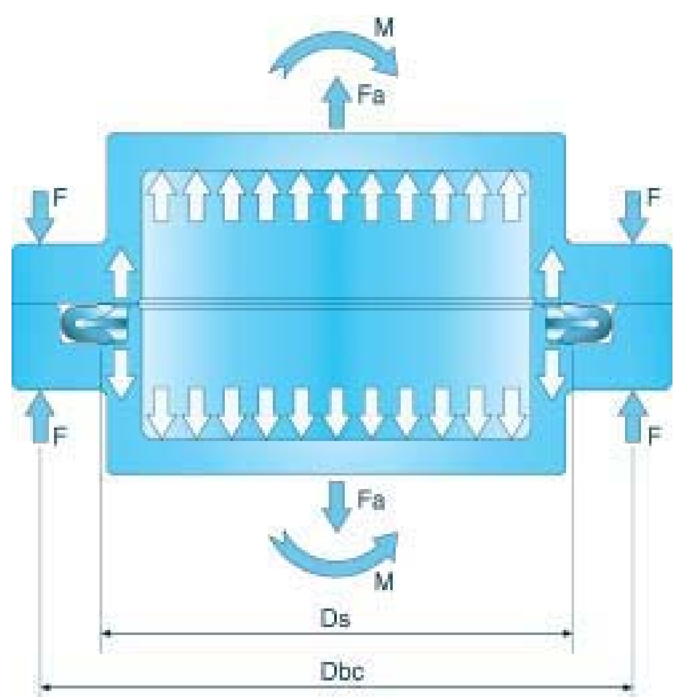
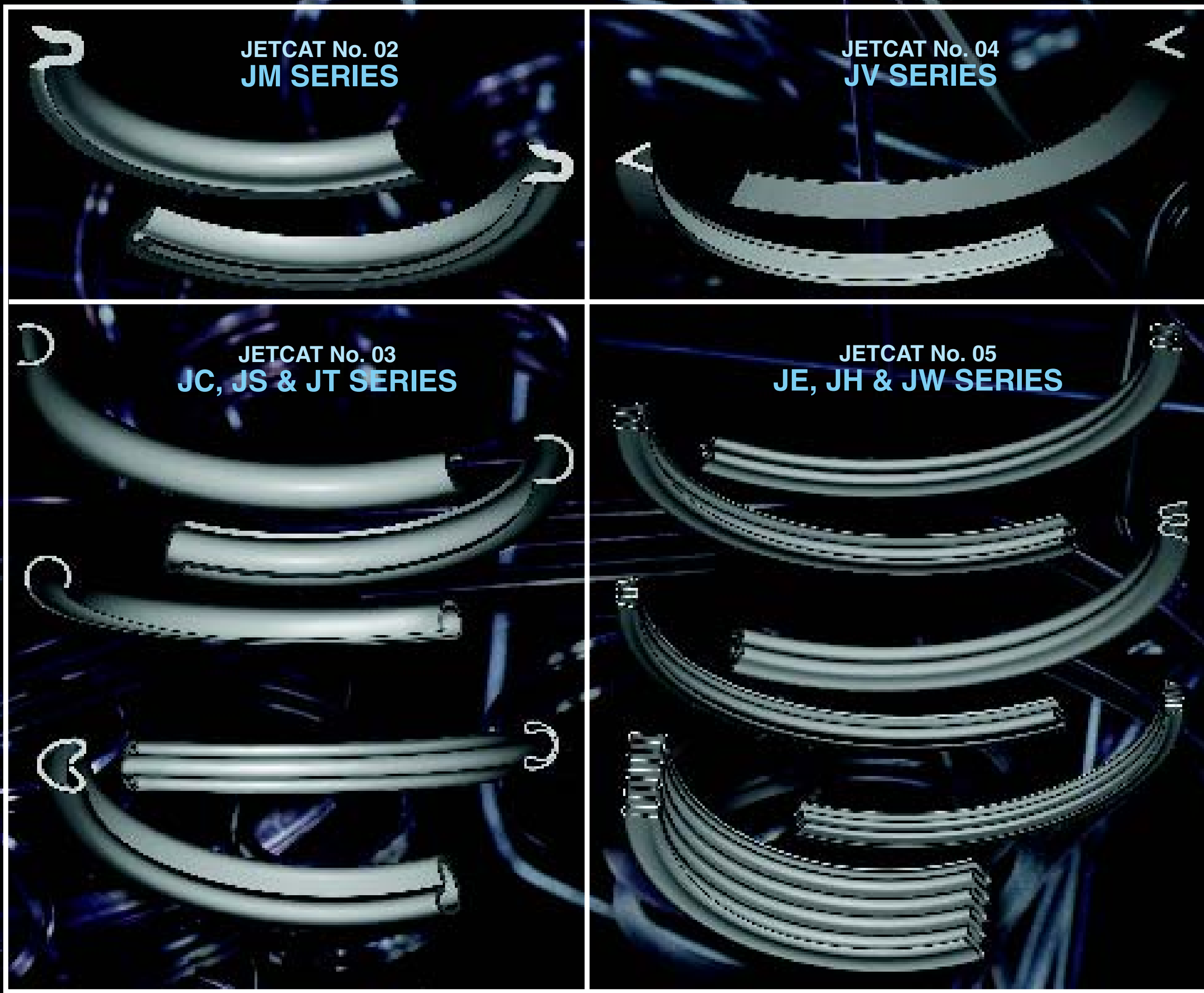


Fig. 2. Axial forces and moments acting on a joint in a closed, pressurized system.

If it is not possible to generate the required closing force, or if transitory conditions sometimes reduce it, the seal may be subjected to partial unloading, through static or cyclic deflections. In this case, analysis must be performed to ensure that unloading of the seal does not result in excess leakage and that if it is cyclic, that the fatigue life of the seal is not exceeded. JETSEAL will be glad to provide support and to assist with analysis.

JETSEAL CATALOG SERIES



- ***JETSEAL GUIDE: JETCAT No. 01***—Jetseal Resilient Metallic Seals comprise several distinct series, each engineered for a specific range of applications. This guide provides selection procedures and general information. Familiarization before proceeding to specific product catalogs is recommended.
- ***JM SERIES: JETCAT No. 02***—The JM Series of High Performance Omega Seals is recommended for the most demanding applications, for aggressive high pressure gases and liquids, where the ultimate sealing efficiency is required, and for 10-10 mb-l/s vacuum applications.
- ***JC SERIES: JETCAT No. 03***—The JC Series of highest quality C-Seals, for high pressure liquid and gas systems. Standard, multi-purpose C-Seals are highly cost effective and offer excellent performance for lightly-loaded seals. Use these seals to obtain a good joint where lightweight flanges must be used. Super C-Seals offer dramatic improvements in springback and sealing efficiency.
- ***JV SERIES: JETCAT No. 04***—The JV Series, like the JM Series, assures the highest degree of sealing efficiency. These seals compare with C-Seals for their compactness. As machined seals, they are somewhat more expensive to produce than formed seals, and are therefore recommended primarily for the most stringent leakage requirements.
- ***JE SERIES: JETCAT No. 05***—Jetseal E-Seals in the JE Series are highly resilient, fatigue resistant seals, intended for high temperature applications in lightweight, flexible systems and equipment. Those in the JH Series are intended for all temperature gas and liquid high pressure systems, in which their excellent elastic-plastic deflection characteristics are combined with lower leakage rates.
- ***JE SERIES: JETCAT No. 05***—Multiple Convolution E-Seals are particularly suited to turbo-fan engine turbine and high pressure compressor gas path sealing, where there are large thermal excursions and tolerance accumulations. They are available in the JW Series. Two convolution seals are standard; seals with more than two convolutions are available as custom-engineered parts.

GRAPHIC DESIGN: PRINTWORKS, Ltd., Madison, CT, 06443 • WWW.Printwrks.com
PHOTO: Edwina Stevenson