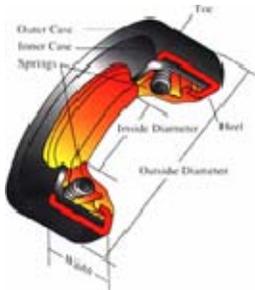


Rotary Shaft Seal Case Design Options

By: Kirk Leach
Marketing Manager
Colonial Seal Company
Westville, NJ

Seal case considerations for optimal seal performance

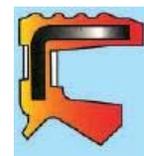


The construction of a typical rotary shaft seals consists of several interrelated components. When combined, these components which include lip material, case design & material and sealing element geometry offer a wide selection of designs for OEM's to choose from. Familiarity with these components and understanding their interaction with each other is critical in effective shaft seal design. This article will assist equipment manufacturers and maintenance professionals by highlighting the basic considerations of the shaft seal case. We will examine the basic rotary shaft seal case profiles and identify the major seal

case materials used in the industry. Additionally, the article will attempt to cross reference the various national standards of metals used for seal case design.

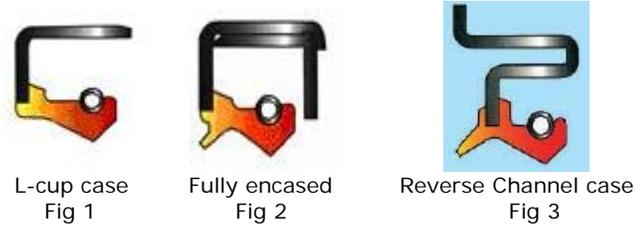
In most shaft seals, the elastomeric portion is chemically bonded to a stamped metal case. Non-elastomeric members such as PTFE, which is more difficult to bond, may be mechanically clamped in place inside the case. The case performs two functions. First, it provides stability, allowing the outside diameter (seal O.D.) to pressfit snugly into a housing bore. Second, the case also provides protection, preventing damage to the lip during installation.

Once the case has been formed or stamped, it is often coated with zinc phosphate to protect against corrosion or the elements. The case will also be coated with an adhesive to facilitate bonding between the metal case and the elastomeric lip. This also sometimes protects the metal case but is not recommended as a process for protection. As an alternative, a rubber O.D. seal (right) may also be used in a corrosive environment because the rubber coating shields the metal case. Care must be taken when using a rubber coated O.D. seal, as the rubber portion can be damaged during installation, if proper lead-in chamfers are not built into the design. Also, there may be a tendency for a shaft seal with a rubber O.D. to unseat itself slightly following installation due to shearing stresses created between the rubber and the housing bore during installation, a phenomenon known as springback. In addition, exposure to excessive heat during service may cause rubber coated seals to take a compression set, thus creating a leak path. Since rubber covered rotary shaft seals have a higher coefficient of thermal expansion than the surrounding metal housing, they typically will have a slightly larger OD when compared to metal cased seals.



*Top- Ribbed Rubber Covered
Bottom-Standard Rubber Covered*

Depending on the needs of the application, and regardless of the coating on the seal, a variety of different case configurations and case materials are possible. The most common and least expensive design is the L-cup case (fig 1). The European (DIN) nomenclature “**B**” is used to identify this profile which is a single lip design, where as the “**SB**” designation is used by Asian (JIS) manufacturers.



Seals requiring more strength and stability may utilize an *inner case* (fig 2 above) inserted into the outer case. This inner case protects both the lip and the spring during handling and installation. This profile is a double lip design with the smaller lip function as a wiper or dust/dirt excluder. These fully metal encased seals are commonly referred to as “**C**” or “**CS**” profiles using DIN nomenclature and “**SA2**” or “**TA2**” using JIS nomenclature. Applications with a large clearance gap between the shaft and the bore often utilize a *reverse channel case* (fig 3 above). This type of design offsets the lip, protecting it from other parts of the assembly that might interfere with it’s performance. The addition of a flange to this design also helps with the removal of the seal. The reverse channel seal will typically be more expensive because it is stamped from a thicker metal sheet. A thicker metal sheet is used to increase the seal strength to increase the seal strength

Regardless of the seal profile, the case is typically stamped from sheet steel stock using a stamping press. The standard case material used for rotary shaft seals is mild carbon steel, an economically priced, general-purpose material. Apart from its cost effectiveness, mild steel’s machineability makes it easier to form and cut compared to low carbon steels.

SAE designation	Type
1xxx	Carbon steels
2xxx	Nickel steels
3xxx	Nickel-chromium steels
4xxx	Molybdenum steels
5xxx	Chromium steels

The steel material used on most rotary shaft seals is typically designated using a four-digit numbering system developed by the Society of Automotive Engineers (SAE) (see table above for typical steel designations). This system, which mirrors the system of the American Iron and Steel Institute (AISI), assigns a four- or five-digit number to each type of steel. This number is based on the differing levels of carbon and other elements present in the steel. The first digit denotes the primary alloying element (such as a “1” for plain carbon). The second digit indicates the presence of other elements. The last two digits specify the amount of carbon in the steel (in hundredths of a percent). For example, a designation of 1005 indicates plain carbon steel (1) with no alloying elements (0) and a 0.05% carbon content (05). Most shaft seal cases are formed from steel with carbon content in the 0.05% to 0.20% range (SAE 1005 to 1020, AISI C1005 to C1020).

As a point of technicality, SAE and AISI are two separate designation systems, but they are nearly identical and have been carefully coordinated by the two groups. It

should be noted, however, that AISI has discontinued the practice of designating steels. The SAE-AISI system is applied to semi-finished forgings, hot-rolled and cold-finished bars, wire rod and seamless tubular goods, structural shapes, plates, sheet, strip, and welded tubing.

Most national steel designations identify each kind of steel by grade, type or class of steel by a number, letter, symbol, name, or a combination of the above. Grade is used to denote chemical composition; type is used to indicate deoxidation practice; and class is used to describe some other attribute, such as strength level or surface smoothness. There are several types of designation systems in use by shaft seal manufacturers based on where they procure the raw material. Typically, carbon steel shaft seals manufactured in continental Europe will have a DIN designation and custom metal cased seals manufactured in the UK will have a BS-EN designation. Rotary seals manufactured in Taiwan or China would have a CNS or YB designation for their steel cases.

The most widely used standard specifications for steel products in the United States are those published by ASTM. These are complete specifications, indicating chemical properties (composition), mechanical properties (tensile strength etc), thermal properties and electrical properties. Many ASTM specifications apply to specific products, such as ASTM A1008, which covers cold-rolled, carbon steel sheets, in coils and cut lengths. These specifications are generally oriented toward performance of the fabricated end product. ASTM specifications represent a consensus among producers, specifiers, fabricators, and users of steel products. In many cases, the dimensions, tolerances, limits, and restrictions in the ASTM specifications are similar to or the same as the corresponding items of the standard practices in the AISI Steel Products Manuals.

Shaft seal cases may also be made from brass or aluminum. These materials are more expensive than cold-rolled steel and are more difficult to form, but do have advantages when used for a seal case in the appropriate environment. For instance, aluminum cased shaft seals are typically used on aircraft applications or where a light weight seal is needed. Aluminum also provides the same coefficient of thermal expansion when used in an aluminum bore. Shaft seals constructed using a brass case will be used to reduce the risk of sparks in fire-safe applications. They can also be found in use in the petrochemical industry.

Shaft seals for use around food or water are required by the Food and Drug Administration (FDA) to have stainless steel cases. Stainless steel cased shaft seals are typically used in the food processing, chemical processing and pharmaceutical industries because of its corrosion resistance and durability. However, not all stainless steel is equal. In general, the properties of the stainless steel alloy are related to its relative composition with regard to chromium and nickel level. Corrosion resistance varies with chromium level, and structural strength varies with nickel level. The American Iron and Steel Institute (AISI) 300 Series Stainless Steel, commonly recommended for food contact surfaces, may be also termed as 18/8 stainless steel indicating that it is 18% Cr and 8% Ni. 3A Sanitary Standards require 316 (or 18/10) stainless steel for most surfaces. They allow the use of 304 stainless steel only for utility usage (e.g. pipes), and restrict the use of 303 stainless steel. In highly corrosive environments, a stainless steel case (SAE 30302 to 30304, AISI 302 to 304) may be needed. Stainless steel cased seals are more expensive than carbon steel cased seal. Typical stainless steel types used on rotary shaft seals include:

- Type 304—the most common grade; the classic 18/8 stainless steel. Also referred to as "A2" in accordance with ISO 3506. Typically used on seals found in food processing plants requiring a high degree of sanitation where the seals may be exposed to Clean-In-Place (CIP) or Sterilize-In-Place (SIP) processes.
- Type 316—the second most common grade (after 304). The addition of molybdenum prevents specific forms of corrosion and provides increased resistance to chloride corrosion. Seals with a SS 316 case are typically used in the chemical processing industry in equipment such as separators and pressure vessels.

3A Standards also provide specifications regarding alloys and other coatings used in shaft seal cases. The properties of stainless steel can change with continued use, especially under conditions where the chromium oxide layer is altered i.e when coming in contact with incompatible cleaners, abrasive media or chlorine rich environments sometimes found in food processing environments. Therefore, it is recommended that shaft seal surfaces be passivated (using nitric acid or other strong oxidizing agents) initially and on a regular frequency thereafter, to maintain a passive (non-reactive) oxide film on the shaft seal case

Steel grades to classify various steels by their composition and physical properties have been developed by a number of national standards organizations. These standards include British Standards – BS, Japanese steel grades – JIS standard and China steel grades - GB standard to name a few. These national standards would be compaed in a future article from Colonial Seal Company.

Given the various profiles, materials, and applications that rotary shaft seals are exposed to, understanding how the elements of a shaft seal's design interact is critical to an effective sealing system. As we discussed above, the case is one of several critical components that needs careful attention because of the myriad of variables that contribute to its design. From the case profile, to the type of material used and even the source of the material, a rotary shaft seals case can be configured to match any operating environment. The above information is provided only as a guide in helping you select the type of seal case for your application. Please Colonial Seal Company, at 800.564.2201 or email sales@colonialseal.com, if you have any concerns about the optimal seal case required for your specific application.

References

1. Shaft Seals for Dynamic Applications
2. SAE Fluid Sealing Handbook Radial Lip Seals 1996 Edition
3. American Iron and Steel Institute