Every two years, a major Midwestern specialty chemicals company conducts its plant shutdown for maintenance. By planning for downtime every other year, the company expects minimal lost production time. However, a critical top-entry mixer seal designed to prevent dangerous hydrogen sulfide from leaking into the atmosphere failed at a frequency greater than the two-year planned maintenance interval, costing the company lost production time.

“When you have to shut down a reactor, you’re not making product, and [the plant] is losing money every minute it’s down. It’s a big job taking this seal apart — maintenance has to install rigging and a rail system to remove the seal. They typically work through the night to be sure they minimize the lost opportunity. Every batch is critical,” says Chris Dinasky, senior sales engineer, Flowserve.

Each seal averaged from three to 10 months of service life. After several replacements — each costing around $20,000 on the hardware alone — the chemical company contacted Flowserve and asked them to design a new seal.

Troubleshoot Until It is Right

Flowserve faced several challenges on the project. First, the original competitor’s seal featured a triple-seal design Flowserve would need to duplicate. Using a triple-seal design, instead of a double seal, provides an extra measure of safety. In addition, the seal had to withstand up to 232°C (450°F) temperatures, 34 bar (500 psig) and harsh chemicals for at least 24 months.

The new design featured a customized QBW mixer seal consisting of a triple seal, silicon carbide faces and Chemraz o-rings to withstand the harsh environment. While this seal performed much longer than its original counterpart, it averaged only 4.08 additional months of service life over the two-year expectancy.

After the seal’s limited success, Flowserve set out to determine how to extend the seal’s life to meet the customer’s needs. Flowserve engineers conducted extensive failure analyses with each seal and discovered several issues.

“The specific wear on some of the seal faces indicated the seal housing was out of perpendicularity. We also saw conclusive evidence of excessive heat on some of the lower o-rings, even though temperatures were not above the limits of the seal,” Dinasky explains.

Based on its findings, Flowserve engineers suggested the company use Flush Plan 54, a pressurized external barrier fluid system that supplies clean, cool lubricating fluid to the seal. The system improves internal conditions and prevents the seal from deteriorating before it reaches the end of its service life.

Despite the discovery and suggestion from Flowserve, the customer insisted there were no heat pockets because external temperature measurements did not show elevated levels. Instead, the customer agreed to another plan from Flowserve.

Flowserve, in addition to suggesting Plan 54, recommended an MW-200 cartridge canister seal with a cooling spool. This design ensured that the perpendicularity of the mating surfaces between metal components and seal faces were under Flowserve’s control. Flowserve worked closely with the mixer OEM to provide specifications for the housing and bearing fit tolerances that were in contact with the MW-200 canister.
Persistence Pays Off

The seal continued to run, but never reached a full 24 months of performance. “We got a couple of runs in — one was 121 days, one was 295 days, and another ran almost a year,” Dinasky says.

Flowserve continued to analyze the seal’s performance after each run and insisted the company add Flush Plan 54 to the seal.

“We had a lot of trouble convincing them to use [Flush Plan] 54, but when you consider the cost of the 54 compared to the cost of just one failure, the cost of using Flush 54 is nothing,” says Robert Smith, senior engineer, Flowserve, who worked on the project.

As a result of the persistence and commitment Flowserve engineers had for the project, the chemical company agreed to use Flush Plan 54 — and the seal began to run successfully.

In June 2011, the company reached its planned shutdown with the seal still performing continuously after 750 days of service. At shutdown, the company replaced the seal with another modified Flowserve MW-200 using API Plan 54.

For more information on the Flowserve MW-200, visit www.flowserve.com/Products/Seals/Mixer/MW200,en_US.
A major chemical plant, a pump used in a food grade sugar slurry application contained a seal that failed monthly, and sometimes even weekly. In some cases, seal failure occurred after just one day. The seal's poor reliability led the plant's maintenance manager to seek a solution to improve the seal's service life.

**A Slurry of Problems**
The slurry consists of heavy alcohol mixed with a fine crystalline sugar. A Flowserve-Durco Mark 3 Gr 2K pump with an FML seal chamber transfers the slurry from an atmospheric mix tank under 25mm vacuum to reactors that feed the continuous operations side of the plant.

The pump has no backup system and operates three to four times per day transferring 18,000 kg/hr (40,000 lbs/hr) of dextrose slurry. Thus, the seal's failure rate limited the plant's ability to keep operations running.

The drop leg from the tank to the pump often holds slurry between batches — even when washed out with heavy alcohol. As a result, the heavy dextrose slurry bottoms that plug or partially plug the suction piping typically caused the seal to fail. Once the pump picked up suction, the slurry would wash out of the suction piping, but the damage to the seal was already done.

In addition, the seal often failed inboard first, which caused the barrier fluid from the reservoir to drain into the process. The dextrose slurry then filled the reservoir, causing the outboard seal faces to fail due to the sugar mixture crystallizing across the face contact area.

“This pump had lots of problems, with mechanical seal reliability often measured in days — weeks at best,” says the plant's maintenance manager. “Poor reliability from this pump and the batch mix operation negatively impacted the plant's ability to keep the continuous operations side of the plant running.”

**Finding a Seal Solution**
Hoping to improve the pump's reliability, the company contacted Flowserve Corp., whose engineers proposed a retrofit, mechanical seal upgrade to the existing pump system. After determining that no major equipment changes could be implemented to improve system reliability, the chemical company decided to try the Flowserve ISC2 seal because it offers numerous advantages.

For example, the seals will run longer, cooler, in tougher conditions, in larger sizes and in more equipment than any other standard cartridge seal Flowserve offers.

In addition, the patented thermal management technology is a key enabler of long-term seal life because it allows the seals to tolerate short-term dry-run events without overheating. Thermally conductive and mechanically compliant graphite material dramatically improves heat transfer between the silicon carbide seal face and the adjacent metal.

“We believed the ISC2's dry-run capability, along with the improved torque load and drive lug features, would help the seal overcome the dextrose bottoms that settled in the pump's suction piping,” the maintenance manager explains.

The new pump also features an API Plan 53, two-gallon reservoir with a heavy alcohol-based product used as the barrier fluid.
API 682 Standard Gets Updated

The Fourth Edition of the standard for mechanical seals and support systems encompasses new piping plans and technologies.

API 682 (ISO 21049) is the world’s most recognized standard for mechanical seals and sealing support systems, and provides seal users and OEMs a common platform to address topics such as nomenclature, design and qualification testing. The Fourth Edition continues this tradition with updated requirements for today’s sealing industry, including the introduction of several new piping plans.

A seal piping plan increases the performance and reliability of a seal and system by improving the environment in the seal chamber. Piping plans range from simple systems to recirculate fluids to complex systems that pressurize, cool and circulate fluids and gases.

In the Fourth Edition, the majority of the piping plans are carried over from the previous edition without any modifications. However, several changes are made to existing piping plans, and several new plans have been added.

Modifications to Existing Piping Plans

One of the significant changes in the Fourth Edition is the move from switches and indicators to transmitters.

Historically, operators used local indicators and switches to monitor and alarm piping plans. This has now shifted to using transmitters with local indicators, which allows continuous monitoring of systems in the control room while still allowing local monitoring by the operator.

New Piping Plans

Plan 03. Historically, a mechanical seal in a seal chamber with no circulation is defined as a Plan 02. This is often used in low-duty applications.

In recent years, however, pump OEMs have engineered pump designs that circulate process fluids to the seal by the innovative design of the seal chamber itself. This eliminates the need for common piping plans such as a Plan 11. A Plan 03 (see Figure 1) was introduced to define this option, and is most commonly used on smaller, lower duty ASME B73 pumps.

Plan 55. Arrangement 3, dual pressurized seals, can be operated with the circulation of a pressurized barrier fluid from an external source as defined in Plan 54. Users have requested that this same concept be applied to Arrangement 2, dual unpressurized seal designs. The unpressurized buffer fluid would be circulated from an outside source while being maintained at a pressure lower than seal chamber pressure. This has been designated as a Plan 55 (see Figure 2).
Plan 65A and Plan 65B. Plan 65 historically has defined a method of detecting atmospheric leakage from a seal. This was achieved by directing seal leakage to a ground-level detection vessel with an orifice in the drain line. If there were a high leakage rate into the detection vessel, the increased level would be detected by a level switch indicating a seal failure. The two primary aspects of this plan were that it detected a high flowrate, and it was instrumented with a level switch.

The Fourth Edition has added an option to detect leakage by measuring accumulated leakage. In this plan, seal leakage will flow into a closed collection vessel. Over time, the level in the collection vessel will rise and provide information on the seal’s performance. This plan will require that the operator periodically drain the collection vessel to allow for continuous operation.

To distinguish between the two options, the detection of a leakage rate has been designated as a Plan 65A (see Figure 3), and the detection of accumulated leakage has been designated as a Plan 65B (see Figure 4).

Both of these plans require the use of a level transmitter to allow for trending of the level in the collection vessel and are considered as technically equivalent to satisfy the requirements of a Plan 65.

Plan 66A and Plan 66B. The primary objectives of these two new piping plans are to provide early detection of seal leakage and to contain leakage in the seal gland. A Plan 66A (see Figure 5) achieves this by using two close clearance bushings in the seal gland. Leakage from the seal will be restricted by the inner bushing and increase the pressure behind the seal face, which will be detected by a pressure transmitter. Low-pressure leakage will flow past this bushing into the drain and be directed to a Plan 65 system.

Plan 66B (see Figure 6) uses only one close clearance bushing in the gland, along with an orifice plug in the drain port. If the leakage rate is high, the drain cavity will become pressurized and will be detected by a pressure transmitter. While this variation is not as sensitive as the Plan 66A option, it can be easily adapted into existing seal glands.

Plan 99. One of the challenges with defining seal piping plans is to capture

Figure 3. Plan 65 has been re-designated as Plan 65A to define a method of detecting atmospheric leakage from a seal by directing the leakage from the seal gland or pump bracket to a ground-level detection vessel that contains an orifice in the drain line.

Figure 4. Piping Plan 65B allows users to detect leakage by measuring accumulated leakage.
all of the variations required by users. Users often introduce new requirements or deviations to existing plans that can change design and operation of the plan or system. The Fourth Edition has recognized this need and allows the user to define a custom piping plan by using a Plan 99.

A Plan 99 is an engineered system that must be fully defined in the project or purchasing specification. That plan has no defined objectives or defined equipment required. The Plan 99 might be a simple addition to an existing piping plan or an entirely new piping plan.

There is an expectation that all requirements of the standard for instrumentation, design guidelines or auxiliary equipment that are applicable to the Plan 99 will be applied.

### End User Needs

Piping plans are an important consideration for successful seal applications, and the Fourth Edition continues to be revised to reflect the needs of the end users and incorporate newer technologies. The introduction of new plans provides additional tools for users to maximize seal performance and reliability.

For more information about the API 682, visit this Flowserve site: www.flowserve.com/files/Files/Literature/FSD/API682.pdf.

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**Figure 5.** A Plan 66A allows installation of two close clearance throttle bushings into the seal gland behind the seal face.

**Figure 6.** The option for a Plan 66B allows the variation of providing only one close clearance bushing in the gland and a plug orifice in the drain line.

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### ISC2 SEAL

#### Upgrade Decreases Downtime

Flowserve was heavily involved in the entire process, working with engineering, maintenance and operations to explain the upgrade. Flowserve also set up a support system that would lower barrier fluid consumption, extending the intervals between barrier fluid system refills.

The first ISC2 seal upgrade was installed more than 18 months ago. The seal has failed once since the first installation, but the plant’s maintenance manager points out that the failure was due to a complete loss of barrier fluid that wasn’t detected until the outboard seal started leaking. Since then, the pump rebuild with the ISC2 seal has been running successfully for almost a year.

“We are very satisfied with the seal upgrade. Decreased system downtime on the pump and its batch operation process — along with not having to run at low production rates on the continuous operations side of the plant — has been a huge upside for us,” adds the maintenance manager.

The seal upgrade has allowed the plant’s maintenance crew to focus on other equipment issues. In addition, the company has systematically converted every competitor mechanical seal that has failed to a Flowserve product. Because of the success of the ISC2 in the dextrose slurry and other bad actor applications, the ISC2 is now the plant’s standard ANSI pump mechanical seal.

For more information, visit www.flowserve.com/ISC2.
Supplying products and services to the energy industry is a big responsibility that OEMs for this industry do not take lightly. So when a global provider of rotating equipment needed help making brush seal technology work successfully on an application, the OEM’s leaders asked Flowserve for help. The two companies collaborated to install the Flowserve Cirpac HP gas seal for the application. As a result, the OEM was able to complete testing and shipment on its newest compressor design to a key customer.

This application would serve natural gas export boosting at an oil platform for a major energy company. The export line already had two compressors running in parallel, but this end user wanted a booster as backup when operators brought down one of the existing compressors for maintenance.

The OEM’s compressor for this project saves space by combining components that usually are separate — compressor, driver, heat exchangers and liquid separator — into one compact package, which is vital for the oil platform’s limited space.

Features include a direct-connected high-speed, process gas-cooled electric motor with magnetic bearings and an integral rotary separator.

The separator is what makes this rotating equipment OEM’s machine unique compared to its competitors. It uses a rotating drum on the compressor shaft to remove liquids from the gas stream, like a centrifuge. In contrast, typical separators are essentially large vessels that use gravity to settle the liquids.

Two Tough Challenges
For several months, the OEM was unsuccessful in using the brush seal technology for the compressor regardless of the design or arrangement of these seals. The brush seal frequently failed when the liquids migrated past the brush seal and damaged the bearings and motor.

In February 2010, company leaders requested help from a Flowserve compressor seal specialist. They held several meetings in February and March to discuss different sealing solutions, and ultimately decided to use the Flowserve Circpac HP gas seal because of the seal’s compact size, and sealing and performance capabilities.

Flowserve also had to meet the OEM’s aggressive delivery date. In anticipation of the quick turnaround needed, the Flowserve engineering team completed most of the seal engineering and detail drawings before the company even received the OEM’s purchase order. Once Flowserve received the purchase order for six seals, it had just two weeks to manufacture them by the April 1st delivery date.

Positive Results
After receiving the purchase order, the Flowserve operations team ordered materials, purchased buyout items, created manufacturing programs and manufactured and assembled these seals — all within the two-week time frame. The company delivered all six seals on April 1, as the OEM requested.

In addition, the OEM has provided positive feedback about the seals’ performance. The company’s testing showed no damage from the test or seal assembly, and operators are thrilled that the seals are working better than expected.

The superb seal performance also allowed the OEM to complete testing and shipment of their newest compressor design to a key customer on time.

For more information about the Circpac HP gas seal and other seal solutions, visit or www.flowserve.com.