The Benefits of Advanced Seal Chamber Design in Double Suction Pumps

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The new Bell and Gossett e-HSC pump boasts an advanced seal chamber design. This paper outlines the benefits in reduced downtime this technology provides in water applications.

The seal is undoubtedly one of the most important parts of a centrifugal pump. Of course there are many critical aspects of pump performance, but when it comes to mean time between failures, it remains that 60% to 70% of centrifugal pump maintenance is seal related (Lobanoff & Roass, 1985). The fact that mechanical seals can only be replaced once the pump has been shut down (and in many cases drained) also means that this can be an expensive repair, depending upon timing.

Pump and seal design must adequately address the potential for abrasive particles which may shorten seal life due to seal face erosion or seal cavity clogging (Shiels, 2004). Double suction pumps, which historically relied on packing as the primary sealing option, transitioned to mechanical seals to eliminate the fluid leakage and the increased power consumption related to gland packing. However, with that transition came the increased seal replacement time, placing even more emphasis on mechanical seal life. Many designs continue to use a stuffing box capable of accepting either packing or a mechanical seal.

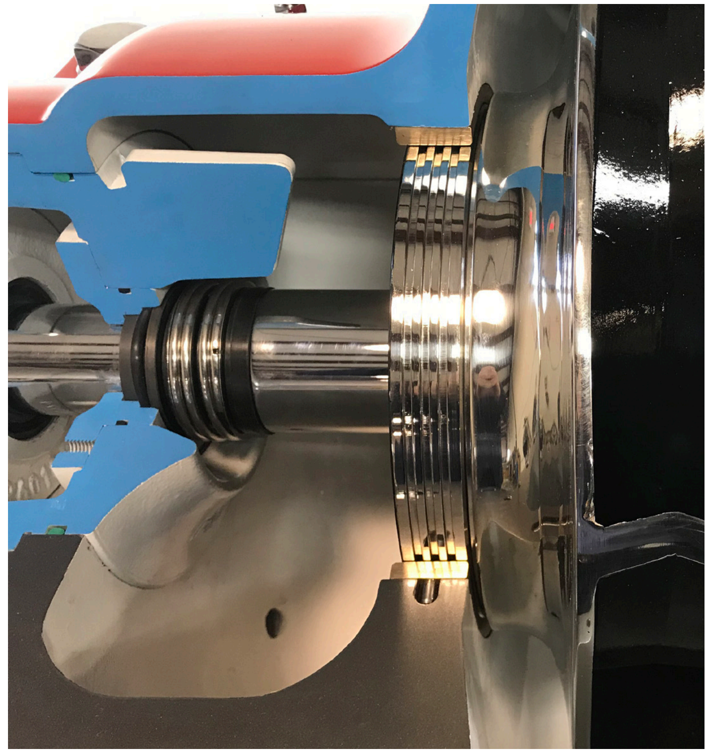
Plans for maintaining seal chamber conditions have long been standardized by the American Petroleum Institute (API) in their Annex G piping plans. **Figure 1** provides details behind the plans typically employed in water applications. Plan 02 and Plan 11 are not effective at limiting contaminant buildup and seal wear. Plan 31, however, flushes utilizing pump discharge pressure and filters utilizing a separator in order to limit contamination. While a stuffing box design allows for handling many industrial process fluids because of the flexibility to employ even more complex plans such as 32, 41, or 53, there are more effective and less complicated approaches for water applications. An API plan 31 needs to consider a balance between seal cavity pressure and flush cooling flow through sizing the throat bushing and adjusting the flush orifice (Shiels, 2004). This can be more of a challenge considering the variable flow and pressure in today's variable speed environment.

API Plan	What	Why	Where
Plan 02	Dead-ended seal chamber with no flush.	No fluid recirculation needed.	Clean fluids.
Plan 03	Circulation created by the design of the seal chamber.	No external fluid recirculation needed. Solids removal from seal chamber.	Large bore/open throat seal chambers. Dirty or contaminated fluids.
Plan 11	Seal flush from pump discharge through orifice.	Seal chamber heat removal. Seal chamber venting on horizontal pumps.	General applications with clean fluids.
Plan 31	Seal flush from pump discharge through cyclone separator. Centrifuged solids are returned to pump suction.	Seal chamber heat removal. Solids removal from flush and seal chamber.	Dirty or contaminated fluids.

Figure 1
American Petroleum Institute seal plans typically seen in water applications (extract from Flowserve FTA160eng Rev 9-17)

In May of 2014 the American Petroleum Institute amended Annex G piping plans to include a tapered bore seal chamber (Plan 03). This was the result of successful application of large bore tapered seal chambers in extending seal life without the complexity of pressurized flush and particle separation. In fact, an extensive study comparing the traditional Plan 02 stuffing box configuration with a variety of enlarged and tapered seal chambers was conducted for the Tenth International Pump Users Symposium with the expressed purpose of improving the uptime of centrifugal pumps. The study concluded that tapered or flared bore chambers without throat restriction allowed for maximum heat transfer with the pumped product, reduced gas in the seal chamber under start/stop conditions and reduced solids concentrations without the need for external flushing (Adams, Robinson, & Budrow, 1993). The study further found that "some form of rib, strake, or protrusion extending axially along the chamber wall could reduce the high azimuthal velocity and impart an inward radial velocity to the particles…this change in velocity and direction would then allow the particles to exit the chamber with the outflow" (Adams, Robinson, & Budrow, 1993). The study was focused on end suction centrifugal pumps, and it did find that there were some impacts on the effectiveness of the seal chamber design created by impeller features such as balance holes and pump out vanes designed to mitigate axial thrust.

Bell & Gossett has incorporated the best aspects of all these design features into a double suction pump. It has an enlarged tapered seal chamber for internal flush that actually opens into the entire suction chamber of the pump. Due to the balanced thrust inherent in the double suction design, there are no balance holes or pump out vanes adding pressure back into the seal chamber against the flow for particle removal. The seal chamber pressure is dictated by the lower, more consistent suction pressure rather than re-circulated flow from the discharge. There is no need to monitor and adjust external flush pressures or install and maintain particle separators. This design brings more consistent performance and lower install cost than a traditional plan 31. In addition, this stuffing box allows for side access to the seal for faster replacement than traditional stuffing boxes where the upper casing must be removed for seal access. The design even includes an axial rib from the CFD (computation fluid dynamics) model to impact the radial velocity of the particles just as the study indicated. Pump downtime is ultimately best reduced by this type of focus on advanced design that increases mean time between failures and reduces repair times on the number one reason for pump failure.



In the above cutaway photograph of the mechanical seal chamber you can see the tapered bore which opens into the suction chamber of the pump. You can also see the axial rib above the seal that impacts the flow within the suction chamber.

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

Lobanoff, V. S., & Roass, R. R. (1985). *Centrifgual Pumps Design and Application.* Houston, TX: Gulf Professional Publishing.

Shiels, S. (2004). Hidden Dangers in Centrifugal Pump Specification: Part One. In S. Shiels, *Stan Shiels on Centrifugal Pumps: Collected articles from "World Pumps" magazine* (p. 275). Oxford, UK: Elsevier Advanced Technology.