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You don't want to compromise a quality gearbox by scrimping on seals and filters. Here's the first in a two-part series, this one devoted to seals.

The gear unit designer pays careful attention to the housing, gears, bearings, and lubrication, but quite frequently the seals and filters are an afterthought. Technical writings and many standards are also very light on the subject. All too frequently they advise contacting the manufacturer as the solution, which is not altogether bad advice.

Seal manufacturers maintain vast experience in seal performance. SAE first issued Recommended Practice J946 "Guide to the Application and Use of Radial Lip-Type Seals" 50 years ago. For a known application manufacturers can make a recommendation, however, because although it is not possible to actually see the seal's performance, their information is based on testing and past experience.

Conventional seal design is a trial and error process, using finite element analysis. Seal selection is frequently an imprecise and time-consuming process, but mechanical seals are the most likely component to fail. The seal's compatibility with the lubricant may require a prolonged test. Some of the required qualities are obvious, but others—such as the strength to resist extrusion under maximum temperature and pressure, stability to resist twisting, and deformation—are not so clear. The selection of seals depends on the environment and the duty. Low speed applications with rolling element bearings are inclined to use elastomeric lip seals with a limiting speed in the range of 3600 fpm.

There is a choice in materials: from low cost nitrile for general use; polyacrylate, which has the ability to resist extreme pressure type additives; silicone rubbers, with excellent high and low temperature properties; fluorocarbons for extreme temperatures; and TFE, which has resistance to aircraft fuels and lubricants. Each material has its own advantages and disadvantages. Buna N seals have a temperature limit of 225°F, polyacrylic 300°F, and Viton 500°F. The seal life of a nitrile seal reduces from 9,400 hours at 155°F to 3,000 hours at 200°F. Some elastomers harden when subjected to extreme pressure additives. The seal's material is sensitive to heat and can absorb oil, changing its properties. In order for the lip-seal to succeed there must be a lubricant film between the lip and shaft, usually about 0.1 mil, and interference in the order of 0.035 in. The thickness is controlled by the mechanical pressure of the seal element and the shaft finish; too thick a film and fluid leaks, too thin and the lip wears and a "slip stick" situation arises. As the lip temperature increases the oil film thins, and even breaks down. The majority of lip-seals will leak a drop of oil every 12 hours or so. Excessive shaft movement will also affect satisfactory performance from lip seals. The AGMA also advises that lip-type seals have a finite life and, at higher speeds, become a fire hazard. Some applicational standards—such as API 613 "Special Purpose Gear Units for the Petroleum, Gas, and Chemical Industries" and API 677 "Gear Units for Refinery Service"—ban lip-type seals in favor of labyrinth seals with deflectors that are made from non-sparking materials. The labyrinth seal limits any leakage by maintaining a close radial clearance between the fixed housing and rotating shaft. Both types of seals will permit oil leakage if the external ambient pressure is lower than the internal pressure of the unit.

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There are several solutions in such instances. Lip-seals can be supplied with a higher spring force, being careful to see that this does not result in excessive wear. A face seal can be used, which seals against small pressure differentials. Labyrinth seals can be internally pressurized or internally drained. A pressure differential of 1-2 psi is usually sufficient to eliminate oil leakage. The shaft finish is critically important and should be between 10 to 20 µin. The two or more knife edges of the seal permit for a drain hole between them that allows the seepage to drain into the housing. Seals have limited life; long life is considered to be in excess of 1,000 hours. The main factors influencing the selection are expected life, wear resistance, pressure, material, temperature, and vibration. Most operations stock spare seals, but some fail to realize seals are delicate and suffer from improper storage and handling.

Seals are constantly being improved. In 1927 the big breakthrough was assembled leather seals that could be press-fitted into a housing. In 1934 the leather was clinched in an outer ring with an added spring. In 1936 the leather was replaced with rubber bonded to a metal stamping. The first Buna-N material developed in Germany became available to U.S. industry in 1939. By 1945 rubber could be bonded without requiring holes in the stamping. Joints today are stronger than the rubber itself. The conclusion to this series, on filters, will appear in the August issue of *Gear Solutions* magazine.

ABOUT THE AUTHOR:

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