# AC COMPRESSOR TRAPPED BUSHING SEALS

*By Rob King and John Decker*

RMS was recently contracted by a major US refinery for field engineering support during a trapped bushing seal (TBS) change out. Utilizing our previous 30 years of OEM TBS seal operation and maintenance experience, the seal components and installation process were validated, seals installed and compressor restarted to resume operation. This series of articles was developed as an overview of the TBS.

The trapped bushing seal is a liquid film compressor seal first developed and patented by the Allis Chalmers Corporation in the 1960's with continued design improvements by the AC Compressor Corp. through the early 1990's. With the market for new equipment shifting to dry gas seals in the last twenty years, the trapped bushing seal was slowly phased out from new installations. Since the seal design was used with good success over a wide window of time, there remains a sizeable fleet of AC Compressor Corp. equipment still utilizing the dependable trapped bushing seals. While replacement parts for trapped bushing seals are available, the necessary technical support and engineering expertise, from both customer internal and OEM sources (when the inevitable issues arise) becomes more difficult to find as maintenance intervals grow longer between outages.

In order to become familiar with the TBS, a brief introduction to the main components is provided in this newsletter article, while later article segments will focus on seal operation and the auxiliary support systems. The major parts of the seal, listed in order of installation are the process labyrinth, stator, seal impeller, stepped dual bushing, and the seal cage.

The process labyrinth is located furthest inboard and thus installed first. It functions as a typical pressure reducing element, separating the process from the seal. It may have provisions for application of a buffer gas to a central located annulus. Buffer gas is used in applications where it's undesirable for oil vapors (inherently present in the inboard drain/vent cavity) to diffuse into the process and also to keep process gas from back diffusing into the seal cavity. If buffer gas is required, it needs to be compatible with the process, and a small buffer gas skid is required to control the flows ensuring the desired outcome is achieved.

The stator is located outboard of the process labyrinth, and is typically made from aluminum for its heat transfer properties. A series of drilled oil passages are present near the OD of the stator for efficient heat transfer to the cooling oil that flows through the seal. The stator has a shoulder and "fingers" at the bore near the impeller; at assembly there must be careful attention paid to maintain the required clearances in order to achieve the pumping action of the seal. The stator bore near the shaft is machined with "wind back" features similar to female threads and thus are directionally different for each end of the machine.

The seal impeller is installed following the stator and is the principle rotating part of the TBS, typically made from stainless steel materials. It becomes fixed to the shaft by the use of a pusher/puller fixture ring to set the seal impeller on to its interference fits, and is secured to the shaft with a seal nut at assembly. The impeller has controlled clearances to the bushing and stator allowing for development of the pumping characteristics of the seal. At installation, the axial position of the impeller relative to stator (controlled with a custom fit spacer ring) must be carefully set in order to achieve the desired axial clearances.

The stepped dual bushing is at the heart of the seal and thus has many features associated with it. Typical materials are aluminum for some low pressure applications, though a Ni-resist material is used for the majority of cases. The bushing is "trapped" within the assembly, located axially in between the stator and seal cage and over the seal impeller. The bushing is a static component with controlled clearance (similar to journal bearing clearance) relative to the impeller, with the clearances being critical to seal performance. Clearances to the cage and stator are more generous, with O-rings used in-between which allow the bushing to "float" with the shaft in operation. A stepped shoulder in the bushing bore creates one side of the "pumping cavity" as the part interfaces with the impeller during operation. Often the bushing has pressure dam features machined into the bores which aid in the stabilization of the bushing, due to the hydrodynamic effects of the rotating impeller and static bushing acting similar to a bearing.

Within the bushing there is typically a small cross-drilling oil passage for pressure equalization on the outboard side, resulting in an overall light pressure loading bias in the outboard axial direction. Flatness and controlled surface finishes are needed at the interface of bushing and cage to create a static sealing face which prevents leakage around the outside of the bushing. During operation a torque inherently applied on the bushing due to oil film shear forces in the bores. Older style seals may utilize an anti-rotation pin and an axial o-ring to prevent bushing rotation, whereas later designs rely on o-ring radial friction to prevent the bushing from rotation. The necessary friction comes from the "squeeze" of the two o-rings at the bushing OD along with the axially loaded surface previously described.

The seal cage is the last of the main TBS components installed. The seal cage is typically constructed of steel for high strength since the differential pressure across it is equal to the seal oil pressure. The cage provides the seal oil inlet, recirculation flow annulus, axial sealing face, and provides containment of the inboard seal components within the cavity. A shear ring set, sized to handle the overall axial load due to pressure bias, is installed outboard of the cage completing the assembly in the machine.

To learn more about the trapped bushing seal, look for the remaining articles in the TBS series within upcoming RMS newsletters. These articles will directly focus toward seal operation and the auxiliary support systems required. The RMS engineering team is always happy to support customers with questions on their compressor seals.

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