Understanding Secondary Sealing Elements in Mechanical Seals

A guide to the function, types and materials of secondary sealing elements.

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Mechanical seals are vital components used in rotating equipment such as pumps, compressors, mixers and agitators. Their primary role is to prevent the leakage of sealed liquid from the process equipment into the environment.

While much attention is often given to the primary seal faces, the secondary sealing elements are equally important to the overall performance and reliability of a mechanical seal.

This article will review the function, types and materials of the various secondary sealing elements used in a mechanical seal. Understanding these supporting elements provides valuable insight for users in learning how mechanical seals function and how secondary seals support the overall sealing process.

However, it must be understood that the selection of secondary sealing elements starts with the collection of application-specific details to assist the sealing device OEM in selecting the right type and material for the application. It is important to realize that there is no single solution for all applications.

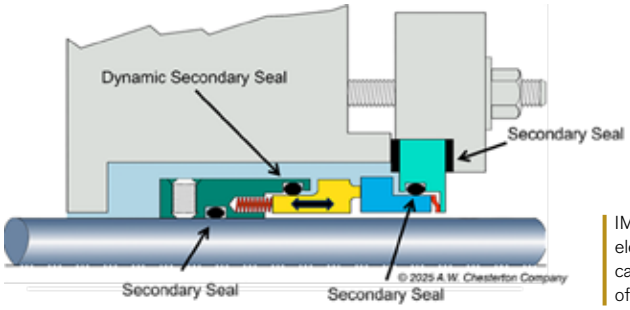

IMAGE 1: Secondary sealing elements in a typical single cartridge seal (Images courtesy of A.W. Chesterton)

What Are Secondary Sealing Elements?

Secondary sealing elements are the components within a mechanical seal that serve to prevent leakage around the seal faces and other adjacent components of the seal. They are just as important to sealing reliability as the primary seal faces.

Secondary sealing elements provide all static sealing within the mechanical seal, as well as the dynamic axial motion of the seal faces (Image 1).

Secondary sealing elements are found in any interface where two components are mated and a leak path exists. Examples include the interface between the mechanical seal's sleeve and the shaft of the sealed equipment; the mechanical seal gland and the mounting flange for the mechanical seal; the interface between the stationary seal face and the gland; and the interface between the rotary seal ring and the holder or sleeve where the seal rings track axially during operation (Image 1). There are several different types of secondary sealing elements, and they come in a variety of materials with various characteristics and capabilities that must be considered.

Types

Secondary sealing elements come in a variety of types, offering varying capabilities and properties. Their selection is based on various factors, including the mechanical seal's design as well as the application performance capabilities it must offer.

1. ***O-rings*** are secondary sealing elements with a circular cross-section. O-rings offer simplicity in installation and versatility in a wide range of sealing applications, and this is why they are the most common type of secondary seal used in mechanical seals. Based on the elastomer chemistry used, O-rings can offer a cost-effective sealing alternative. O-rings can be made from several different elastomeric compounds that can range from a very low cost to extremely expensive depending on their performance capabilities (temperature and chemical compatibility). O-rings also come in different durometers (hardnesses), which gives the designer the ability to tailor the seal design to a specific application (e.g., high pressure or temperature), which can benefit from higher durometer O-rings. Image 2 illustrates a basic mechanical seal with O-ring secondary seals.
2. ***Elastomer*** or ***thermoplastic bellows*** are found in a variety of seals where sliding dynamic secondary seals are not optimal. These elastomeric bellows are designed not to slide relative to other components in the mechanical seal, but they deflect to allow motion of the seal faces. Like O-rings, these bellows come in a variety of material choices based on the specific application and seal design requirements. These bellows may be called "boots" because they encapsulate the dynamic seal face like a boot. Image 3 illustrates a basic elastomeric bellows seal design.
3. ***Wedges (polytetrafluoroethylene [PTFE]*** or ***carbon/graphite)***, like O-rings, get their name from their cross-sectional shape. This type of secondary sealing element is used in a mechanical seal where an O-ring or other type of secondary sealing element is not a suitable choice due to temperature or

IMAGE 2: O-ring pusher seal

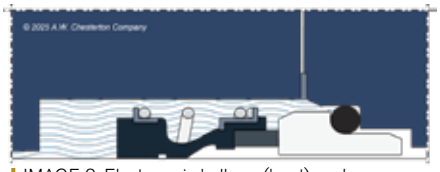

IMAGE 3: Elastomeric bellows (boot) seal "nonpusher" design

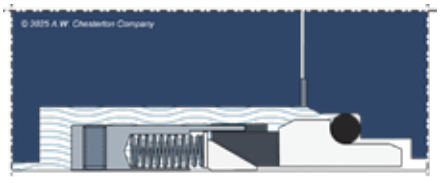

IMAGE 4: PTFE wedge seal

chemical exposure concerns. While wedges require external energization to seal effectively, they can offer a cost-effective solution to higher cost performance elastomers. However, wedge seal designs do have some limitations the seal designer or user should be aware of. These limitations include potential for "hang-up" in dirty services with solids and contaminates, fretting of the pump shaft/sleeve due to the axial motion of the wedges against the mating surface and limited axial motion capabilities. Image 4 illustrates a basic wedge seal design.

4. ***Metal bellows*** are used in place of elastomeric elements and are common in high-temperature, vacuum or hygienic applications. Metal bellows are either formed from a single piece of metal or welded from multiple thin metal plates. Metal bellows serve a dual purpose, providing secondary sealing as well as the spring load that allows for axial movement of the seal rings. Image 5 shows a welded bellows seal design.
5. ***Flat gaskets*** of various material types are frequently used to seal the mechanical seal's gland to the mounting flange on the piece of equipment to be sealed. Flat gaskets may also be used on other static applications within the mechanical seal assembly. As flat gaskets have no ability to move, they are only used in static interfaces where they can be compressed to provide sealing. As these are compression types of seals, they should only be used once and replaced when the mechanical seal is refurbished for further use. Image 6 shows the use of a gasket in a mechanical seal.
6. ***U-cups*** and ***V-rings*** are yet another type of secondary sealing element named for their cross sections. They can be made from either an elastomeric or thermoplastic material found in earlier secondary seal designs. U-cups and V-rings find application in low temperature, higher pressure applications and where chemical compatibility requires.

Materials

Secondary sealing elements come in a variety of materials depending on specific application and operating requirements. The selection of a specific secondary sealing material is a function of several parameters including operating temperature range, chemical compatibility, operating pressure range, type of sealing (static or dynamic), size and hardness.

The major categories of materials used in secondary sealing elements include elastomeric materials, thermoset plastics, metal alloys, flat gasket materials and carbon/graphite materials.

Elastomeric materials

Elastomers are one of the most widely used materials for O-rings and other flexible seal components. They come in a multitude of materials, as shown below:

- Synthetic rubber is a low-cost, general-purpose sealing material for lower temperature water. It also performs well in lower temperature oil/grease applications. Materials include:
  - Nitrile/Buna-N (NBR)
  - Neoprene
  - Chloroprene rubber (CR)
- Fluoroelastomer (FKM) offers a higher operating temperature range and good chemical compatibility. It is widely used in mechanical seal applications.
- Ethylene propylene diene monomer (EPDM) offers good compatibility in water and steam applications but is not compatible with hydrocarbons.
- Tetrafluoroethylene propylene (FEPM) offers good chemical and temperature resistance to aggressive chemicals typically found in the pulp and paper and other chemical industry applications.
- Perfluoroelastomer (FFKM) materials offer excellent chemical compatibility as well as high operating temperatures ranges. However, care must be taken to select the right grade of material for the specific application to ensure optimal performance.
- Other elastomeric materials used less frequently include:
  - Silicone, which operates over a wide temperature range (from cryogenic to high). It has good resistance to ozone and corona discharge around electrical components.
  - Fluorosilicone, a type of silicone rubber that is resistant to hydrocarbons and extreme temperatures as well as ozone, UV radiation and weathering.

Thermoset plastics

Thermoset plastics that are typically used as secondary sealing elements are:

- PTFE, a chemically inert, nonelastomeric material used for wedges, bellows and gaskets.
- Polyether ether ketone (PEEK), a high-performance thermoplastic that has high temperature resistance and good structural strength. This makes it an ideal material in backup ring applications (used behind an O-ring to increase the seal's pressure capabilities).

Metal alloys

Metal alloys are used for either formed or welded metal bellows. Typical materials used include:

- Stainless steel (316, 316L), which is common and corrosion resistant.
- Ni-Cr-Mo alloy, which is excellent in aggressive chemical environments.

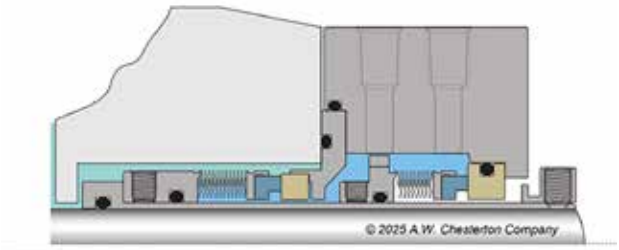

IMAGE 5: Welded bellow tandem seal with the bellows acting as both the spring system and secondary sealing for the dynamic face

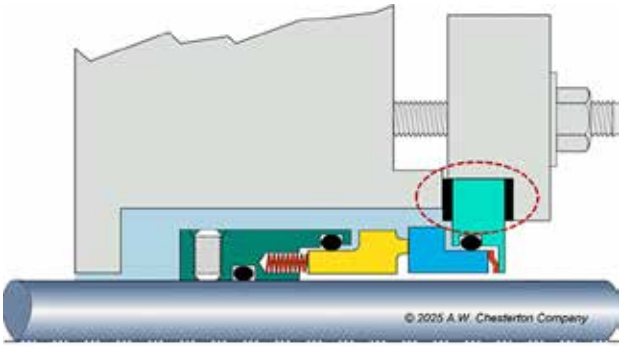

IMAGE 6: Gasket secondary seals (circled)

- Ni-Cr alloy, which has high strength and oxidation resistance at high temperatures.

Flat gasket materials

Gasket materials used in mechanical seals fall into two categories: synthetic fibers with an elastomeric binder and carbon/graphite. The selection of either is dependent on the chemical compatibility, temperature and/or pressure requirements for the application.

Carbon/graphite materials

Carbon/graphite materials are used in applications that require high temperature with good chemical compatibility. They are only used in static sealing applications within a mechanical seal. These types of materials are used in hot oil applications where temperatures can approach 750 F (398 C). ■

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