WHAT IS ACCEPTABLE SEAL LEAKAGE?

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Mechanical seals, used to isolate the liquid medium in a rotodynamic pump from leaking to atmosphere, are designed to leak from the moment they are pressurized. This paper will only deal with elastomer bellows type mechanical seals, like the one shown in the below photo, that are used primarily in water or water/chemical services, at operating pressures less than 150 psig and flows less than 1000 GPM.

PAC-SEAL Type 31

Better than 90% of the warranty claims by customers for alleged "defective pumps" (leaking liquid), can be traced to the mechanical seal. It is rare, in a standard centrifugal pump design, that the volute, impeller, shaft or bracket would be the cause of reoccurring leakage problems. The vast majority of mechanical seal failures are directly related to misapplication or careless operation of the pump. The most common seal failures are due to operating the pump/seal without sufficient liquid or abrasive contaminates in the liquid that find their way to the seal faces. The second most common cause of failure is the wrong selection of seal type or materials for the application.

Mechanical Seal Design

Mechanical seals are designed to be controlled leakage devices, not zero leakage devices. The principle of operation is that a rotating (primary) and stationary (secondary) sealing face are forced together by a spring, and (when operating) pump discharge pressure, to limit the amount of liquid that can pass between them. The flatness of the faces is as little as 2 helium light bands (23 microinches). The operating distance between the faces can be 5 to 50 microinches or more depending on the hydrodynamic effect of the liquid.

The pumped medium provides cooling and lubrication to the seal faces when it passes through the faces on its way to atmosphere. The seal face separation distance, seal face condition, differential pressure and viscosity of the liquid determine how much liquid is allowed to pass or leak to atmosphere.

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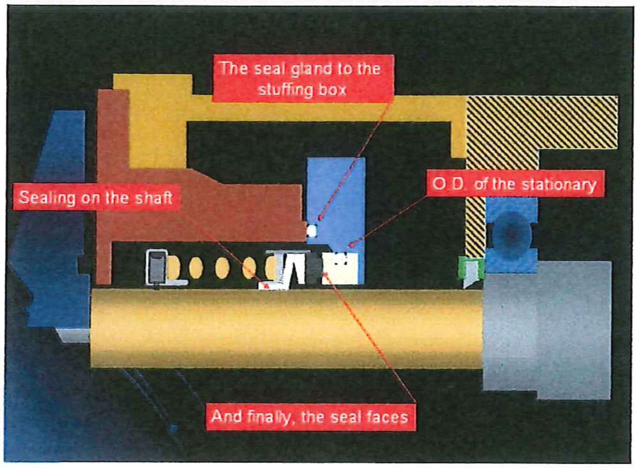
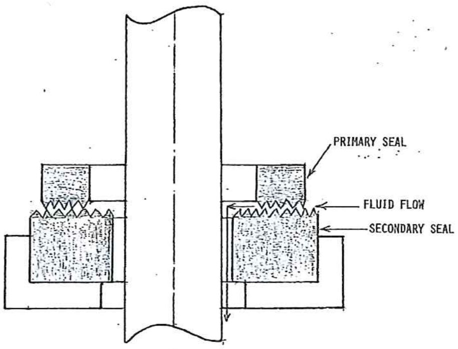
There are two additional leak paths through the seal assembly. The first is the elastomer bellows that seals to the pump shaft and the second is the O-ring or "U" cup that forms a seal between the stationary seal face and the pump seal stuffing box. (See illustration below)



Mechanical Seals At Rest

Even at 2 helium light bands, a microscopic cross sectional view of the mating seal face surfaces looks like the peaks and valleys of a mountain range rather than a flat desert. (See illustration below with seal face surfaces exaggerated!)



"At rest" seal faces do not necessarily form a tight seal, therefore it is likely low viscosity liquids or gasses will pass through the faces, if there is sufficient differential pressure across the faces. This does not lend itself to gas or pneumatic pressure testing of pumps with mechanical seals. Generally speaking, pumps can be hydrostatically tested on water and the "at rest" seal faces will not leak, but don't be surprised if they do. Remember, mechanical seals are not designed to form a seal when idle.

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Mechanical Seal Operation

As a pump is started, the primary (rotating seal face) begins to move with its surface peaks contacting the surface peaks of the secondary (stationary) face. As the face speed increases the faces are held apart by the hydrodynamic effect of the liquid between the faces. At initial start up the faces are unstable for a second or less until the hydrodynamic effect takes over. This effect can be compared to your auto tires hydroplaning on a wet surface. The deeper the tire tread, the less propensity to hydroplane. A badly worn seal, with an irregular surface, and nonparallel face contact, will likely leak.

New seal vs. Worn seal

As a seal operates, the faces "wear in", meaning the "peaks" of the faces are slowly worn down due to friction. Since the hydrodynamic bearing is lost at starting and stopping, intermittent pump operation will frequently increase the seal face wear and reduced seal life.

Some factors adversely effecting seal life are:

- Abrasives in the pumped fluid that chip away at the outside diameter of the seal material or get between the seal faces and score the faces.
- Damaging the elastomers that seal the primary face to the pump shaft or the secondary seal resting in the seal box.
- Cavitation of the pumped liquid across the faces.
- Dual phasing of the pumpage from liquid to vapor.
- Too much eccentricity between the pump shaft and the seals.

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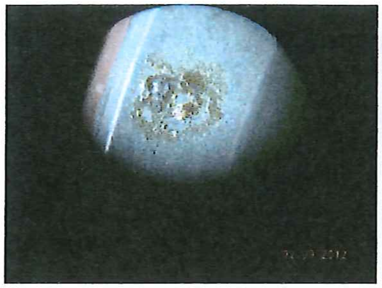
- Seal faces not parallel to each other.
- Too low or too high seal face loading.
- Selection of wrong seal materials or type for the service specified.
- Material film transfer between the faces not uniformly built-up on the faces can cause higher leakage rates.

The below photos are examples of the various types of damage that result in seal excessive leakage.

Contaminate deposits



fractured face

Scored face

Normal leakage

As already mentioned, seals are designed to leak, but how much is acceptable? The answer is dependent on the application. A tap water application, in an industrial environment, can likely tolerate a higher leakage rate than deionized water in a semiconductor fab or hospital application. Some chemicals, due to EPA or AQMD regulations will have much lower acceptable leakage rates than water.

In some cases, a zero leakage, seal-less pump may be required, but that is a subject for another paper.

The leakage rate at start-up tends to be higher than when the seal has "worn in". This is particularly true with hard face seal material combinations, such as silicon carbide. The wearing process will change the seal face surface finish to compensate for the seal face pressure, face fit and minor thermal distortions.

The rate of leakage through the seal mating faces will be dependent on the following:

- Seal face contact surface area.
- Seal face linear speed.
- Non-contact area between the operating faces.
- Surface finish of the faces.
- Differential pressure.
- Liquid viscosity.

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Seal leakage rates in low duty applications can be measured in drops per hour, whereas a high duty application would be measured in drops per minute. Low duty pumps would be defined as:

- ≤ 3600 rpm
- ≤ 319 psi (22 bar)
- -40°F (-40°C)- +300°F (180°C)
- Shaft diameter ≤ 3"

Drops per hour may not be visible due to constant evaporation on exit from the pump seal to atmosphere. Placing an appropriately colored collection paper in the area of the seal leakage may be necessary to observe the severity of leakage. Basically, if the liquid puddles and persists before evaporating, it is too much.

Occasionally, seals will leak on startup due to contaminates either collecting on the faces during assembly or the "debris of construction" entering the faces on initial start. The contaminate will frequently "pass through" the faces after a period of operation or several starts and stops. This should be considered before replacing the seal.

It is also possible for leakage to occur past the elastomers sealing the shaft or stuffing box. If this is the leak path the elastomer must be replaced, as it is likely defective from the manufacturing process or damaged while installing.

If the leakage is persistently visible, the seal should be replaced.

This paper is meant to be a guide and not an absolute conclusion to this subject. It's advisable to use common sense and good engineering practice for what might be acceptable or not acceptable relative to seal leakage rates.

Consult with the seal manufacturer and pump manufacturer if you are in doubt about seal application, or operation.

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