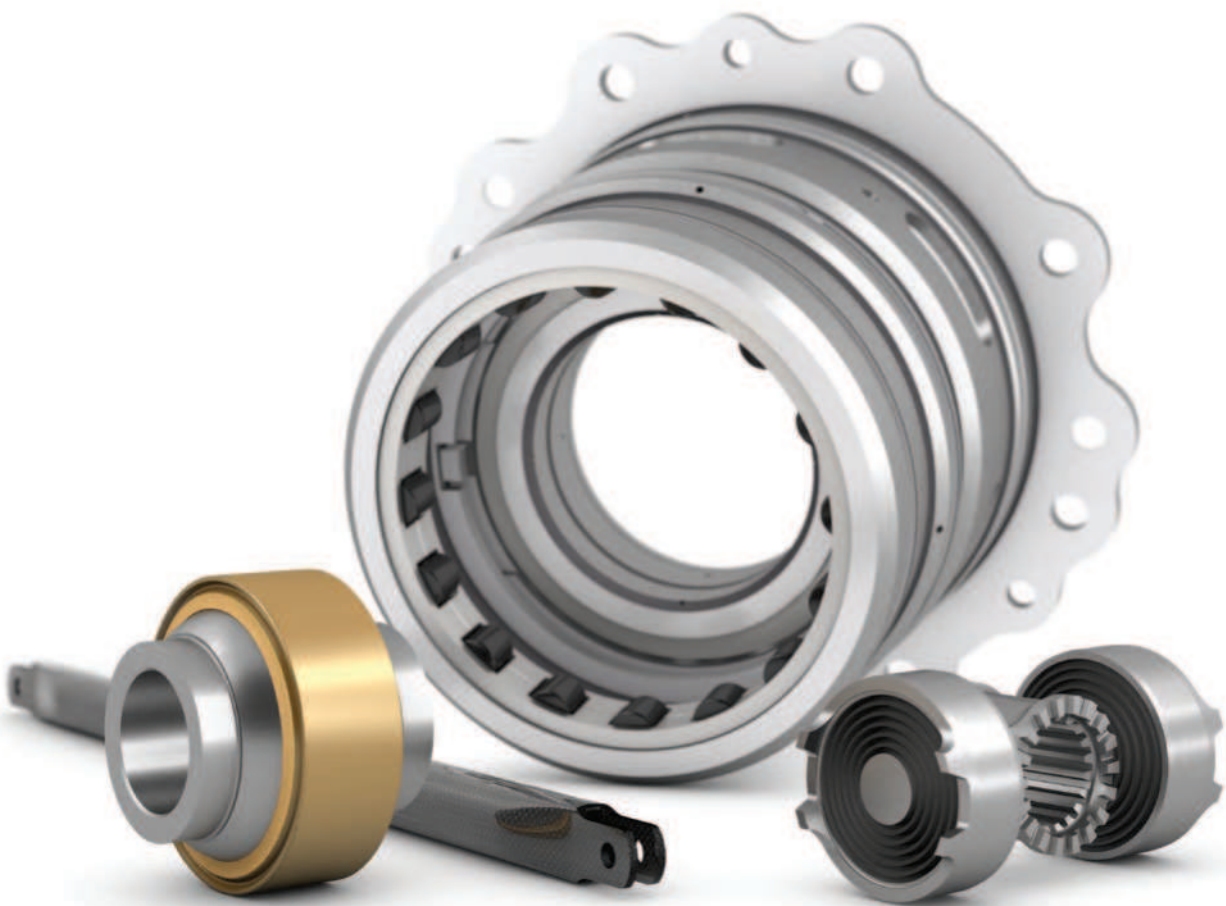


Aerospace solutions



Materials

SKF supplies balls in a wide range of materials, designed to meet a variety of needs, including:

- **52100 steel**

The standard material for most off-the-shelf balls, with excellent strength characteristics and the capability to withstand moderate impact loading conditions. With suitable through-hardened heat treatment, 52100 steel can be used at operating temperatures up to 200 °C (400 °F).

- **Tool steels such as M50 steel**

Suitable for temperatures between 200 and 427 °C (400 and 800 °F), M50 steel maintains its hardness, capacity and thermal stability better than standard bearing steels in high-temperature applications. The vacuum arc re-melting process used to produce M50 steel results in extremely clean material that is highly resistant to wear and oxidation, offers consistent metallurgical properties, and maintains a typical hardness range of 60 to 65 HRC.

This material can be nitrided (M50-NiL steel) for greater fracture toughness that makes it ideal for high-temperature applications that also involve high shock loading conditions.

- **440C stainless steel**

This high carbon chromium steel is designed to provide maximum hardness in stainless ball applications. When heat treated, 440C stainless can attain 63 HRC hardness.

Balls made of 440C stainless perform exceptionally well in corrosive environments. When treated with a low-temperature process using liquid nitrogen, they can maintain their stability at temperatures down to nearly -185 °C (-300 °F).

- **Silicon nitride**

The characteristics of silicon nitride make it ideal for use in applications where high speed, high temperature, low operating noise, electrical insulation, high stiffness and high hardness are required. As a result, ceramics balls offer significant advantages over traditional materials when used in rolling bearings, ball valves, gage tips and ballizing applications.

SKF has pioneered the use of silicon nitride balls by developing a unique production process and the quality control procedures required to reliably manufacture high precision, ceramic rolling elements.

The result of this process is exceptional quality and reliable performance.

- **Other materials for specific applications**

Other corrosion-resistant steels and tool steels (including tungsten carbide tool steel), nickel based alloys (including Inconel or Hastelloy) or cobalt alloyed steel for high temperature applications, non-metallic (including nylon, typically used for lightweight solutions) and glass materials, titanium alloys, etc.

Ball grades

SKF Aerospace specialty balls can be supplied with tolerances compliant to ABMA grade 3 to 1000. See **table 1** for more information.

Table 1

SKF Aerospace specialty ball grades				
ABMA grade	Ball diameter tolerance	Spherical form uniformity tolerance	Basic diameter tolerance	Surface roughness
$\mu\text{in./}\mu\text{m}$				
3	3/0,08	5/0,13	± 30 $\pm 0,75$	0.5/0,012
5	5/0,13	10/0,25	+50/-40 +1,25/-1,00	0.8/0,020
10	10/0,25	20/0,50	+50/-40 +1,25/-1,00	1.0/0,025
16	16/0,40	32/0,80	+50/-40 +1,25/-1,00	1.0/0,025
24	24/0,60	48/1,20	± 100 $\pm 2,50$	2.0/0,050
48	48/1,20	96/2,40	± 200 $\pm 5,00$	3.0/0,080
100	100/2,50	200/5,00	± 500 $\pm 12,50$	5.0/0,125
200	200/5,00	400/10,00	± 1000 $\pm 25,00$	8.0/0,200
500	500/13,00	1000/25,00	± 2000 $\pm 50,00$	- 1)
1000	1000/25,00	2000/50,00	± 5000 $\pm 125,00$	- 1)

1) Not applicable



Aerospace sealing solutions



11 Aerospace sealing solutions

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SKF supplies a wide range of sealing solutions, from seal replacement to the design of customized seals for extremely demanding applications. This is enabled by SKF's unmatched understanding of the interaction between seals, bearings, lubrication and operating conditions (temperatures, speeds, pressures, etc.).

With unique capabilities in seal design, materials, testing and manufacturing, SKF sealing solutions meet the most demanding application requirements. They can be found in power transmission systems, actuators, pumps and fluid handling systems.

SKF supports the entire product life cycle with:

- SKF simulation tool for seals, used to explore the non-linear behaviour of various sealing materials and designs. This helps to predict sealing performance under various operating conditions.
- Tests that can be conducted on-site at your location, or at one of our global testing facilities. Seals can be tested in static or dynamic loading conditions using rotating and reciprocating test rigs capable of simulating operating conditions including extreme pressures and temperatures. SKF testing capability also includes tests of durability, performance, contaminant exclusion, salt fog corrosion, cold fracture, pump rate, frictional moment, dry wear, and chemical compatibility.
For example, SKF has made significant investments in high speed test rigs for carbon seals to allow demonstration testing of new designs and validation testing of design changes. Testing is performed to match flight profiles for engine applications under simulated flight conditions.
Results from thousands of seal tests conducted by SKF annually, generate valuable know-how for failure analyses and performance optimization.
- High manufacturing flexibility. SKF manufacturing capability includes both moulded (in compression, injection or transfer) and machined seals. SKF manufactures seals on demand and delivers them worldwide and in quantities ranging from a few parts (prototypes for example) to serial production.

Product range

Aerospace seals are available in a wide range of designs and materials, for applications from the smallest gearbox to the largest swash plate.

SKF's assortment comprises many products that meet international and customer standards including ISO, ASTM, or DIN standards.

When needed, a combination of different seals and arrangements can be used to achieve best sealing performance in complex operating conditions.

Materials

Aerospace seals are exposed to a wide range of challenging operating conditions such as high temperature, speed, pressure and contact with chemicals. To handle these and other harsh conditions, it is essential to select the most suitable sealing materials.

To meet the most demanding application requirements, SKF sealing solutions use a wide range of rubbers, thermoplastic elastomers and other materials such as high-performance plastics:

- **Thermoset elastomers**
Extremely flexible materials that can be stretched and deflected with relatively little force. Many of them deliver excellent resistance to oils, greases, or other media.
- **Thermoplastic elastomers**
Thermoplastic elastomers offer advantages typical of both rubber and plastic materials. SKF's high performance polyurethanes (TPU) combine excellent abrasion and wear resistance, low compression set and tear strength, and outstanding pressure resistance.
- **PTFE**
Engineered to handle extreme conditions, polytetrafluoroethylene (PTFE) and its compounds can withstand aggressive chemicals plus high temperatures and pressures. Thanks to their extremely low coefficient of friction, they can also tolerate dry running conditions.
- **Carbon**
Carbon is typically used for applications with very high-speed and high-temperature rotary sealings, as in aircraft engine and auxiliary power unit (APU) main shafts. In such extreme operating conditions, elastomer, thermoplastic or PTFE materials may not be adequate.
- **Plastics**
From engineering plastics to high performance plastics such as polyether ether ketone (PEEK), SKF's range of specialty plastic materials can meet higher temperature, chemical and mechanical property requirements.
- **Other materials**
Including rubbers and metals. SKF also constantly develops solutions that are uniquely engineered for high performance applications, such as ECOPUR thermoplastic polyurethane, a proprietary SKF material.

Sealing rings

SKF is a major designer and manufacturer of sealing rings, used to meet the most demanding application requirements.

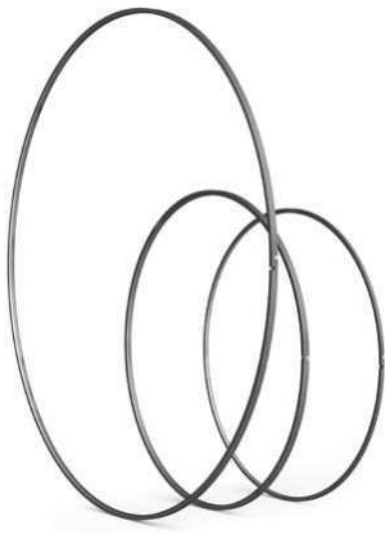
SKF sealing rings are specified for a broad range of static and dynamic aerospace applications including:

- Turbine engine bearing damper
- Piston engines
- Secondary seals in carbon seal assemblies
- Actuators
- Auxiliary power units (APU)
- Environmental control units
- High temperature valve applications

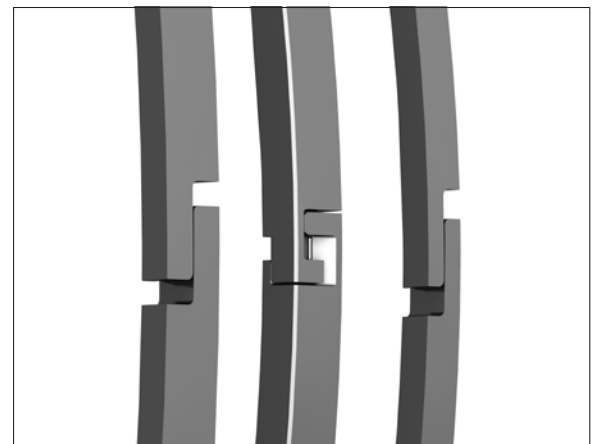
Patented joint configurations are available for applications requiring the strictest leakage control and for blind assembly applications. Various coatings are also used and are specified based on the needs of the application.

For sealing rings, SKF provides a proprietary AMS 7310 iron. This is a preferred ring material for many aircraft engine applications with a proven history of superior performance characteristics. Metallic ferrous rings, high temperature alloys such as Inconel, and thermo-plastic and thermoset non-metallic materials can also be supplied. For example, SKF's proprietary PTFE blends can be used for optimum wear and sealing efficiency to meet specific application requirements.

SKF designs and supplies the optimum sealing ring solution for your application to ensure long life, performance and reliability.



Sealing rings



Sealing ring solutions

Aerospace carbon seals for turbine engines

Carbon seals reduce costs by extending life and delivering outstanding performance in harsh operating conditions, setting quality standards for many commercial and military engines.

Applications

- Main shaft bearing seals in aircraft engines
 - Bearing compartment face seals
- Bearing compartment circumferential seals
- Bearing compartment bushing seals
- Main engine bearing compartment seals
 - Turbine engine shaft seals to seal the main shaft bearing compartment and oil sump
- Air seals
- APU seals
- Auxiliary gear box seals
- Engine seals

SKF carbon seals can be designed with features providing hydrodynamic capability. Such features have shown clear performance advantages in reducing heat generation and extending seal life, reducing load on engine oil management systems and maximizing time on wing.

SKF carbon seals can be supplied with shaft seal runners. Runners are used to interface with the seal. They have a fine surface finish and surface treatment to ensure optimum performance. SKF also supplies other support structures and spacers to the sealing assemblies to assure the proper interface of mating components.

Radial shaft seals

SKF supplies an array of proven shaft sealing solutions that protect bearings, keep lubricants in and improve system reliability.

At work in power transmissions across aerospace and every major industry, SKF radial shaft seals support greater uptime in everything from the smallest high-speed machine tools to the largest wind turbines.

SKF rubber and metal outside diameter shaft seals resist aggressive aerospace oils and can be designed with hydrodynamic features to optimize the functionality of the seal. Such designs are moulded in geometries that induce a hydrodynamic pumping action that allows the temperature under the lip to remain lower and reduces the carbonization of oil at the main sealing surface.

11



Carbon seals



Radial shaft seals