Springer Vieweg

MTZ extra

ElroSeal™ E

High-performance Rotary Shaft Seals for Electric Drives

elringklinger
Engineered Plastics

ElroSeal E – A New Standard for Electric Drives

Electric mobility and alternative drive systems are responses to climate change, diminishing fossil resources, and local environmental pollution. Electric motors form the basis of battery-powered, fuel cell, and hybrid drives. ElringKlinger has developed a series of gaskets for high-speed applications, based on the Speedflon high-performance seals, especially for electric mobility.

AUTHORS

Dipl.-Ing. (FH) Uwe Koch
is the responsible Product Engineer for Rotary Shaft Seals at ElringKlinger Kunststofftechnik GmbH in Bietigheim-Bissingen (Germany).

Dr.-Ing. Uwe Wallner
is Head of Product Development at ElringKlinger Kunststofftechnik GmbH in Bietigheim-Bissingen (Germany).

HIGH SPEEDS

The trend is toward integrated e-axles, where the electric motor, transmission, and drive axle are combined in a single unit. At the transition between the electric motor and transmission, speeds of 12,000 to 17,000 rpm create conditions that place substantially greater demands on the gasket than the speeds of a combustion engine, and the trend is toward even higher values. Extreme challenges arise from the necessary shaft diameters due to very high circumferential speeds in combination with operating conditions at high and low temperatures, the required chemical resistance, and potential dry-running phases. Conventional elastomer rotary shaft seals reach their limits here.

Based on experience with very high-speed Speedflon rotary shaft seals [1] for speeds exceeding 150,000 rpm, ElringKlinger Engineered Plastics has developed the new ElroSeal sealing system modules, **TABLE 1**, to meet these difficult conditions for specific applications.

All seals can be optimized specifically for customers and adapted to the required speeds and direction of rotation. Spiral structures on the shaft, or special profiling of the sealing lip, can generate a hydrodynamic transport effect that further improves dynamic oil sealing behavior. The benefit is that this is possible with very low radial sealing lip contact pressure and low frictional losses. Combined with ElringKlinger's alternating spiral design, the sealing function can be ensured in both directions of rotation.

MATERIAL

The use of the right sealing lip material also plays a critical role. ElroSeal seals are produced with sealing lips made of PTFE compounds. The fillers incorporated in the PTFE base material have been adapted specifically to this application by in-house material development.

Soft shafts can be sealed successfully with the use of special filler materials. Electrically conductive fillers can also be incorporated in the sealing lip material to prevent static charge buildup. The best results with respect to wear under dry running conditions were shown by the material polytetraflon HS 22157, which produced the results listed below.

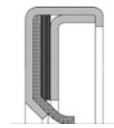
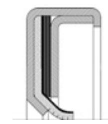
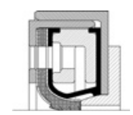
Description	Design example	Recommended circumferential speed	Special feature
ElroSeal E		20 to 40 m/s	Reduced-friction seal design
ElroSeal E Speedflon		40 to 60 m/s	Single-spring design
Speedflon	 	60 to ≥ 100 m/s	Double-spring design with patented pressure relief system for turbochargers and other applications

TABLE 1 Representatives of the ElroSeal family of seals (© ElringKlinger)

TEST CYCLE

To evaluate the sealing properties and promote targeted further development, ElringKlinger runs specially developed rotary shaft seal test benches that can map speeds of up to 150,000 rpm. The results below were obtained using test benches with a maximum speed of 50,000 rpm, designed especially for applications in electric mobility.

Various approaches exist to determine service life, leakage, or wear behavior. There are manufacturer-specific test cycles based on ISO 19865-4, **FIGURE 1**.

The test cycle shown describes a typical driving situation with city traffic, country roads, and freeway portions. The freely programmable speed is 16,000 rpm at maximum, the medium temperature is 135 °C, the pressure corresponds to the ambient pressure. This cycle is repeated until the required test duration has been reached. **FIGURE 2** shows the result of the wear test.

FRICTIONAL LOSS AND WEAR

The wear curve shows a typical pattern for rotary shaft seals, with greater wear during the run-in phase and asymptotic behavior toward the end. Rotary shaft seals lubricated with oil were investigated. Wear behavior with insufficient lubrication, and partial dry running, is shown in the limit curve.

The frictional loss of a rotary shaft seal is critical to its functional behavior. Too much frictional loss can cause high temperatures, leading to rapid failure of the sealing system. The frictional losses of ElroSeal seals at various speeds are shown in **FIGURE 3**. Regardless of the direction of rotation, the frictional loss increases as speed increases at a constant temperature. At an increased temperature of 135 °C, the

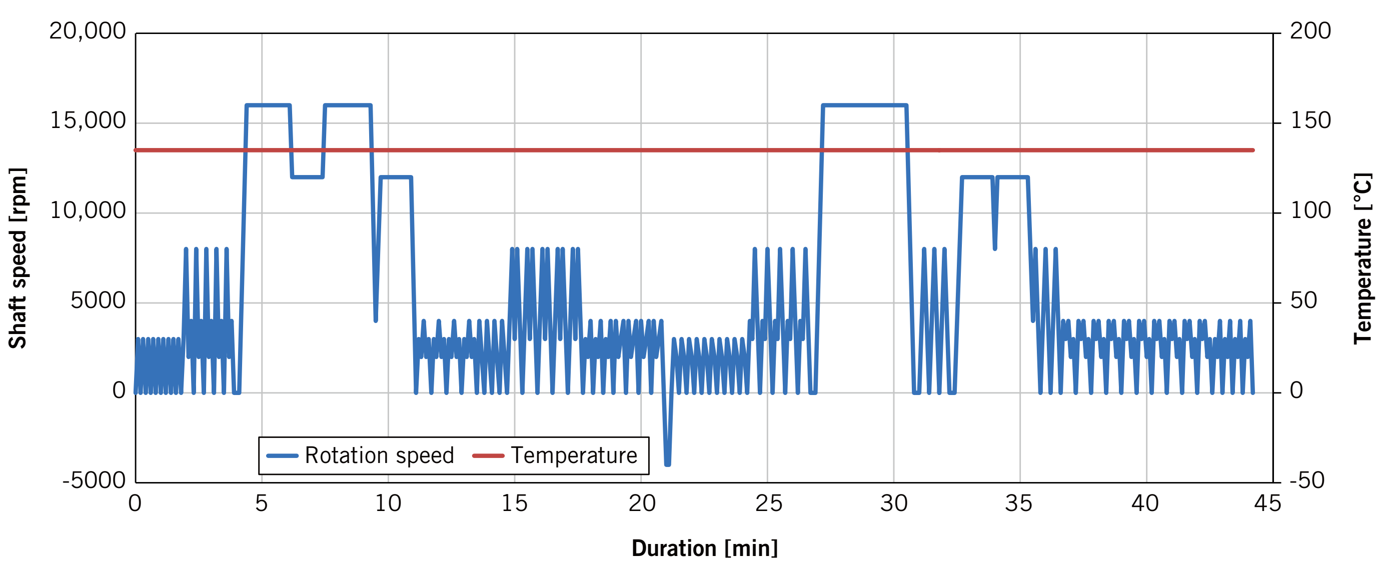


FIGURE 1 Temperature and speed cycle per ISO 19865-4 (© ElringKlinger)

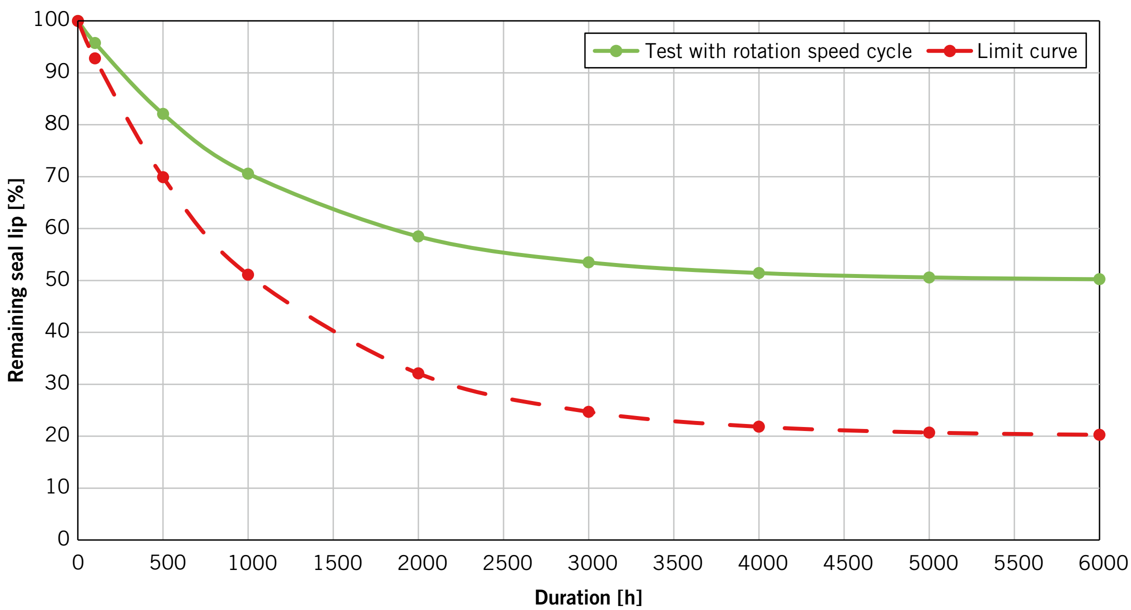


FIGURE 2 Wear curve for ElroSeal E with 38 mm shaft diameter; speed cycle per ISO 19865-4 up to 16,000 rpm (© ElringKlinger)

seal shows permissible levels of frictional loss. This means that the seal functions without leaking, even under deteriorating lubrication conditions.

ElroSeal rotary shaft seals demonstrate only a slight decrease in radial sealing lip contact pressure with very low frictional loss after running with oil or dry, **FIGURE 4**. The comparison with an elastic sealing lip material shows significantly higher residual force here.

ElroSeal PTFE rotary shaft seals demonstrate a significantly lower drop in radial force, both in lubricated and dry conditions, in comparison with the measured elastomer rotary shaft seal.

STATIC LEAK TIGHTNESS

In addition to the dynamic properties, static leak tightness is another significant property when considering the system. Static sealing behavior of the shaft seal is determined in part by pressing the seal into the installation space. This property is checked with a static air leak test on the test bench or as an end-of-line test during assembly. Static leak tightness is tested according to an internal standard at a temperature of 23 °C and test air overpressure of 0.2 bar after 5 s. The maximum permissible pressure drop is 0.05 bar.

In application, the shaft seals are typically pressed into aluminum installation spaces. The ElroSeal design has been customized for this application in terms of press-in force and static sealing behavior. This means that ElroSeal seals can be used in aluminum installation spaces, even with suboptimal surface roughness in the installation space and without additional elastic coatings on the outer diameter of the housing.

This has the advantage that critical conditions can be avoided after temperature effects, aging, or chemical exposure in comparison with elastomer-coated outer housings, by reducing press-in force. In the example above, the press-out force after the test cycle (100 h, 135 °C, transmission oil) was determined as only 23 % of the press-in force. ElroSeal PTFE rotary shaft seals demonstrated very good residual force, at 67 % press-out force to press-in force.

Much discussed is the influence of the surface conditions of the installation space on static leak tightness. Tests show no problems when installing ElroSeal E in aluminum

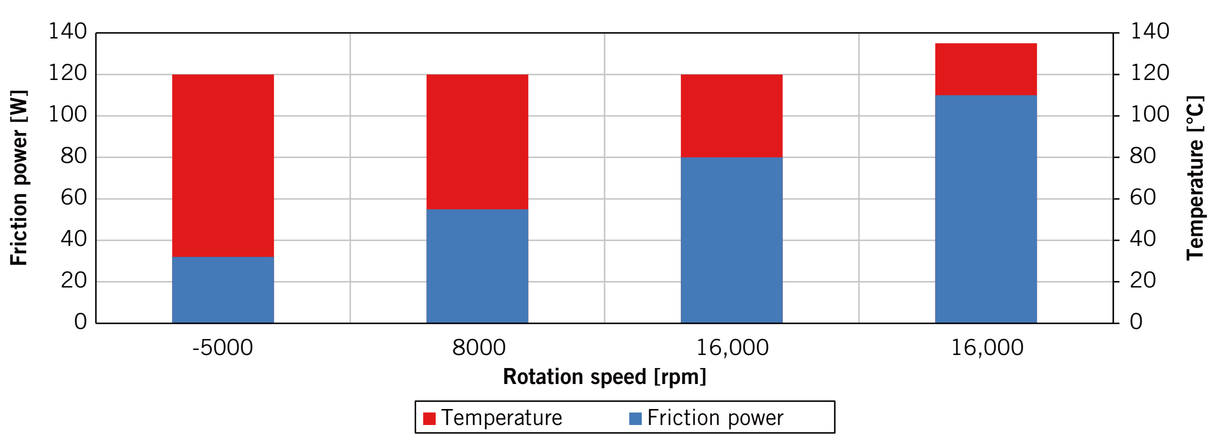


FIGURE 3 Frictional loss at various speeds and temperatures; ElroSeal E with 38 mm shaft diameter; constant speed per DIN 3760 (© ElringKlinger)

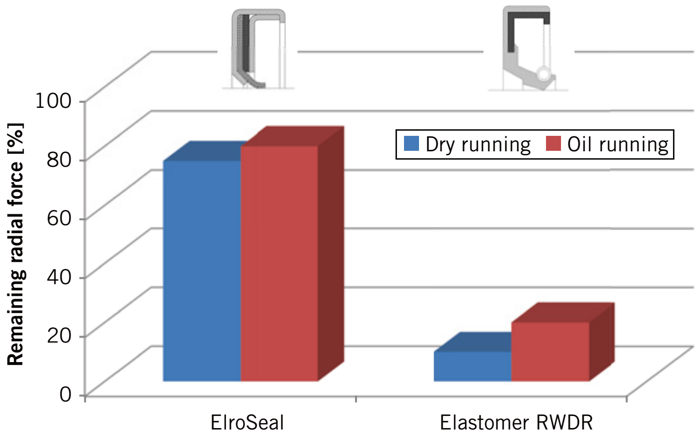


FIGURE 4 Radial force after 100 h of testing under dry-running and oil-lubricated conditions, after running the test cycle for 100 h at a maximum of 16,000 rpm (© ElringKlinger)

installation space with high roughness. An elastomeric layer at the outer diameter is not necessary.

To test this, ElroSeal seals with stainless steel housings were pressed into an aluminum installation space with a uniform H_8 borehole. The outer surface roughness of the shaft seal was produced at a standard surface roughness of ≤ Rz 8 µm. The inner aluminum surface is produced in a turning process with a surface roughness of Rz 21.1 µm. To evaluate the press-in conditions, an average press fit was set up between the outer diameter of the seal housing and the diameter of the installation space.

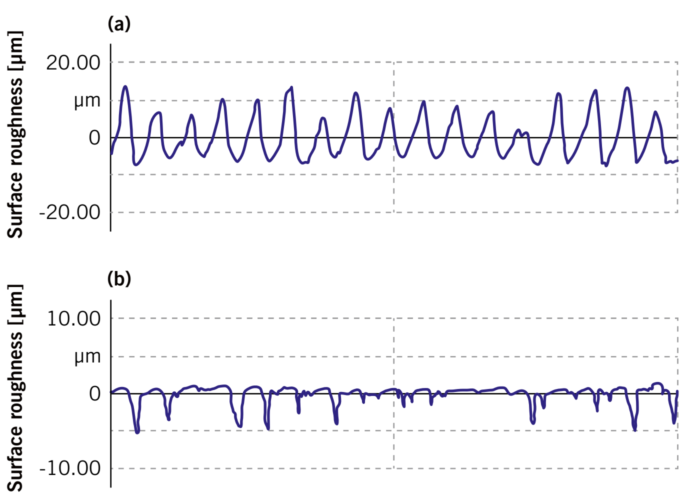


FIGURE 5 Surface roughness of the installation space before installation (a) and after installation (b) (© ElringKlinger)

After pressing in the seal with about 6000 N, the surface of the aluminum installation space was measured again in the region of the press-in surface. With a surface roughness of Rz 6.9 µm, significant smoothing of the aluminum surface was evident. The special outer geometry produced compression of the aluminum installation space without forming chips. When the seal is pressed out afterward, running counter to the press-in direction, only a slightly lower press-out force was measured in comparison with the press-in force, **FIGURE 5**.

The percentage contact area increases in the example shown from 22.2 to 84.8 %. Static leak tests demonstrate that ElroSeal rotary shaft seals fulfill the requirements for static leaktightness without any additional elastic housing coating.

SUMMARY

ElroSeal rotary shaft seals demonstrate excellent leakage behavior, even in the conditions required for electric mobility. After long periods of dry running, the shaft seal still holds up without leaking in a subsequent oil run. By smoothing the aluminum installation space, the ElroSeal E rotary shaft seal places no special requirements on the surface there. The sealing concept is also ideal for very high-speed applications due to its low and constant frictional loss and very good wear resistance over the required service life. For these reasons, ElroSeal rotary shaft seals are already in use in many electric mobility applications.

REFERENCE

[1] Cankar, M.; Koch, U.: New Radial Shaft Seals for Turbo Applications. In: MTZworldwide 11/2016, pp. 56-60

IMPRINT:
Special Edition 2021 in cooperation with ElringKlinger Kunststofftechnik GmbH, Etzelstr. 10, 74321 Bietigheim-Bissingen; Springer Fachmedien Wiesbaden GmbH, Postfach 1546, 65173 Wiesbaden, Amtsgericht Wiesbaden, HRB 9754, USt-IdNr. DE811484199

MANAGING DIRECTORS:
Stefanie Burgmaier | Andreas Funk | Joachim Krieger

PROJECT MANAGEMENT: Anja Trabusch

COVER PHOTO: © ElringKlinger Kunststofftechnik