FLUID SEALING ASSOCIATION FSA

From the voice of the fluid sealing industry

SEALING SENSE

What is the most effective seal design when misalignment is present?

Shaft misalignment is one of the most common causes of premature mechanical seal failure. Higher leak rates typify these failures. Rapid failures can occur in high pressure and speed applications.

Misalignment may be static or dynamic in origin. *Static* misalignment is measurable when the equipment is not in operation, while *dynamic* misalignment is detectable only during operation. Static misalignment is most prevalent and will be our focus. Causes of static misalignment include parts that are out of tolerance, static shaft deflection and improper installation.

Evidence that misalignment was the cause of a seal failure includes one or more of the following: broken springs, worn and/or extruded dynamic gaskets, fretting corrosion of metal surfaces adjacent to the dynamic gasket or worn drive mechanisms. No single mechanical seal design can fully compensate for poor alignment. Some designs are more forgiving of misalignment than others, but there can be performance compromises when selecting the seal design that best compensates for poor machine alignment. The first priority should always be to correct the misalignment so optimum seal performance can be achieved.

Causes of Misalignment

Seal housing misalignment may be caused by a permanent bend in the shaft, excessive shaft deflection or by misalignment between the rotor assembly and the seal housing. Determining shaft condition should be the first step when checking for misalignment at the seal housing.

Bent shaft

A bent shaft is easy to detect but often difficult to repair. To determine if a shaft is bent at the seal housing, mount a dial indicator on a stationary surface and measure the runout on the shaft sleeve while turning it 360-deg. *Total Indicated Runout (TIR)* of more than 0.002-in (0.05-mm) warrants a repair or replacement of the pump shaft.

It is possible for the shaft to be bent at a location that will not be evident when checked at the shaft sleeve. A shaft should also be checked for straightness if vibration readings indicate an out-of-balance condition. The detection procedure is the same. Mount the indicator on a stationary surface and take a reading from the shaft while turning it.

It is usually less expensive and more reliable to replace a bent shaft than to straighten it.

Shaft Concentricity and Parallelism

Misalignment from a lack of concentricity or parallelism can be measured by a dial indicator on the shaft. While rotating the shaft and dial indicator, measure runout on the seal housing bore or register for concentricity at the seal housing face for parallelism (angularity).

If the seal housing concentric runout is greater than 0.005-in (0.125-mm) or the face runout is greater than 0.0005-in/in (15μm/3cm) of seal housing bore diameter, further investigation and corrective action is warranted. Potential causes of an out-of-tolerance seal housing runout reading include:

- Excessive static shaft deflection
- Out-of-tolerance assemblies
- Deformation of the pump assembly due to high structural loads

Tolerances

Misalignment from the tolerances of the assembled machined components is harder to detect. There are usually several register fits between the bearing supports and the seal housing. These fits need to be machined concentric and square.

Measurements should be made on a machine. Although an individual register may appear to be out of tolerance by only a small amount, it is important to remember that the total misalignment of the assembled parts will be the sum, or stack up, of the individual component misalignments. Register fits are subject to wear and corrosion over time and should be checked as part of any major maintenance.

Mounting

Many pumps have four or more mounting pads for mounting the pump to the baseplate. A pump often does not have 100 percent contact with all of the baseplate mounting surfaces. This is often called a *soft foot* condition.

Bolting a pump to a base with a soft foot condition may result in misalignment of the pump shaft to the seal housing and place stress on the bearings and other components. To check for soft foot, mount a dial indicator on the baseplate and take a measurement from the pump adjacent to a hold-down fastener. A change of the indicator of more than 0.002-in (0.05-mm) while tightening or loosening a hold-down fastener indicates a soft foot. Use stainless precision shims between the baseplate and pump to compensate. It is generally good practice to monitor shaft runout at the seal

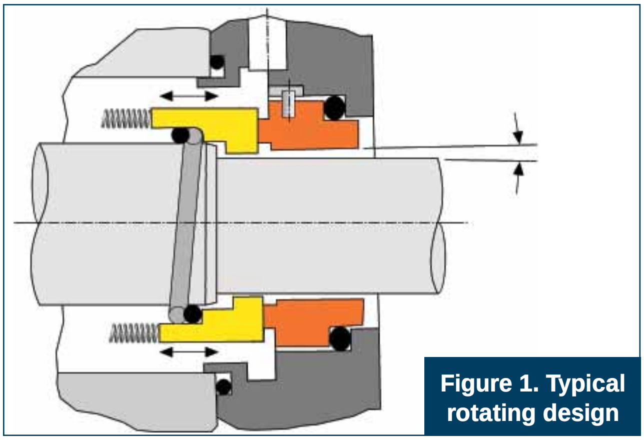

Figure 1. Typical rotating design

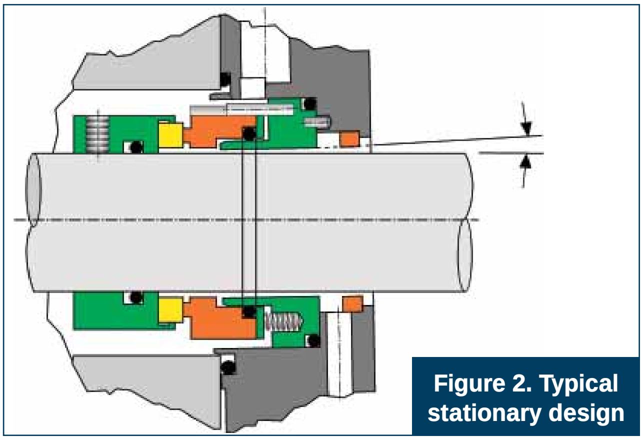

Figure 2. Typical stationary design

housing while installing a pump on its baseplate and connecting the pump to its piping.

Flanges

Mating flanges should be concentric and parallel. Bolting of misaligned piping to a pump will cause both the piping and the pump to distort. The amount of distortion is relative to the size and strength of the pump and piping, as well as the distance from the nearest fixed hold down. A good rule of thumb is that if mechanical leverage is needed to bring the flanges into position, then the nozzle loads should be checked.

If the piping connections are suspected, mount a dial indicator to check for shaft alignment at the seal housing to check shaft angularity and parallelism. If connecting or disconnecting the piping changes the shaft alignment, corrective action should be taken.

Seal Designs

Most seal designs are manufactured to operate with a maximum angular misalignment of 0.003-in (0.08-mm). This includes the out-of-square tolerance and the shaft-to-seal chamber bore concentricity. There are two primary designs used to accommodate misalignment. One design utilizes a *rotating compression unit* where the springs rotate with the shaft.

The other, a *stationary design,* uses a stationary compression unit where the springs do not rotate with the shaft. The stationary

Fluid Sealing Association

Sealing Sense is produced by the **Fluid Sealing Association** as part of our commitment to industry consensus technical education for pump users, contractors, distributors, OEMs and reps. *This month's Sealing Sense was prepared by FSA Member Phil Peck.* As a source of technical information on sealing systems and devices, and in cooperation with the **European Sealing Association**, the FSA also supports development of harmonized standards in all areas of fluid sealing technology. The education is provided in the public interest to enable a balanced assessment of the most effective solutions to pump technology issues on rational total Life Cycle Cost (LCC) principles.

The **Mechanical Seal Division** of the FSA is one of five divisions with a specific product technology focus. As part of their mission they develop publications such as the *Mechanical Seal Handbook*, a primer intended to complement the more detailed manufacturer's documents produced by the member companies. This handbook served as the basis for joint development of the more comprehensive *Hydraulic Institute* publication: *Mechanical Seals for Pumps: Application Guidelines*. Joint *FSA/ESA* publications such as the *Seal Forum*, a series of case studies in pump performance, is another example as is the *Life Cycle Cost Estimator*, a web-based software tool for determination of pump seal total Life Cycle Costs. The Sealing Systems Matter initiative was also launched to support the case for choosing mechanical seals that optimize life cycle cost, safety and environmental compliance.

The following members of the **Mechanical Seal Division** sponsor this *Sealing Sense* series:

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design compensates for misalignment with one adjustment, while the rotating design must compensate at every revolution of the shaft. This movement predisposes the spring mechanism to fatigue, which can cause premature failure. The stationary design is the better choice when misalignment occurs.

The same concept also applies to welded metal bellows technology. Utilizing a stationary bellows allows for a one-time reposition of the stationary face, eliminating constant flexing/movement of the thin cross section bellows leaflets.

Most of the seal manufacturers use the flexible stationary design in their modular or cartridge seals because of space limitations. The excessive flexing and fatigue of the many thin cross-section springs is avoided, as is contact with the process fluid.

Stationary designs are gaining acceptance for several other reasons. First, they keep the small multiple springs out of direct contact with the product being pumped. Many fluids contain solids which can clog the small multiple springs, hang up the seal and cause premature failure. Second, high speed applications—those with shaft speeds in excess of 4,500 feet per minute (23-m/s)—usually require special design attention. Above this speed, dynamic forces begin to exceed the limitations of a conventional rotating design.

Utilizing the stationary design reduces the secondary seal and drive mechanism movement, which could cause excessive wear and fretting damage. The stationary design also provides better seal face tracking capability and improves seal life. Further, the drive mechanisms can be increased to handle the higher torques associated with these speeds.

Summary

Mechanical seal failures are usually the symptom and not the cause of maintenance problems, many of which are related to static misalignment. In operation, other forces such as radial loads, impeller balance and cavitation also affect seal alignment. While some seal designs are more tolerant of misalignment, they ultimately are not the solution for a misaligned system. Optimum performance, which includes maximum seal life, can only be achieved by correcting the root cause of the misalignment. Always try to obtain more detailed information about suitable seal designs from seal manufacturers.

Next Month: *What is the impact of flange finish on gasket performance?*

We invite your questions on sealing issues and will provide best-effort answers based on FSA publications. Please direct your questions to: sealingquestions@fluidsealing.com.

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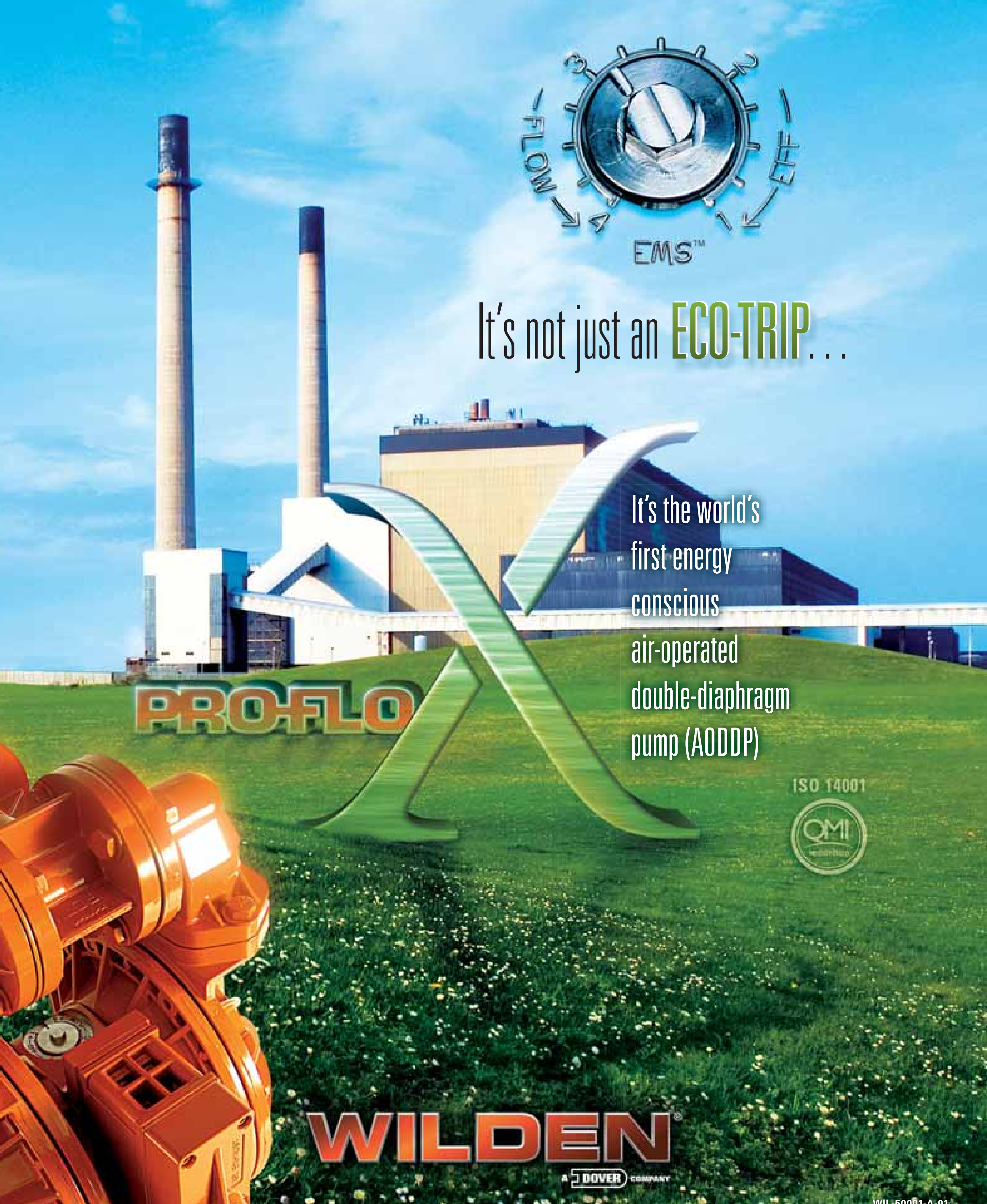
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