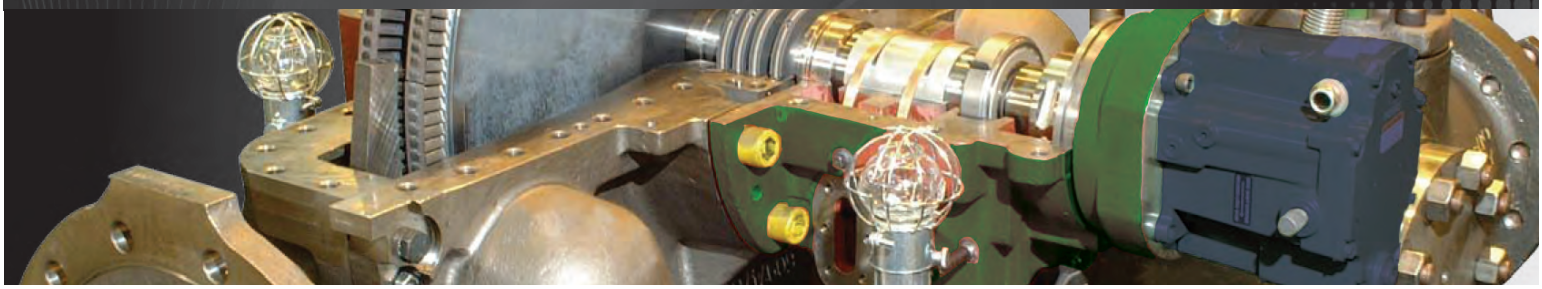


CASE STUDIES: SENTINEL® FBS | PROCESS STEAM TURBINES

Steam Leakage Reduction and Ease of Installation: Evaluating Carbon Ring Alternatives

Carbon rings remain the standard in general purpose steam turbine sealing, despite well-known shortcomings. Chief among those shortcomings is wear at the rings' inner bore, gradually increasing shaft clearance and steam leakage and leading to regular replacement – as frequently as four times per year. Carbon rings are simple to install and the replacement cost for a complete set is less than $1,000, so the cost of maintaining sealing with carbon rings may seem modest. However, there are further costs associated with the wear and potential breakage of carbon rings, including higher water costs due to steam losses and degraded bearing performance due to oil contamination and higher operating temperatures.

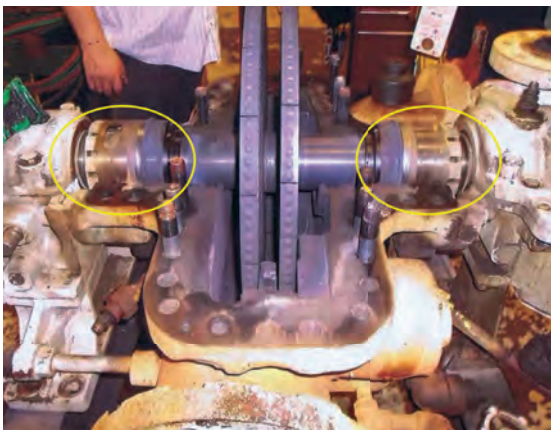
For operators looking to reduce steam leakage and increase equipment reliability, there are two primary alternatives to carbon rings on the market: mechanical seals and the Sentinel® Floating Brush Seal.

A carbon ring's three segments and garter spring

CANDIDATE 1: MECHANICAL SEALS

Mechanical seals used in general purpose steam turbines are a derivative of dry gas seals. A unique profile – spiral grooves – on one of the seal faces draws in steam, which creates a pressure dam that pushes the rotating and stationary seal faces slightly apart for a non-contacting, film-riding sealing interface. Resulting leakage is extremely low and measured in parts per million.

With a design distinctly dissimilar to conventional carbon rings, the mechanical seal requires major modifications to a turbine's existing gland box configuration. On steam turbines where the steam chest and gland boxes are individual components, the mechanical seal assembly can be bolted on to either end of the steam chest in place of the carbon ring gland boxes. On turbines where the steam chest and gland boxes are one piece, major machining is required to fit the mechanical seals. In addition to gland box modifications, the turbine shaft may require modification to secure the seal's rotating assembly. Final setting of the mechanical seal requires careful alignment with the rotor and casing to ensure proper sealing between the rotating and stationary seal faces.



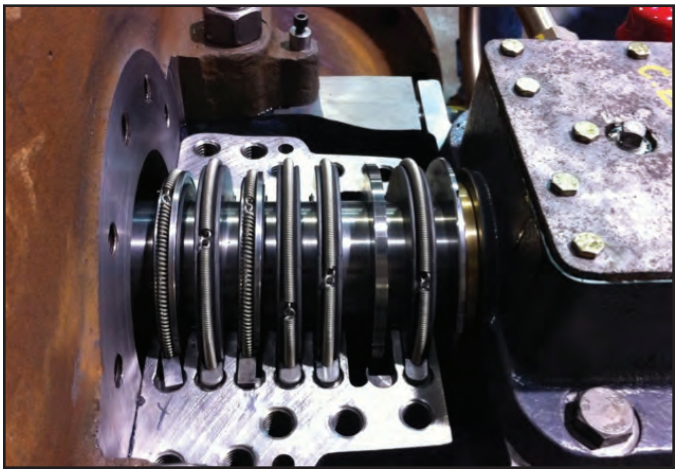
Machined gland boxes with a mechanical seal assembly

The hardware cost for a set of mechanical seals to replace the inlet and exhaust gland boxes can range from $20,000 to $30,000. When taking into account hardware, installation and downtime costs, a mechanical seal upgrade can easily cost more than half the price of a new turbine.

CASE STUDIES: SENTINEL® FBS | PROCESS STEAM TURBINES

The life of a mechanical seal is directly affected by steam quality. Mechanical seals work best in dry steam conditions under a continuous duty cycle to alleviate condensate formation. Even in such an environment, however, steam impurities will crystallize at the pressure dam over time and ultimately increase face separation and leakage. Intermittent duty cycles can promote the formation of condensate within the steam lines, steam chest and gland boxes while the turbine is at rest. Although operators may blow condensate from the system prior to start-up, residual condensate can be problematic for the mechanical seal. The flashing of the condensate into a gas, which can best be described as a small explosion, can catastrophically damage the seal faces.

Sentinel® Floating Brush Seal



Gland box upgrade with two Sentinel Floating Brush Seals

CANDIDATE 2: SENTINEL FLOATING BRUSH SEAL

The second candidate for replacing carbon rings is the Sentinel Floating Brush Seal (FBS). The Sentinel FBS combines a carbon seal with brush seal technology encased in a lightweight stainless steel band to withstand condensate flashing while providing a lower, more stable leakage rate. Additionally, as a floating seal, the FBS is more tolerant to vibration, bearing failures, and radial movement than both carbon rings and mechanical seals. The brush seal acts as the primary shaft seal and faces the high pressure steam. It provides immediate pressure reduction while its bristles filter out steam contaminants, thereby protecting and extending the life of downstream carbon rings. The carbon ring of the Sentinel FBS provides a face seal against the downstream gland wall or separator plate.

Designed to fit the same space as a carbon ring, the Sentinel FBS is a drop-in replacement and simple to install. The seal has a split design, with two segments held together by a garter spring. Its self-centering assembly eliminates the need for an involved alignment procedure. Therefore, operators trained in the replacement of carbon rings can just as easily replace a carbon ring with an FBS. In fact, with only two segments compared to the carbon ring's three, the Sentinel FBS offers greater installation simplicity.

Furthermore, with a complete steam turbine upgrade to Sentinel FBSs costing no more than half – and maybe even one quarter – the cost of mechanical seal hardware, not to mention the cost of a mechanical seal installation, the Sentinel FBS is a more cost-effective option for many operators.

Ultimately, a plant must evaluate which candidate for carbon ring replacement checks all the boxes: suitability for operating conditions, including steam quality and duty cycle; sufficient reduction of steam losses; improved reliability; and low investment and maintenance costs.