When it comes to maintaining a high-functioning rotary shaft, you need to select the appropriate lip seal.

The shaft seal protects the rotary shaft from contaminants such as dust and dirt, and it keeps water out and lubricant in.

A rotary seal, also known as a radial shaft seal, typically sits between a rotary shaft and a fixed housing — such as a cylinder wall — to stop fluid leaking along the shaft. The rotary seal’s outside surface is fixed to the housing, while the seal’s inner lip presses against the rotating shaft.

Common applications for shaft seals include motors, gear boxes, pumps and axles. They’re also increasingly used for food and chemical processing, as well in pressurized gas applications.

Three of the most important considerations when the choosing the best lip seal for a rotary shaft are:

1. The material the seal is made of,
2. the hardness of the shaft’s surface, and
3. the roughness of the shaft’s surface.

Here’s your quick go-to guide on how to achieve optimum performance and longevity for your seals and shafts, ultimately minimizing the risk of seal failure. Presented by our partners at Eclipse Engineering:
What Material Is Best for Rotary Seals?

The standout material of choice for a rotary shaft lip seal is polytetrafluoroethylene, also known as PTFE. This material is commonly used in seals because of its extremely low friction and resistance to wear and tear.

It also performs exceptionally well at high operating temperatures, requiring minimal lubrication. Plus, it is compatible with many chemicals, making it a good universal choice.

Rotary shaft lip seals made of PTFE are very tough and have a low coefficient of friction, which allows them to slip over the highest points of the mating surface (in this case, the rotary shaft) while resisting abrasion. And they can do it without lubrication.

Which Properties of Metal Rotary Shafts Most Affect Sealing Performance?

The roughness and hardness of a metal rotary shaft are the two most important characteristics to be considered when designing a lip seal for the shaft. Let’s look first at roughness.
What is Roughness in a Rotary Shaft?

Roughness, in the context of a rotary shaft, refers to the unevenness of the surface of the shaft. The way we measure shaft roughness is by measuring the high and the low points of the shaft’s surface, then calculating the difference. This is called the machined tolerance.

Roughness can be minimized by properly finishing the surface of the shaft. A well-finished surface with an appropriately machined tolerance will allow for excellent seal performance, as well as longevity.

A rotary shaft with a high surface roughness can allow paths for leakage through the low points on the shaft’s surface. The abrasiveness of the surface can also wear down the seal quickly, leading to failure.

Generally, the smoother the rotary shaft surface, the better the seal will perform. However, excessive smoothness beyond spec can actually decrease the effectiveness of a seal. This is because in extremely smooth surfaces, a film of lubricating fluid is not allowed to flow between the seal and the mating surface.

The passage of this film lubricates the seal and extends its longevity. Without it, the seal will wear out sooner. Essentially, if your rotary shaft’s surface is too smooth, a seal will perform too well — until it doesn’t.

What is Hardness in a Rotary Shaft?

The hardness of a rotary shaft is measured by looking at how deep an indenter can penetrate into the surface of the shaft when forced upon it at high pressure. Using a Rockwell scale, we can measure the penetration depth relative to that made by a reference pressure.

A seal should always be softer than the rotary shaft. This ensures it wears out instead of the shaft. So the harder the shaft, the more options you have for seal material.

In metal rotary shafts, the harder the surface, the better. Increased hardness allows for the use of highly reinforced seal materials, which will increase the lifespan of both the lip seal and the shaft itself.

The alternative, a softer metal shaft, is susceptible to abrasion and erosion from the best seal lip materials (PTFE). So when you’re working with a soft rotary shaft, you need to use a softer seal. This is a workable solution, but it does mean you’ll be stuck with a shorter seal life.

There is, though, one advantage to keeping rotary shaft surface hardness below 45 on the
Rockwell C scale, and this is that most seals will actually polish the shaft surface during the initial “bedding in” period.

After that period, the wear upon the rotary shaft will ease off, depending on the PTFE material of the seal, the shaft’s surface finish, and Pressure*Velocity (PV rating) of the application.

When hardness exceeds 45 Rockwell C, the initial manufactured surface finish is absolutely crucial to seal life. Why? Because there is not much polishing allowed for in the “bedding in” period. When hardness is high, any roughness in the surface will cause wear on the seal.

So as you can see, the roughness and hardness of the surface of the rotary shaft are not independent properties when it comes to lip seal design — as the hardness goes up, roughness needs to go down. Alternatively, a less hard surface allows for a bit more roughness.

**What is the Recommended Hardness for a Rotary Shaft?**

The ideal hardness for a metal rotary shaft depends on shaft speed and environmental pressure.

- At the low end of the spectrum, in rotary shaft speeds up to 150 sfpm (0.76 m/s), with 0 psi, hardness should be at least 35 Rc (with high lubrication) or 44 (if no lubrication).
- 70+ Rc may be required for 1000 psi at the same speed (up to 150 sfpm).
- 60+ Rc may be required for 2500 sfpm at the same pressure (0 psi).

In typical engineering practice, the hardness used is normally a compromise between the expense of harder finish metals and seal life. As with any design task, the challenge is finding a solution that meets not only the technical requirements, but also falls within the logistical (i.e., budgetary) limits.

**Achieving the Optimum Match Between Rotary Shaft and Lip Seal**

Because of the wide range of PTFE fillers and material specifications, it’s not always easy to find exactly the right rotary seal for your shaft to ensure optimum seal effectiveness and longevity.

If you can’t find an existing shaft seal that meets your needs, you may need to design a custom seal. That’s where Gallagher Fluid Seals and our partners at Eclipse can help you achieve your specific application criteria for your sealing needs.
The original article was written by Cliff Goldstein at Eclipse Engineering and can be found here.

For more information about rotary seals or lip seals, contact Gallagher Fluid Seals today.