



PUMPS THAT EXPERTS SELECT.

Don't Let Slurries Ruin Your Seals

William McNally



A slurry, which consists of solids suspended in a liquid, can damage mechanical seals, regardless of whether the solids are abrasive. Identifying the solids or their size doesn't help, because no one knows exactly how they relate to seal problems.

When you deal with slurries, you must consider several potential problems:

- The slurry can clog the flexing parts of the mechanical seal, causing the lapped faces to open as a result of both shaft and seal movement.
- An abrasive slurry can wear rotating components, which can be a serious problem with thin plate metal bellows seals.
- A slurry can erode the impeller and other pump components, putting the rotating assembly out of balance and, in turn, spurring excessive movement of seal components.
- The pump will lose its efficiency as wear destroys critical tolerances, leading to vibration and internal recirculation problems. The erosion also will necessitate frequent impeller adjustments that will cause problems with mechanical seals.

The main problem with slurries is that solids penetrate between the lapped seal faces and cause damage. They cannot penetrate until the seal faces open.

Seal faces should be lapped to within three helium light bands. That is a distance just short of 1. This tight tolerance means that as long as you can keep the two lapped faces in contact, there is little chance for solids to penetrate between the faces and do any type of damage.

The alternatives

There are three approaches to the sealing of solids:

1. Design a seal with non-clogging features.
2. Create a clean environment for the seal.
3. Do a combination of both.

To build a seal with non-clogging features, you can:

- Take the springs out of the sealing fluid. They can't clog if they're not in the slurry.
- Make sure the sliding or flexing components of the seals move toward a clean surface as the seal faces wear.
- Employ centrifugal force to throw the solids away from the sliding/flexing components and lapped seal faces.
- Provide a non-stick coating to prevent solids from sticking to the sliding components.
- Use only balanced seal designs that generate less stuffing box heat than standard, unbalanced designs. Additional heat generated at the seal faces can cause many products to solidify, coke and crystallize, creating an additional solids problem.
- Increase the thickness of the plates in metal bellows designs so they last longer. Extra convolutions also will have to be provided to compensate for the higher spring rate caused by these additional plates. Rotating the abrasive fluid with the bellows can be a big asset. Some commercial designs have this feature.

There are several approaches you can use to create a clean sealing environment.

Give the seal as much radial room as possible. You can either bore out the packing chamber or install a large-bore sealing chamber. Try to give yourself at least 1 in. of radial space, if possible.

Try to remove the solids from the sealing area. A number of techniques can be used; some work and some don't.

Bad Solution No. 1. Place a filter in the line between the pump discharge and the stuffing box. The filter will clean up the fluid flowing to the stuffing box. The problem with this idea is that the filter will continuously clog and the likelihood that filter maintenance will be ignored is great.

Bad Solution No. 2. Install a cyclone separator instead of a filter. This idea is just as bad as the first. A cyclone was never intended to be a single-pass device. It works well if used in a bank of several filters, but there is not enough pressure differential between the suction side of a pump and the stuffing box for a cyclone to be effective.

Bad Solution No. 3. Place the seal outside the stuffing box so the springs will not be located in the dirty fluid. The problem with this idea is that as the seal faces wear, they will move into the dirty fluid. The result will be that the movable face will hang up in the solids and the faces will open. Another downside to this approach is that centrifugal force throws the solids into the seal faces instead of away from them.

Bad Solution No. 4. Install a double rotating seal in a "back to back" configuration with a higher-pressure, clean liquid barrier between the seals. This is a very common approach to the problem and presents all of the same problems associated with installation of the seal outside the stuffing box. In addition to a rapid failure, you also will experience product dilution as the barrier fluid leaks into the pump.

Bad Solution No. 5. Using two hard faces as a first choice. Needless to say, this will not prevent the faces from opening, and experience shows that when they do open, you are going to destroy both hard faces. Don't believe some salespeople's claims that the seal faces are designed to "grind up" the solid particles into a fine powder.

Now, let's look at some methods that work:

Good Solution No. 1. Flushing with a clean liquid is an effective way to clean up the pumping fluid. Various fluids can be used:

- the finished, clean product or one of the mixture's clean ingredients;
- a compatible fluid;
- a solvent;
- an additive that will be mixed in downstream and could be injected into the stuffing box location;
- clean water; or
- a compatible grease (this is suitable with most balanced seals running at lower speeds).

Never introduce steam into the stuffing box because it could cause product to flash and the pump to cavitate.

Inject flushing fluid at a pressure that is a minimum of 15 psi higher than the stuffing box pressure.

Good Solution No. 2. Install an oversized, jacketed sealing chamber and "dead end" the fluid -- that is, make sure that no circulation lines either come into or go out of the sealing chamber.

You can use the cooling jacket to remove the heat being generated by the seal faces. Centrifugal force cleans up the solids that are present in the small amount of fluid trapped in the seal chamber. This solution works exceptionally well with fluids, such as heat transfer oils, in which temperature control is important.

If the fluid you are sealing is not hot, the cooling jacket will not be necessary. Sometimes, a single charge of clean liquid into an oversized, dead-ended stuffing box is all that is required to seal even severe slurries.

If the solids have a lower specific gravity than the liquid, use a clean flush or one filling of a higher specific gravity, compatible liquid.

Good Solution No. 3. If the solid particles are sub-micron in size, as is the case with kaolin (china clay) and some dyes, two seals with a higher-pressure barrier fluid are required. In some instances, you may want to use two hard faces on the inner seal.

Good Solution No. 4. Install a large seal chamber on the pump and connect a recirculation line from the bottom of the stuffing box to the suction side of the pump. This will cause liquid to flow from behind the impeller to the stuffing box and then on to the suction of the pump. Fluid entering the stuffing box from behind the impeller has been centrifuged and should be a lot cleaner than the fluid you are pumping.

This solution works well with closed impeller pumps and those open impeller designs that adjust to the front of the pump volute.

However, do not use this technique if:

- You are pumping close to the vapor point of the fluid. Lowering the pressure could cause the pumping fluid to vaporize in the stuffing box and, in some cases, between the seal faces.
- You are sealing a pump where the impeller adjusts to the back plate.
- You are using double-ended pumps where the stuffing boxes are at suction pressure.
- The solids float on the liquid.

Imbalance compensation

The rotating unit will go out of balance, so you should compensate for that. The seal faces have to be vibration-dampened. The elastomer in O-ring-type seals provides a natural vibration damper. Metal bellows seals have to be provided with some other method.

Shaft runout and vibration can cause the seal rotating components to contact the inside of the stuffing box unless you have installed an oversized sealing chamber.

Use motion seals if the runout or vibration is excessive. Most of the popular designs can compensate for $\frac{1}{8}$ in. in a radial direction and $\frac{1}{8}$ in. in an axial direction.

Move the seal closer to the bearings. Split seal designs are a logical choice because most of them come with a stuffing box extension gland that positions them next to the bearings. A support bushing or sleeve can be installed in the end of the stuffing box to minimize the effects of imbalance, vibration, and shaft whip or wobble.

Pump wear

The pump will lose its efficiency and experience more shaft movement as erosion takes its toll on close tolerances.

Open impellers will require frequent adjustment. In this case, a cartridge seal is your best option because impeller adjustments can be made without disturbing the seal face loading. Split seals can compensate for the initial impeller setting; split seals mounted on a split sleeve will easily make up for movement caused by temperature growth or impeller adjustment.

Closed impeller pumps will have to be disassembled and their wear rings changed when clearances become excessive. If you have adjustable wear rings on your pump, then only an outside adjustment will be needed and the pump will not have to be taken out of service. Cartridge seals can almost always be reused in these applications because the seal faces are not separated when the pump is disassembled.

Remember that the wear rings in closed impeller pumps will have to be replaced when the normal clearance doubles. A good rule of thumb is that the pump will lose 1% of its capacity for each 0.001 in. of wear-ring wear.

A few more thoughts

Sometimes two hard seal faces have to be employed because a carbon seal isn't suitable. Carbon cannot be used with oxidizers or if carbon black could cause a color-contamination problem.

Use of packing and a split mechanical seal has proved to be an ideal solution in many applications. With the seal installed, there is no pressure differential across the packing and, therefore, the solids do not try to penetrate. Move the packing flushing line to the bottom of the split-seal housing and flush the packing through this connection instead of the lantern ring or seal cage. The flushing is necessary to remove the additional heat being generated by the packing.

You should be able to cut the flushing fluid volume down to about one-third of the amount you had been using with the seal alone. Because the packing is not being forced to the shaft, only a small amount of cooling is necessary. Caution: It is important that the flushing fluid be kept at a higher pressure than the stuffing box pressure. Loss of this pressure differential could force the packing into the rear of the mechanical seal. A split adapter plate installed between the split seal and the stuffing box face can prevent the packing from blowing out if the flushing pressure is lost.

If you elect to use a rotating metal bellows, remember that the bellows should rotate the fluid in the sealing chamber. Most bellows designs allow the thin bellows plates to cut through the abrasive slurry and, therefore, the plates suffer severe wear and breakage in a short period of time.

William McNally has more than 45 years of experience with pumps and seals. He runs the McNally Institute (www.mcnallyinstitute.com), which conducts courses on pumps and seals.

LaBour Pump Company – 901 Ravenwood Drive, Selma, Alabama 36701

Ph: (317) 925-9661 - Fax: (317) 920-6605 - www.labourtaber.com

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