FLUID SEALING ASSOCIATION FSA

From the voice of the fluid sealing industry

SEALING SENSE

Q. *Can I seal vertical shafts with standard mechanical seals?*

A. Mechanical seals are used to seal vertical shafts every day in industry. Selecting the correct design and piping plan will lead to longer seal life and more reliable equipment operation. Vertical-shafted fluid handling equipment, though, presents slightly different sealing challenges than those found in other types of equipment.

With vertical shafts, four variables influence choice of seal design, seal face materials and piping plan. They are: shaft speed, pressure, shaft size and equipment function.

Shaft speed typically is characterized as low-, high- or extremely high-speed service. Low speed is typically defined as rotating at or below 300 RPM; high speed as 300 to 3700 RPM, and extremely high speed as above 3700 RPM.

Shaft size also is an important sealing consideration. The seal's velocity is defined as the speed of a point at the center of the narrow seal face (or the corresponding wide face, if it rotates) and the distance that point travels in a given time interval. Imperial units identify this velocity as "surface feet per minute." The diameter of the shaft, at this point, is converted to the circumference of its path during rotation and then multiplied by the number of revolutions per minute. Smaller-diameter shafts will have a lower velocity, while larger shafts at the same speed will experience a higher velocity given the same rotational speed. This means that a 2" shaft rotating at 200 RPM, sealing 45 PSIG, can be sealed without liquid face lubrication, while a 4" shaft under the exact same speed and pressure will suffer rapid wear and failure.

Surface speed is important because most mechanical seals can run with vapor lubrication up to the Pressure-Velocity (PV) limit of the seal face material combination. The PV limit is expressed mathematically via the PV expression that describes the forces and velocity acting on the seal faces.

Manufacturers test their seal face material combinations during the product design and evaluation phase. During this phase, they run these combinations with and without liquid lubrication under increasing pressure at a constant speed. Rapid wear or leakage as pressure is increased indicates a failure point. The failure point establishes the PV limit of the face material combination. Slower-speed, lower-pressure services can often be sealed without liquid lubrication to the seal faces. Higher-speed and extremely-high-speed services require either liquid lubrication to the seal faces or a film of gas between these faces to prevent material breakdown. Check with your seal vendor for their limits and expected performance under dry-running conditions.

$$PV = (P_{sp} + P_p(b-k))*V_m$$

Where:
P_{sp} = Spring pressure in Kg/cm² or Psi
P_p = Sealed pressure in Kg or Psig
b = Seal Balance (Example 80% = .8)
k = Pressure Drop Factor(50% or .5 is common)
V_m = Velocity of mean diameter in meters/second or feet per minute

Pressure velocity expression

Pressure typically is characterized as low, high or extremely high pressure. Low pressure generally is considered below 30 PSIG, high pressure over 100 PSIG and extremely high pressure above 600 PSIG. Lower-pressure services often can be sealed without liquid lubrication to the seal faces. High-pressure and extremely-high-pressure services require either liquid lubrication to the seal faces or a barrier of gas between the seal faces to prevent breakdown of the materials.

Equipment function is crucial in determining which seal design and piping plan should be used. Some equipment that typically uses vertical shafts is listed below:

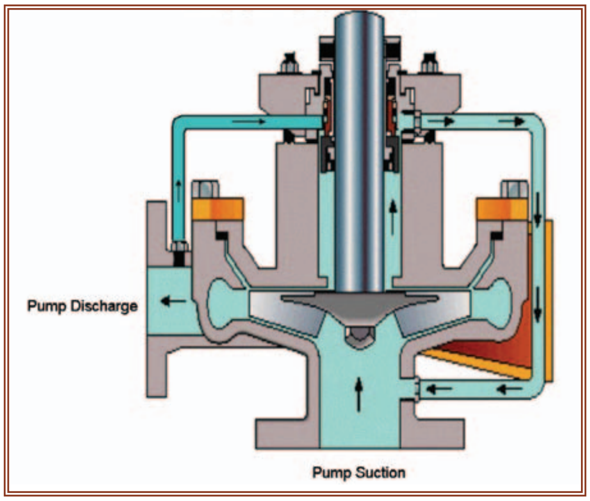
Submersible Pumps are usually found in higher-speed services. The intent of most mechanical seals in submersibles is to protect bearing lubricant from the flow stream. Generally, these seals are single or dual liquid-lubricated designs. Dual liquid-lubricated seals typically use a reservoir to provide clean fluid to the inner and outer dual mechanical seals.

Vertical Single Stage Pumps circulate fluid or lift it to a processing area. They are generally used in lower-pressure, but higher-speed services sealed with a single or split mechanical seal. They usually provide adequate liquid lubrication, but may require a piping plan to remove vapor from around the seal and keep entrained solids from clogging or damaging the single mechanical seal.

Vertical Multi-Stage Pumps are used to pump high-vapor-pressure liquids through a process. Services typically are high-speed and high-pressure. They are sealed with a single (but more often) dual tandem mechanical seal. Gas seals are sometimes used in these services.

Piping Plans

Seal vendors have developed a series of piping plans that extend the life of mechanical seals in vertical pump services. (See API and ASME publications for details.) Selecting the correct plan is critical to seal survival. Remember that entrained gases in the flow stream will rise to the highest point in the system because, in most cases, they are lighter than the fluid being pumped. Since the sealing device is generally located at the highest point above the fluid being processed, entrained gases will accumulate around it. As previously discussed, these gases provide poor face lubrication in high-speed and high-pressure service. Acting as an insulator, they also prevent frictional heat being conducted away from the liquid lubricated seal faces. To remove these gases, we use either API Piping Plan 13 or 14. Both plans specify that a tubing line (typically 3/8" to 3/4") be connected from the gland port marked "F" (flush) to the pump suction or sump. This port allows the gases, which collect around the inboard seal faces, to escape. Piping Plan 14 specifies an additional tubing line from a higher-pressure discharge point on the equipment to an additional gland port marked "F" to provide a flow of liquid around the seal faces to remove heat.



API Plan 14 - Suction and Discharge Re-Circulation

API Piping Plan 53 often is used in submersible pump and mixer services to provide clean fluid to cool and lubricate both the inner and outer seal faces of dual seals. It calls for a pressurized reservoir connected to the seal gland via an input and output tubing line to provide the clean fluid to the seal. Convection or a pumping device in the seal circulates the fluid to remove heat from the seal.

API Piping Plan 74 is used with gas seals. It introduces a small amount of clean gas to the mechanical seal to establish a thin film between the seal faces. The gas then enters the product. The thin film minimizes or eliminates frictional heat and allows the gas seal to be used in low-, high- or extremely-high-speed services.

Next Month: Comparing non-metallic expansion joints with metallic in flue duct applications

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

Sealing Sense is produced by the *FSA* to provide technical information on sealing systems and devices to pump users, contractors, distributors, OEMs and reps. The *Mechanical Seal Division* is one of six in the FSA with a specific product focus. Among this division's more recent contributions to the association's educational mission is the *Life Cycle Cost Estimator,* a Web-based software tool for determination of pump seal LCC. The following members of the *Mechanical Seal Division* sponsor this *Sealing Sense*:

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