FLUID SEALING ASSOCIATION FSA

From the voice of the fluid sealing industry

SEALING SENSE

Q. *What are the symptoms, causes, and corrective actions for failure of mechanical seals by thermal attack?*

A. One symptom of thermal attack is the appearance of fine-to-large radial cracks that emanate from the center of the metal or ceramic ring. Characterized as *heat checking,* these cracks act as cutting edges on the carbon-graphite and other seal face materials, and the consequent scraping action rapidly wears out the seal.

Common causes of heat checking include: (1) insufficient lubrication; (2) vaporization at the seal faces; (3) inadequate cooling; and (4) excessive pressures and velocities. Any one or a combination of these factors can result in higher friction and heat at the seal faces. The excessive thermal stresses that develop will result in fine fractures.

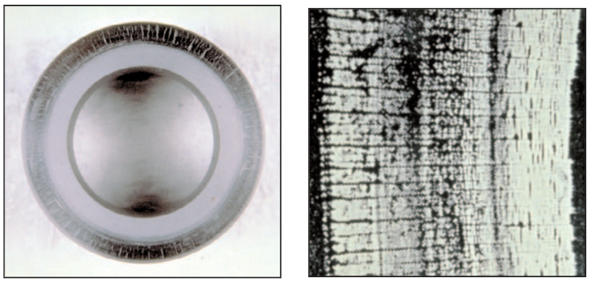

Figure 1. Ceramic ring with typical heat checking cracks

Corrective Actions include:

- Checking operating conditions to ensure they are within the prescribed limits for the seal.
- Confirming adequate coolant flow at the seal faces to carry away seal-generated heat; guidelines are that (a) the temperature rise of the fluid flowing through the seal cavity should not exceed 40° F (22° C); and (b) pressure of the seal cavity product should be maintained 25 PSI (1.72 bar) above the vapor pressure of the seal cavity fluid to avoid vaporization.
- Checking that the seal is not overloaded so that a thrust bearing or thrust collar in the equipment becomes damaged or inoperative, thereby creating excessive seal face loads.
- Upgrading to seal face materials with higher pressure-velocity (P-V) limits and resistance to heat checking such as tungsten carbide or silicon carbide. (P-V is the pressure (PSI) at the seal faces, multiplied by the velocity (ft/min) of the outside diameter of the seal face.)
- Consulting the manufacturer to obtain revised dimensions that will reduce the hydraulic load at the seal faces to provide a lower P-V for the same face materials.
- Verifying ample cooling and lubrication at the seal faces.

Popping, puffing, and blowing of vapors at the seal face, known as *vaporization,* is another symptom of thermal attack that results in excessive leakage and damage. If vaporization doesn't cause failure, it usually shortens seal life and impairs seal performance. Inspection of the seal faces usually shows chipping at the inside and outside diameters, and pitting over the entire area.

Vaporization occurs when heat at the seal faces cannot be adequately removed, and the liquid between them rapidly evaporates or flashes. It also can be caused by operating the seal too near the flash temperature and flash pressure of the product in the seal cavity. Other operating conditions that cause vaporization include: (1) excessive pressure for the seal; (2) excessive seal face deflection; (3) inadequate cooling and lubrication of the seal. Vaporization may be an indication that a seal flush has become inoperative, or that cooling water flow to a heat exchanger has been shut off or reduced.

Corrective Actions include:

- Improving circulation and cooling at seal faces.
- Assuring that the seal is operating at temperatures and pressures well below the flash conditions of the product in the seal cavity; guidelines are that the operating temperature and pressure at the seal should be at least 25° F (14° C) and 25 PSI (1.72 bar) below the flash temperature and flash pressure of the product in the seal cavity.
- Checking seal design to assure operation within pressure and speed limits.
- Consulting seal manufacturer for recommendations on reducing self-generated heat.

Blistering is another symptom of thermal attack characterized by small circular sections that appear raised on the carbon seal faces. This condition is best observed by using an optical flat or lightly lapping the seal faces. These blisters separate the seal faces during operation and cause high leakage rates. Blistering usually occurs in three stages: Stage I—Small raised sections will appear at the seal faces; Stage II—Cracks will appear in the raised sections, usually in a starburst pattern; Stage III—Blisters will be pulled out, leaving voids in the seal face.

The exact cause of blistering is still not well defined. The best explanation is that high viscosity fluids, such as SAE #10 oils, penetrate the interstices of the carbon seals over time. When the seals heat up, the oil is rapidly driven from the pores. Blistering often occurs in seals that frequently start and stop in high viscosity fluids.

Corrective Actions include:

- Reducing the viscosity of the fluid in the seal cavity by substituting a new fluid or by increasing the fluid's temperature.
- Eliminating frequent starts and stops of equipment with mechanical seals.
- Substituting a non-porous seal face material such as tungsten carbide, silicon carbide or bronze for the carbon-graphite.
- Checking cooling and circulation to the seal faces; improper cooling and circulation will make seals more susceptible to blistering.

Spalling is similar to blistering, but occurs on surfaces away from the seal face, such as the outside diameter and the back of the seal. Like blistering, spalling is caused by excessive thermal stresses in a carbon-graphite seal. Unlike blistering, however, spalling seems to occur with virtually any fluid, and is the result of moisture suddenly being driven off when the seal is overheated. It is almost always due to dry running of the seal. If seal parts are heavily spalled, it's a good indication that the equipment was allowed to run dry for an extended period of time.

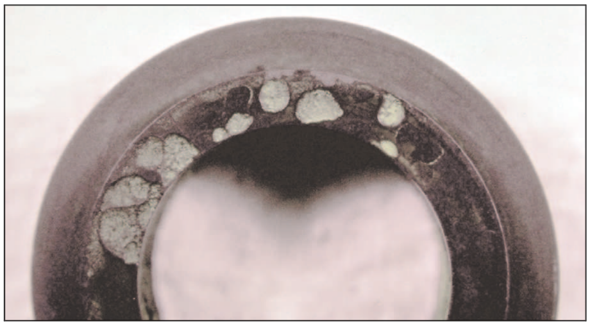

Figure 2. Carbon-graphite seal exhibiting spalling

To avoid dry running of a mechanical seal, a pressure or load switch should be added to the equipment. Or, an alternative sealing method should be supplied, such as a double seal incorporating a thermal-convection or forced-lubrication system.

Overheated, elastomer O-rings harden, crack and become very brittle. PTFE secondary seals will harden, tend to discolor (becoming bluish-black or brown), show signs of cold flowing, or take the shape of the secondary seal cavity.

Overheating is generally due to inadequate coolant flow in the seal cavity. It also can result from excessive temperatures, or simply by an incorrect materials selection. If O-ring overheating is noted: (1) check coolant flow in the seal cavity area, including the lines for blockage, and heat exchangers for buildup of scale; (2) increase cooling. If the temperatures are still too high for a given elastomer secondary seal, consider a metal bellows seal with higher temperature limits.

Next Month: The introduction of a new software tool for calculation of mechanical seal Life Cycle Costs.