The Advantages of API Piping Plan 03

Tapered bore seal chambers cool seal faces and minimize solids and gas buildup.

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The fourth edition of the American Petroleum Institute (API) Standard 682 was released in May 2014. The May edition includes several updates to reflect the changing design and application needs of mechanical seals. Annex G defines several new piping plans and associated auxiliary hardware.

Piping Plan 03 (see Figure 1) is defined as a dead-ended seal chamber with a tapered bore and no throat bushing. Tapered bore seal chambers are well-established in many industries. These designs have significant performance differences from traditional, closed-throat cylindrical bore seal chambers, which are defined separately in Piping Plan 02 (see Figure 2).

History

Until the late 1980s, mechanical seals were most often applied to pumps and other rotating equipment in a seal chamber that was originally designed to accommodate packing. These radially narrow cavities often had a close clearance throat bushing near the impeller to retain the packing rings. Mechanical seals could fit into these chambers, but the small radial space left little room for good fluid circulation around the mechanical seal. The close clearance bushing effectively isolated the chamber from the process fluid.

As a result, piping plans, including Plan 11, were incorporated to manage heat, debris and other issues related to the seal chamber design. The dead ended Plan 02 arrangement was—and still is—limited to only the lowest duty applications.

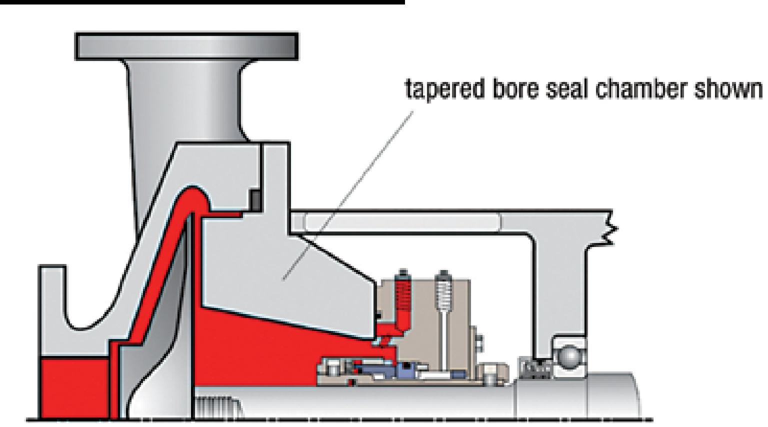
In the mid-1980s and early 1990s, seal manufacturers worked with pump manufacturers and standards organizations to develop and advocate seal chambers specifically designed to house mechanical seals. New standards from the API, American National Standards Institute (ANSI), Deutsches Institut für Normung (DIN) and International Organization for Standardization (ISO) codified enlarged bore and tapered bore seal chamber designs. Today, most original equipment sold with mechanical seals includes an enlarged bore or tapered design seal chamber.

Pump designs have also incorporated other flow-enhancing and wear-limiting designs. The basic guidelines for chamber design and application were formed after researching the varying dimensions of seal chambers depending on the pump's application.

Cooler Operation

Seal chamber design can affect flow patterns and gas entrainment significantly. In one example, conventional seal chambers tended to cause gas accumulation in mechanical seal faces when a pump operated under cavitation.[1] The seal face temperature rose 101 to 362 degrees Celsius (C) (180 to 650 degrees Fahrenheit—F) above the nominal seal chamber temperature.

Figure 1. Piping Plan 03 *(Courtesy of Flowserve Corp.)*

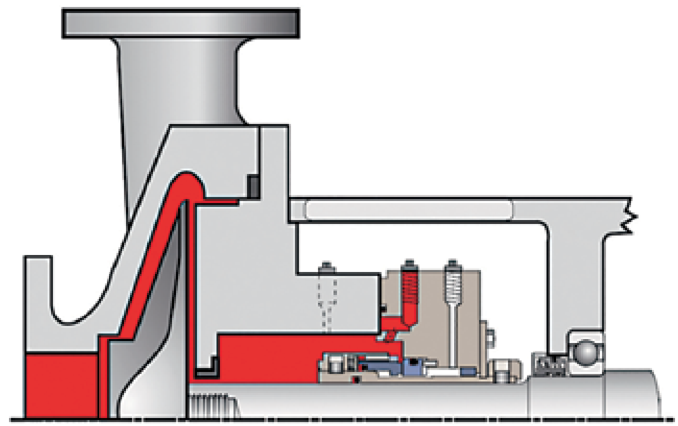


These conditions quickly damaged the seal face and degraded the secondary seals.

In another example, different tapered bore seal chamber configurations were tested. These designs resulted in a much lower seal face temperature rise of 17 C to 34 C (31 F to 61 F) above the seal chamber temperature. High flow helped reduce gas accumulation in the seal chamber under vacuum conditions.

Additional studies showed a significant temperature difference during normal operation between a traditional seal chamber and a tapered bore seal chamber. Figure 3 (page 116) shows temperature data from a 48-hour test of a traditional chamber. The temperature rose approximately 5 C to 8 C (10 F to 15 F) in the seal chamber (Chamber ΔT) and 14 C to 33 C (25 F to 60 F) above chamber temperature at the seal faces (Seal Face ΔT).

Figure 2. Piping Plan 02 with a closed-throat chamber *(Courtesy of Flowserve Corp.)*



Both studies indicate that tapered bore seal chambers create greater fluid circulation and resist gas buildup in the seal chamber, resulting in cooler running seals.

Significant spikes and fluctuation accumulation also occurred at the seal faces.

The tapered bore chamber test shows a much lower and more even temperature trend (see Figure 4). The seal chamber temperature varied less than 3 C (5 F), and the seal face temperature rose approximately 7 C (12 F).

Both studies indicate that tapered bore seal chambers create greater fluid circulation and resist gas buildup in the seal chamber, resulting in cooler running seals. Excessive heat buildup in seal chambers can lead to premature seal failure, especially during off-design pump operation. Applications with cavitation or fluids pumped near their flash point can particularly benefit from tapered bore seal chamber designs because of their ability to reduce seal chamber temperatures and expel vapor. In some cases, Piping Plan 03 may be used instead of more complex flush arrangements such as Piping Plan 11.

More Space for Seals

Tapered bore seal chambers also create much more space for the mechanical seal design. Typical standard bore seal chamber designs have a radial cross section of 5/16 to 3/8 inch (8 to 10 millimeters), leaving little room for seals, particularly in cartridge configurations. Tapered bore seal chambers typically have a radial cross section of 7/8 to 1 inch (22 to 25 millimeters), allowing larger and more robust seal designs.

Self-Venting

In a Piping Plan 02 configuration, seal chamber designs that incorporate a close clearance throat bushing near the impeller will not fully vent during initial pump startup. A bubble will form at the top of the seal chamber. This bubble can cause partial dry running of the mechanical seal at startup and, because of the chamber's limited fluid circulation, may remain in the seal chamber during a long period of time. Tapered bore chambers naturally and fully vent during pump flooding and startup, leaving no trapped gas in the seal chamber.

Solids Handling

The open design of tapered bore seal chambers also means that they effectively prevent solids accumulation in the mechanical seal. The high flow created in the tapered bore seal chamber eliminates stagnation points that can result in solids accumulation around the mechanical seal. However, high flow can also erode the mechanical seal. Fluid velocities, particle size, hardness and density, and solids concentration in the pumped fluid must be consider.

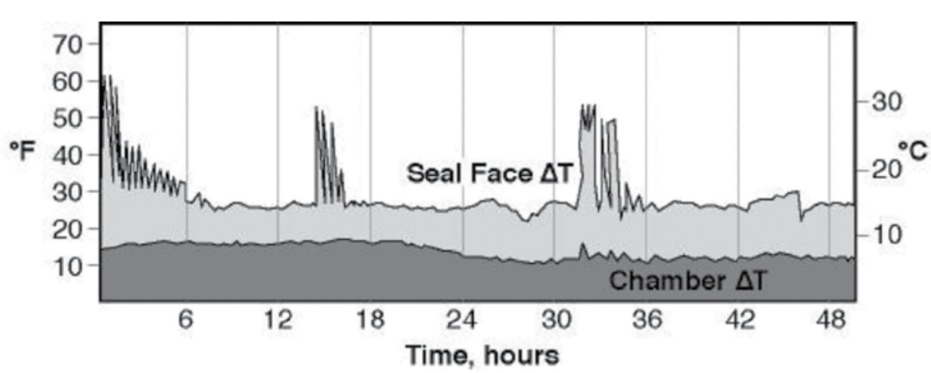
Several design enhancements reduce the velocity and concentration of solids in the seal chamber, particularly in slurries and dirty applications. These features extend the range of Piping Plan 03 in most aggressive solids-handling applications.

Conclusion

Piping Plan 03 for dead-ended seal chamber applications helps differentiate between the performances of typical standard bore seal chambers and enlarged bore tapered seal chambers.

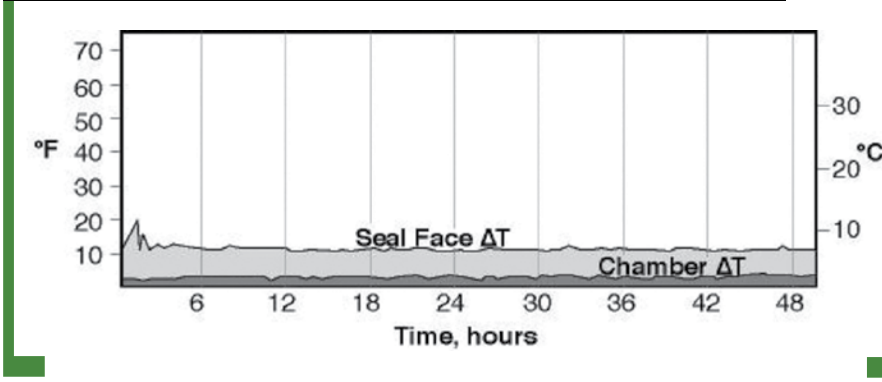
Tapered bore chamber designs

Figure 3. Traditional seal chamber temperatures during a 48-hour test *(Courtesy of FSA)*



excel in off-design pump operation, venting, space availability and solids handling. By specifying Piping Plan 03, end users and seal manufacturers can work together to identify appropriate seal designs and operating practices to improve equipment reliability. P&S

Figure 4. Tapered bore seal chamber temperatures during a 48-hour test *(Courtesy of FSA)*



Reference:

1. Adams, W.V, Robinson, R. H and Budrow, J.S., "Enhanced Mechanical Seal Performance Through Proper Selection and Application of Enlarged-Bore Seal Chambers," 10th International Pump Users Symposium, Turbomachinery Laboratory, Department of Mechanical Engineering, Texas A&M University, College Station, Texas pp. 15 – 23 (1993)

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