

XXL-Size Seals and Molded Parts

Powerful Solutions for Large-Scale Applications



ENGINEERING YOUR SUCCESS.

Seals and Molded Parts in **XXL** Sizes

Powerful Solutions for Large-Scale Applications

High Performers in Extra-Large Sizes

There is a wide range of industries where, in addition to average-size and miniaturized equipment, large-scale systems are used that require components and sealing systems matching the size of the equipment. While average sealing systems rarely have diameters larger than 100 mm, diameters of several meters are not uncommon in some sectors. Examples include manufacturing plants and equipment, buildings and pipelines, tunnel construction and mining, energy, oil and gas, high-tech medicine, aerospace and many others.

As a specialist in engineered materials, engineering design and process technology Parker Prädifa offers an extensive portfolio of large-size seals and molded parts made of polymers such as NBR, EPDM, FKM, PTFE and PEEK, as well as metal.

Machined up to 4.5 m or Continuously Vulcanized in any Desired Size

In addition to metal seals, sealing solutions made of polymeric materials like rubber, thermoplastic elastomers or other thermoplastics such as TPU, PTFE or PEEK are commonly used. As varied as the material selection for applications of polymeric sealing solutions may be the production of XXL seals from any of these materials always involves

greater effort and expense and is only possible with special, complex manufacturing technology.

Machinable polymer seals made of materials like PTFE and PEEK can be produced at Parker Prädifa up to a diameter of 4.5 meters instead of the previously possible 3 meters, using new manufacturing technology.

Practically no size limitations exist in the case of vulcanized elastomer seals. Thanks to the innovative manufacturing technology of continuous vulcanization utilized by Parker Prädifa, O-rings and profile seals in large dimensions can be cost-efficiently produced in precision quality.



Material Selection to Suit any Application

Besides the appropriate seal design which Parker Prädifa develops for you using advanced simulation technology and virtual prototyping by means of Finite Element Analysis (FEA), the selection of the suitable compound is crucial for XXL-size seals and molded parts as well. Thanks to in-house compound development, we offer an extensive range

of high-performance polymers meeting the most exacting demands.

Based on in-depth knowledge of a wide range of applications and their specific requirements, we make the appropriate selection in close cooperation with our customers, modify existing materials to suit special needs or

develop new ones if necessary. The result is sealing solutions that deliver high performance in terms of design and material in any size you need, including XXL.

XXL Seals Made of Rubber Compounds Using Continuous Vulcanization Technology

Precision O-Rings in any Desired Diameter



Precision O-rings are manufactured by vulcanization in a closed mold using compression or injection molding. This makes it possible to produce O-rings in relatively small manufacturing tolerances and with good surface quality according to ISO 3601-1 and ISO 3601-3. Due to defined vulcanization parameters, precision O-rings exhibit consistently high mechanical properties across the entire circumference. This high quality level is an indispensable prerequisite for achieving consistently good sealing effects over a long period of time.

However, up to now, this production technology has been regarded in the sealing industry as not being economically feasible for O-rings in very large dimensions due to the enormous work and related costs involved in making extra-large molds. In addition, such large molds are extremely difficult to handle and therefore cannot be accomplished by many seal manufacturers.



Conventional Production Technologies and their Disadvantages

Due to the high manufacturing complexity involved in producing XXL O-ring seals described above, these seals are typically created by joining round cord stock using joint vulcanization or splicing to achieve the desired length. Although both methods are particularly economical, the joints pose a problem. As the joints are weak areas, the seals exhibit physical properties that are inferior to those of precision O-rings. For instance, in applications involving gases, high pressures or vacuums, this may result in leakage. Chemical-physical attacks are more likely due to the joints as well. Spliced round cord in particular is vulnerable, as the

chemical resistance of the adhesives used is frequently ignored in subsequent applications. In addition, due to the nature of the process, the tolerances involved in the production of round cord are higher, as irregularities such as diameter variations in the round cord cross-section may occur when the cord exits the extrusion die. This may lead to varying and insufficient compression of the seal cord in the groove across the circumference and a resulting higher risk of leakage. Due to the higher risk of failure of this low-cost sealing solution, joint-vulcanized or spliced round cord seals cannot be utilized in safety-relevant components.

Advantages of Continuous Vulcanization

The innovative manufacturing technology of continuous vulcanization used by Parker Prädifa, which does not involve failure-prone joints, enables the cost-efficient production of precision-quality O-rings with high mechanical load resistance in nearly any desired diameter, i.e. >200 mm for industrial applications and >380 mm for special applications (see tables). The technical properties of continuously vulcanized O-rings are comparable with those of O-rings produced by conventional compression molding. As a result of being molded, these XXL O-rings are quality products for challenging applications.

Customer-Specific Geometries for Static and Dynamic Applications

In addition to precision-quality XXL O-rings, Parker Prädifa offers the development and production of customer-specific geometries in large diameters. A wide range of materials is available according to the application requirements (see tables).

The surface qualities and tolerances correspond to those in ISO 3601:2012.

However, this standard only covers cord thicknesses of up to 8.4 mm.

To ensure that customers receive reliable and consistently high-quality O-rings where cord thickness is >8.4 mm, Parker Prädifa has developed an in-house standard based on ISO 3601:2012.

Applications for Continuously Vulcanized Large Elastomer Seals

Industries

- Chemical process industry
- Pharmaceutical industry
- Semiconductors
- Oil and gas
- Aerospace
- Energy

Products

- O-rings
- Seals and wipers for large-scale ball bearings, e.g. for wind turbines
- Seal profiles for boiler seals used in food and chemicals production
- Seal profiles for rocket stages
- Cylinder head gaskets for stationary heavy-duty engines
- Other profile seals



Standard Compounds

| Polymer | Compound | Hardness (Shore A) | Temperature Range (°C) | Color | Range of Application |
|---------|----------|--------------------|------------------------|-------|--|
| NBR | N0674 | 70 | -35 / 100 | Black | Standard compound for hydraulics and pneumatics. Good resistance in hydraulic oils and water glycols, against mineral oil products, animal and vegetable fats. |
| EPDM | E0540 | 80 | -50 / 150 | Black | Good hot water resistance. Suitable for hot air up to 150 °C and steam up to 200 °C. |
| FKM | V0747 | 75 | -25 / 200 | Black | Standard compound for the general chemical industry. Suitable for flame-resistant liquids and chlorinated hydrocarbons. |

Available Cross Sections for Standard Compounds [mm]

| | | | | | | | | |
|------|------|------|------|-------|-------|-------|-------|-------|
| 2.62 | 4.50 | 5.70 | 7.00 | 8.50 | 10.82 | 13.00 | 16.00 | 20.00 |
| 3.00 | 5.00 | 6.00 | 7.50 | 9.00 | 11.00 | 14.00 | 17.00 | 22.00 |
| 3.53 | 5.33 | 6.35 | 8.00 | 9.50 | 12.00 | 14.40 | 18.00 | 24.00 |
| 4.00 | 5.50 | 6.50 | 8.40 | 10.00 | 12.70 | 15.00 | 19.00 | 30.00 |

Special Compounds

| Polymer | Compound | Hardness (Shore A) | Temperature Range (°C) | Color | Range of Application |
|-------------------|----------|--------------------|------------------------|-------|---|
| CR | C0557 | 70 | -40 / 100 | Black | Frequently used in refrigerants. Good weather and salt water resistance. |
| HNBR | KA183 | 85 | -50 / 150 | Black | Special compound for oil and gas applications with very good sour gas resistance. |
| HiFluor® FB (FKM) | V8991 | 75 | -25 / 200 | Ocher | Challenging hygienic and aseptic applications in the chemical, food, cosmetics, pharma and medical device industries with all required approvals. |
| Parofluor® (FFKM) | V8910 | 75 | -20 / 220 | Black | Very good chemical resistance, very good solvent and paint resistance. |
| Parofluor® (FFKM) | V8545 | 75 | -15 / 300 | Black | Very good chemical resistance including hot water and steam, etc. |
| Parofluor® (FFKM) | V8800 | 75 | -15 / 320 | Black | High-temperature compound with very good chemical resistance. |

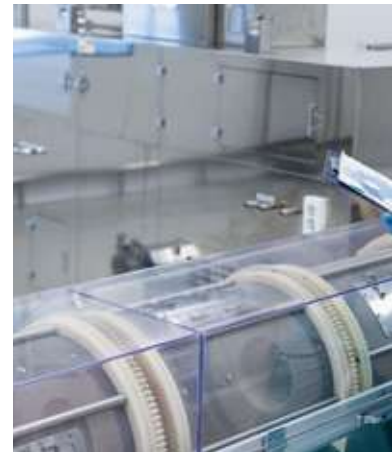
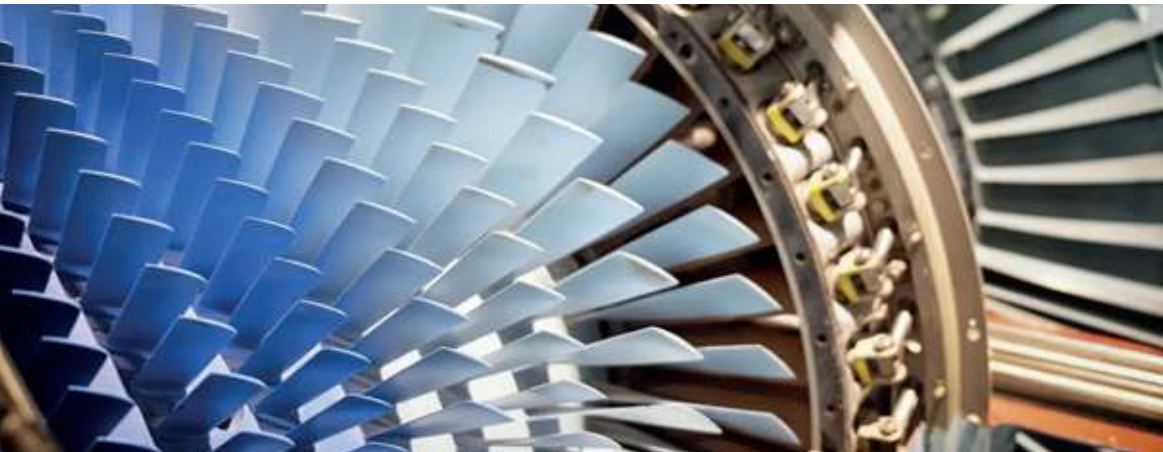
Other compounds available on request

Available Cross Sections for Special Compounds [mm]

| | | | | | | | | |
|------|------|------|------|------|------|------|-------|-------|
| 3.53 | 4.00 | 5.00 | 5.33 | 6.00 | 6.99 | 8.00 | 10.00 | 12.00 |
|------|------|------|------|------|------|------|-------|-------|

Other cord thicknesses available on request

Application Examples



Chemical Process Technology – Sealing Solution for a Nutsch Dryer

The challenge >> In a nutsch dryer used for the production of pesticides, an FEP-covered FKM O-ring was initially utilized. The nutsch dryer is a combination of a filter (nutsch) and dryer and has the advantage that the separation and subsequent drying process can take place in the same device, which allows small batches of toxic, highly precious or solvent-wet substances to be treated without a risk of contamination and with low loss. The O-ring serves as a primary seal and has to seal the container wall against the bottom to prevent the suspension from escaping into the atmosphere.

The originally used FKM O-ring was produced from extruded

round cord. Due to the process involved, this type of O-ring exhibited cross-section irregularities that repeatedly led to leakage. In addition, the size of the O-ring (diameter >1,000 mm) made it difficult to install the seal. For greater ease of installation, or to even make it possible due to the required high assembly forces, the O-ring required complex greasing. This additional process step, which also entailed the risk of contaminating the product, was to be eliminated.

The solution >> Parker Prädifa developed a sealing solution without a fault-prone joint and with minimal tolerance width according to the specified groove geometry to seal the existing gap.

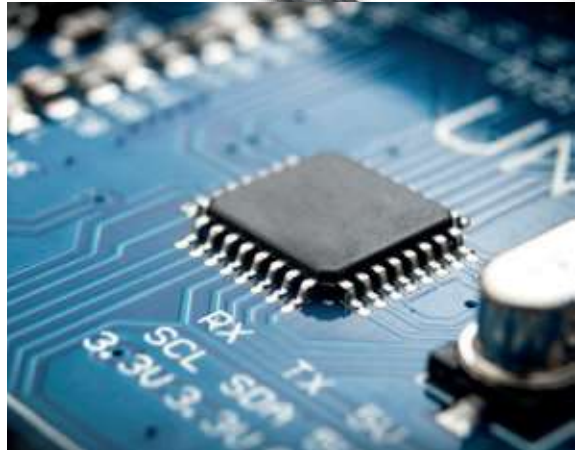
To ensure resistance against the wide range of chemicals present in the application at permanent temperatures of 100 °C the Parofluor® (FFKM) compound V8910 was selected. The material exhibits very good chemical resistance against a wide range of media and good thermal resistance. To simplify installation and to eliminate the critical process step of greasing the O-ring (inner diameter >1,000 mm × 10 mm) was coated with PTFE, which clearly reduced the required assembly forces.

Oil and Gas – Sealing for Centrifugal Compressors

The challenge >> Centrifugal compressors have to cover a wide range of applications, pressures and media. The O-rings used (>2,500 mm × 8 mm) must withstand temperature cycles from -45 to 205 °C without suffering any losses in chemical and mechanical properties throughout the entire service life.

The solution >> Parker Prädifa was involved in the development project from the beginning and developed an O-ring made of the VG109 (FKM) high-performance compound for oil and gas applications that achieved outstanding results in all tests. It scores with excellent temperature and media resistance as well

as resistance against rapid gas decompression (RGD). Its low compression set ensures consistent elasticity resulting in reliable sealing function throughout the seal's service life.



Pharmaceutical Industry – Sealing Solution for Centrifuge

The challenge >> In the large-scale industrial production of semi-synthetic antibiotics, up to 500,000 liters of antibiotics are produced per batch. For such large-scale production to be economically feasible equipment of corresponding dimensions is required. In addition to large fermenters with diameters of several meters in which the biotech antibiotic is bred, centrifuges of similar dimensions are utilized to separate the antibiotic from

process agents. Leakage must be prevented at all cost for safety and economic reasons. A leaking centrifuge might contaminate the antibiotics, resulting in high financial losses or, worse yet, in health and environmental hazards.

The solution >> Parker Prädifa was involved in the project at an early stage to develop a reliable sealing solution. The utilization of continuously vulcanized,

i.e. jointless precision O-rings ensures the requisite reliability. Besides the seal design, the compound properties, particularly temperature and media resistance, play a key role. In addition to permanent temperatures of 250 °C, the seal has to withstand the aggressive media used in antibiotics production. The Parofluor® (FFKM) compound V8920 was selected as the suitable material for this application.

Semiconductor Industry – Lip Seal Ring for Lithography System

The challenge >> The development of a new lithography system for semiconductor manufacturing posed the challenge of sealing two halves of a housing. Due to the tolerance situation in producing the respective housing halves, there was a risk of a gap of up to 0.5 mm occurring between the two halves in the assembled housing.

The solution >> In sealing technology, the gap dimensions to be bridged are typically bet-

ween 0.05 mm and 0.25 mm. As larger gap dimensions available for sealing in the groove in this application could not be reliably sealed, or only by entailing a higher risk of leakage, with a solid seal such as an O-ring, a conventional O-ring sealing solution was not selected here, but a profile seal featuring a lip design. This seal was developed using Finite Element Analysis (FEA) to ensure reliable sealing of large gaps and tolerance variations in the seal groove between the two

halves of the housing. In addition, the shape of the seal prevents twisting during installation and reduces the required assembly forces.

In the selection of the seal compound, high purity requirements had to be considered. Due to specific post-curing processes, the FKM compound V0747 with low outgassing properties achieves outstanding results.

XXL Seals Machined from Polymer Materials

Polymer materials like PTFE, PEEK, TPU and selected elastomers are suitable for machining such as turning or milling. This makes it possible to economically manufacture both larger and smaller volumes because no additional tooling costs for molds are incurred.

Parker Prädifa has been producing complex machined polymer seals with diameters of up to 3 meters for decades. In the light of a growing demand for increasingly large seals Parker Prädifa has continually developed the manufacturing technology of machining further and is now able to offer diameters of up to 4.5 meters at the highest level of quality. The production of even larger diameters is currently in the pipeline.



Engineering, Testing, Manufacturing and Quality Assurance Using State-of-the-Art Methods

The production of large seals for challenging applications is not simply a matter of scaling up know-how of traditional seal design and machining. The reason is that XXL sizes not only pose particular handling challenges in the manufacturing process, but do so even earlier, in the design and testing stages.

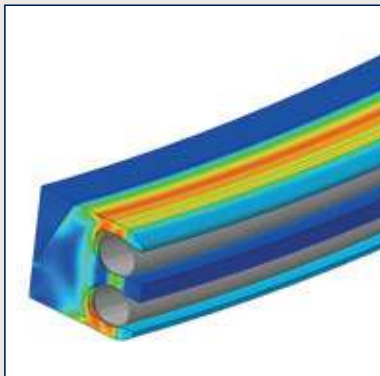
The evaluation of the performance of large-scale seals under various load and temperature conditions requires sophisticated simulation models. Particularly

critical factors to be considered in the design of large seals include thermal shrinkage and expansion. In addition, even relatively low pressures may result in extreme forces acting on the seals, leading to considerable deformations or even seal failure.

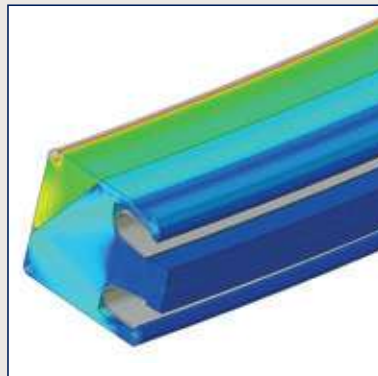
As damage caused by seal failure and leakage may be particularly severe in the case of large seals, reliable sealing functionality must be comprehensively validated prior to their utilization in the respective application.

Parker Prädifa uses virtual prototyping for validation. Due to the advanced method of virtualization utilizing sophisticated FEA models costly tests with real-world parts can be avoided and development cycles significantly reduced.

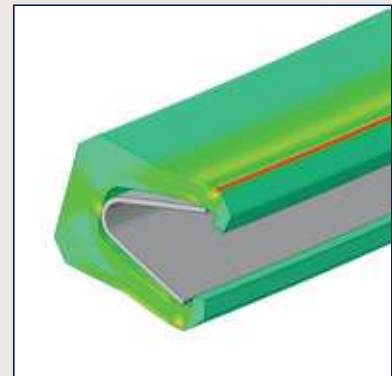
Virtual Prototyping using Finite Element Analysis



Double-cavity FlexiSeal® with helicoil springs and triangular back-up ring: Von Mises stress after installation.



Double-cavity FlexiSeal® with cantilever springs and triangular back-up ring: At 500 bar pressure and a temperature of 150 °C increased stress can be seen at the back-up ring corners.



FlexiSeal® with cantilever spring: At 30 bar pressure and ambient temperature highest stresses are located at the contact area of the lips with groove and cover.

Materials

| Material family | Diameter range | Temperature range (°C) | Use as dynamic element | Chemical resistance | Cost index (1-5) | Typical flex modulus [MPa] |
|---|----------------|------------------------|------------------------|---------------------|------------------|----------------------------|
| Virgin PTFE | ≤ 3 m* | -260 / 260 | No | Excellent | 2 | 500 |
| PTFE compounds | ≤ 3 m* | -260 / 300 | Yes | Excellent | 2 | 700 |
| UHMW PE | ≤ 4,5 m | -200 / 80 | Yes | Fair | 1 | 1000 |
| Virgin PEEK | ≤ 4,5 m | -200 / 250 | No | Good | 3 | 4000 |
| Filled PEEK | ≤ 4,5 m | -200 / 250 | Yes | Good | 3 | ≤ 8000 |
| PVDF | ≤ 4,5 m | -200 / 120 | No | Good | 2 | 2500 |
| X-series composites** | ≤ 4,5 m | -200 / 300 | Yes | Excellent | 5 | 10,000 + |
| Other machinable polymers (e.g. NBR, HNBR, TPU,...) | ≤ 4,5 m | -60 / 200 | Yes | Fair | 1 - 2 | |

* Diameters up to 4,5 m. Ongoing development for diameters beyond.

** On request



Applications for Large Machined Polymer Seals

Oil and Gas

- FPSO (Floating Production Storage and Offloading) swivel stacks
 - Environmental seals / housing seals
 - Anti-oozing seals
- Oil field compressors
- Gas turbines

Aerospace

- Door seals
- Engine casings

Military

- Turret seals for tanks, vessels

Medical Device Technology

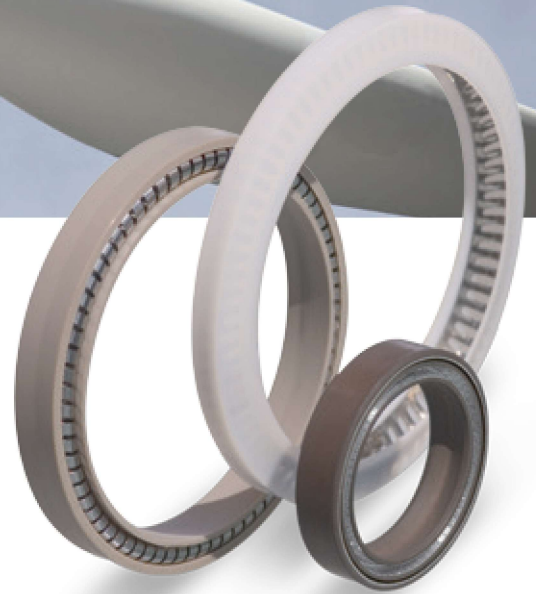
- Casing seals for MRI scanning equipment

Renewable Energies

- Turbines (wind power, wave power)

General Industrials

- Tunnel boring equipment
- Ceramic presses



Products

- O-rings
- Bearings
- Machined components
- FlexiSeals® (PTFE seals energized by a stainless steel spring)
- FlexiCase (rotary PTFE seals with metal casing)
- Wipers
- Chevron stacks
- Slipper seals® (seals consisting of a PTFE ring and an O-ring energizer)



Parker Prädifa ensures top quality of XXL sealing solutions using quality assurance technologies developed in-house. Picture: X-ray inspection of large-diameter seals.



Application Examples

Renewable Energies – Sealing Solutions for Bearings in Wind Turbines

The challenge >> Wind turbines are becoming increasingly large in the light of consistently growing efficiency and performance demands. The larger shaft diameters result in higher loads based on pressure and surface speed ($p \times v$ [m/s \times bar]). For such applications PTFE materials

with their outstanding chemical and thermal resistance, low wear rates and friction values are more suitable than elastomeric sealing compounds. Thanks to these properties, for instance, incompatibilities of the seal compound with the oils and greases used in the application can be avoided.

The solution >> For these applications of large rotating shafts, Parker Prädifa offers low-friction PTFE seals energized by metal springs for example.

Oil and Gas – Environmental Seals in FPSO Swivel Stacks

The challenge >> Swivel stacks are the centerpieces of Floating Production Storage and Offloading (FPSO) units. They form the flexible connection between the subsea riser and the storage and distribution systems on the vessel. Swivel stacks require

complex sealing systems, both for interior and environmental sealing.

The solution >> Parker Prädifa offers large seal solutions for these applications in both areas, some of which are combined

with back-up ring combinations. Manufacturing examples include environmental seals with complex geometries in diverse materials such as UHMW PE and PTFE in diameters of up to 4.5 meters.

Medical Device Technology – Seals for Magnetic Resonance Imaging (MRI) Systems

The challenge >> Magnetic resonance imaging systems are high-tech devices with motion controlled at high levels of precision. The utilization of fluoropolymer seals guarantees low friction which avoids issues that might result from breakaway friction.

The solution >> Examples from Parker Prädifa's product portfolio for these applications include profile NLI FlexiSeals® and suitable sealing compounds for use in medical equipment with respective European and global approvals. If required, final cleaning and packaging can be performed

in clean-room conditions to avoid contamination by particles from the production process or during shipping.

Metal Seals for Harsh Application Conditions

The most important manufacturing technologies used to produce metal seals from stainless steel or nickel alloys are rolling, forming, CNC machining, welding, heat treatment and coating/plating. In its more than 60-year history of producing metal seals, Parker has continually tackled the challenge of manufacturing increasingly large metal seals. Currently, spring-energized C-rings with a diameter of up to 7.6 m can be produced for which special forming machines and patented welding techniques were developed. They are supported by optimized special heat treatment and electroplating processes that make it possible to manufacture high-quality products even in such large dimensions. Additionally, Parker offers non-rotationally symmetric metal seals. These E-, O- and C-seals can be produced in lengths of up to 2.3 m on machines specifically developed for this purpose.

The base materials used are special nickel alloys that withstand temperatures of more than 800 °C. These cobalt-nickel-chromium-tungsten alloys or heat-treatable nickel super-alloys make high demands on the welding technology used and are reliably processed at Parker due to optimized manufacturing processes and comprehensive suitability tests.

The choice of plating is primarily focused on wear protection, corrosion resistance and improvement of the sealing properties. For this purpose, the surface properties of the metal seal are modified and a formable external surface layer with adjusted hardness is created. Parker's application engineering team will advise you in making the appropriate selection from the available plating range of gold, silver, nickel or TriCom® coating.



Applications

Energy Production

- Gas turbines
- Steam turbines
- Compressors

Aerospace

- Aircraft turbines
- Satellites
- Liquid gas tanks and valves of rocket engines

General Industrial Applications

- Container engineering
- Pressure vessels
- Door seals
- Chemical industry

Products

- C-seals: ≤ 3,000 mm
- Spring-energized C-seals: ≤ 7,600 mm
- O-rings: ≤ 1,200 mm
- E-seals:
 - Heat-treated ≤ 2,700 mm
 - Segmented ≤ 7,600 mm

Application Examples

Energy Production – Gas Turbines with up to 800 MW Capacity

The challenge >> Temperatures inside the turbine rise to 650 °C under high pressure. This pressure and the thermal expansion lead to the formation of gaps at the housing joints through which the hot medium can escape to the outside, resulting in a potential hazard to life and limb. Additionally, this considerably reduced the effectiveness of the turbine.

The solution >> Gas turbines are optimized by using metal seals featuring an advanced segmen-

ted design. Either metal E-seals or spring-energized metal C-seals are utilized depending on the expected size of the sealing gap. Metal E-seals are characterized by low compression force and high resilience, whereas C-seals have less resilience and better sealing performance. Both reliably seal the gap between the housing segments.

Linear metal seals are inserted between the upper and the lower part of the housing in the turbine, which prevents leakage at these critical joints.

To facilitate assembly of the housing halves weighing several tons, Parker has developed a special technology that causes the seal to completely rest inside the groove during installation and to contact the opposite flange area only after the turbine's initial run. Application-critical transitions between seals and surrounding components are effectively closed using special end pieces, designed accordingly in the customer's hardware.

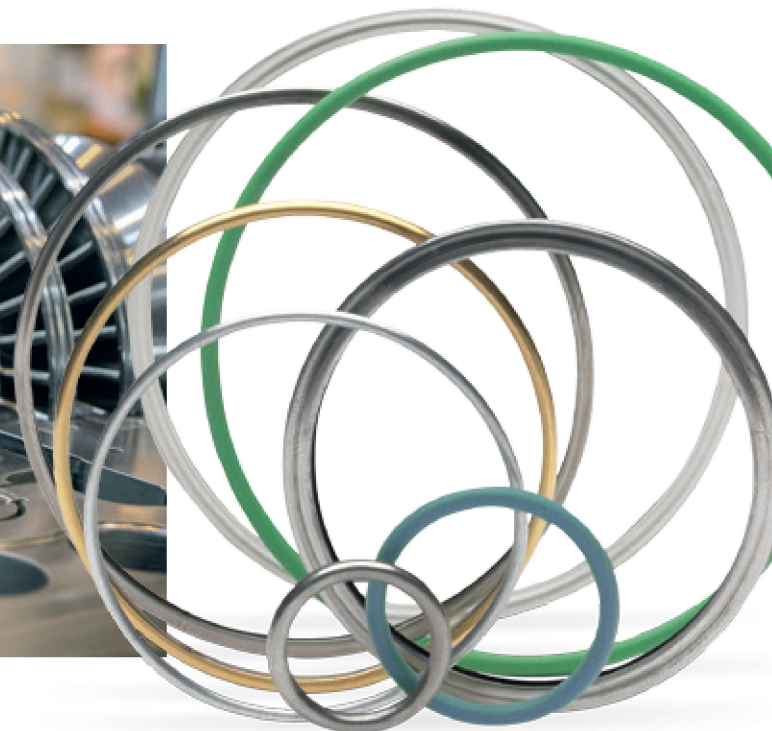
Chemical Process Industry – Heat Exchangers

The challenge >> Heat exchangers are operated at temperatures of 350 °C and steam pressures exceeding 100 bar. The joint between the main body and the lid requires steam-proof sealing. The seal has to resist the high temperatures and high pressures, must not be attacked by the medium and ensure reliable sealing performance even in

case of warping of the adjacent components.

The solution >> Utilization of a spring-energized metal C-ring made of a nickel alloy with silver plating and a diameter of 1.3 m. The high compression force of the spring-energized metal C-ring in combination with the silver plating results in minimal

leakage and good adaptation to flange irregularities. The nickel alloy selected is permanently heat-resistant up to 650 °C. Long lifecycles have demonstrated that the seals have a positive effect on the economy of the overall systems.





Parker Hannifin GmbH
Engineered Materials Group Europe
Arnold-Jäger-Str. 1
74321 Bietigheim-Bissingen · Germany
Tel.: +49 7142 351-0
Fax: +49 7142 351-432
E-mail: praedifa@parker.com
www.parker.com/praedifa