



FLOWSERVE

Face to Face

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THE SEALING TECHNOLOGY MAGAZINE

**Innovative compressor
seal service and support**

Say goodbye to packings



**Retrofit success
in Oman**

Fast-tracked Oman compressor success

Quick and cost-effective compressor re-wheeling and Gaspac seal retrofit enables gas plant to operate with falling inlet pressures and meet peak demand

The summer in the Sultanate of Oman is hot. As early as March, air conditioners start running day and night, pushing the envelope of electricity demand.

The government's natural gas plant in Yibal was officially inaugurated in 1979 to utilize the country's rich gas fields and support the country's growing gas-fueled industries.

Dependent on its compressors

As part of its long-range planning, Petroleum Development Oman (PDO) had scheduled to bring down certain wells for service and maintenance. At the same time, the plant had a variety of new wells under construction.

Accommodating the service and new construction presented PDO engineers with a challenge: Inlet pressures to the plant's compressors would fall to an estimated 44 barg by the summer of 2006, a pressure at which some of the plant's older compressors would cease operating.

Tests at Yibal confirmed that the plant's three Solar Turbines Mars single-stage compressors could operate with inlet pressures as low as 43 barg with reduced flow. However, the plant's four older Solar Centaur C-304 three-stage compressors, limited by their speed, could not operate below a minimum inlet pressure of 46 barg.

Another challenge for the plant's production capacity was presented by the wet seals on the Centaur compressors. Today's gas compressors typically use more effective and reliable dry gas seals. The existing wet seal malfunctions caused unacceptably low availability of the compressor units over the

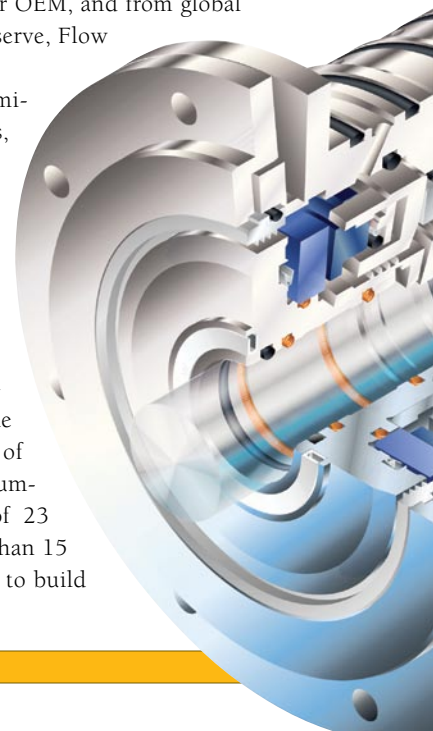
previous three years, measured at 75% availability in 2002, 50% in 2003, and only 27.5% in 2004.

PDO does not run all of the compressors at once; instead, they operate the Centaurs in tandem in a parallel configuration with the three Mars compressors. PDO engineers were concerned that if low inlet pressures forced the Centaurs offline, the power plant would be totally dependent on the Mars units and more vulnerable if they were to go down.

An economical choice

PDO had the choice of either replacing the Centaur compressors or upgrading them with the addition of a fourth compressor wheel. The group commissioned an engineering review from Solar Turbines, the compressor OEM, and from global sealing specialists, Flowserve, Flow Solutions division.

Based on the preliminary engineering findings, PDO was convinced that the re-wheeling upgrade from three-stage to four-stage units would provide an economical and effective solution. Without the re-wheeling, PDO engineers estimated that the plant would fall short of the predicted 2006 summertime gas demand of 23 million Sm³/d by more than 15 percent. While a project to build



Re-wheeling and dry seal conversions

Managing turnkey projects under tight schedules

Unreliable wet seal systems for compressors in critical petroleum industry applications have always been a matter of concern. The persistent need for compressor maintenance is inherently uneconomical and downtime is costly. Even the idea of purchasing new compressors with factory-installed dry gas seals implies the complete removal and replacement of unreliable compressors and a huge capital investment.

One objective behind retrofitting compressors with Flowserve dry gas seals is to raise uptime to as high as 98%. In 2000, Flowserve acquired Revolve Technologies, a company known worldwide for its compressor upgrades and dry gas seal retrofits. Now, Flowserve is capable of providing a full turnkey contract for compressor re-wheeling, overhaul and dry seal conversion.

Engineering and design

The Flowserve retrofit team in Calgary, Alberta, Canada, includes highly qualified and experienced dry gas seal retrofit engineers. They start projects with extensive design calculations based on the conditions provided in the customer records. Subsequent project management includes making site visits and producing specifications, inspection plans, installation and commissioning procedures, machine and piping drawings, dry seal and system integration plans as well as O&M manuals. Flowserve has a highly qualified group of on-site specialists to help the customer start and commission the compressor after retrofit and who also are capable of providing onsite training for different level of stakeholders for a smooth technology transfer to the ultimate user. Flowserve uses genuine OEM components for compressor upgrades. The retrofit team develops wheel maps and relies on rotor dynamic analysis, compressor modeling and strict non-destructive testing.

Management challenges

Even at remote sites, Flowserve arranges for logistics, including transporting compressors to offsite repair facilities if necessary.

Flowserve arranges for craft staffing including shaft machining, upgrading bearing capsules and bearing pads, installing dry gas seals, replacing labyrinth seals and O-rings, and balancing rotors to better than API specifications. Safety is paramount and

Flowserve provides grated flooring and handrails at any open space around removed components.

Justification

Flowserve dry gas seals improve equipment reliability, reduce operating costs, increase efficiency, provide a maintenance advantage, improve safety and offer a positive environmental impact.

There are many tangible factors that justify converting to Flowserve dry gas seals. For example, dry gas seals don't require oil or its reclamation. About 95% of the oil added to the wet seals is lost into the process. This can be as much as eight barrels per year. If the used sour oil isn't reclaimed, consumption can run as high as 300 barrels a year. Handling costs are an additional expense. Environmental regulations governing sour oil add more cost. Flowserve dry gas seals, on the other hand, avoid these issues.

Some of the input power to a compressor is consumed in oil shear loss at the wet seals. The difference in seal shear loss between a wet and dry system is about 0.4% of the output horsepower per seal. A 10,000-hp machine with two seals gains 80 hp by switching to dry gas seals.

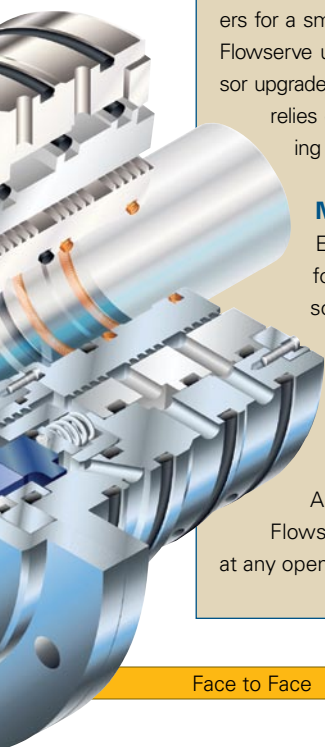
Conversion to Flowserve dry seals can render oil pumps, coolers, control logic and electrical wiring unnecessary. Removing this extraneous hardware yields savings in reduced utility, maintenance and inventory costs.

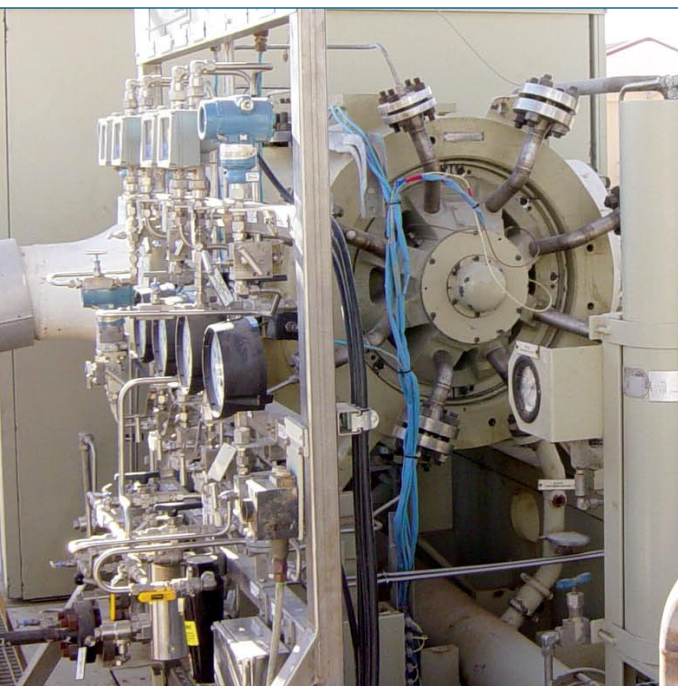
Flowserve dry gas seals, which use an inert buffer gas, eliminate greenhouse gas emissions and comply with present and future environmental regulations. On the other hand, reclaiming pipeline compressor seal oil using a degassing system results in flaring 50 to 100 times as much valuable process gas as is leaked to atmosphere through dry gas seals.

The expected annual maintenance cost for dry gas seals is \$5,000 per compressor, whereas the expected annual maintenance cost for wet seals is \$50,000 to \$100,000 per compressor.

Dry gas seals won't initiate compressor problems, including vibration, component wear and failure. Although wet seals can dampen rotor dynamics, they also can cause instability that damages bearings, shafts, internal labyrinths and couplings.

Dry gas seals on upstream compressors can't release a slug of oil that damages a downstream unit. Also, a rupture in a wet seal oil line leads to cleanup cost and compressor yard cleanup after station blow downs. The cost of cleaning a pipeline contaminated with seal oil is significant. And, seal oil contamination reduces product quality in the chemical and refinery industries. In the pipeline industry, contamination reduces cooling efficiency and flow.





up well pressures was planned for early 2007, the 2006 shortfall loomed.

“They faced a very challenging situation,” says Prathap Ramachandra, Flowserve compressor seal specialist, who is based in Oman and worked on the project. “It was important that they work with a trusted partner who had experience with similar situations.”

PDO goes global to find a fast solution

After approaching several other compressor and seal manufacturers, PDO turned to Flowserve to provide a full turnkey proposal for the entire project. In mid-2005, PDO awarded Flowserve a contract for the compressor re-wheeling, overhaul, and dry seal conversion to Flowserve Gaspac seals. The project included all electrical and controls decommissioning and upgrades associated with the compressors.

Backed by decades of global staff engineering expertise, Flowserve got the support of PDO engineers for the project based on the company’s experience with compressor re-wheels, its industry-leading seal retrofit capabilities, and its ability to complete the project on time to meet the critical peak electricity demand.

Adding Flowserve Gaspac dry gas seals was expected to improve availability on the Centaur compressors to 98 percent. Re-wheeling, which comprises an addition of a 2B wheel to the existing three-wheel configuration, dry gas seal retrofits, and the compressor modifications, was expected to allow all four Centaur compressors to be fully commissioned before the onset of summer.

“We estimate that as many as 8,000 compressors at refineries, petrochemical plants, and pipelines around the world could benefit from a similar upgrade,” says John Sears, Flowserve worldwide director of compressor seal retrofits and systems, who worked on the Oman project. “Re-wheeling and seal retrofits can provide enormous benefit to these facilities.”

A turnkey project

The scope of the Yibal project – completely turnkey – is impressive. It features the supply of all re-wheeling components and spare parts, including additional wheels/diaphragms, modified compressor parts, labyrinth seals/O-rings/gasket kits for the new diaphragm, journal and thrust bearings, labyrinth wheel seals for existing stages, balance piston seals and other needed parts.

Flowserve is also responsible for the design, manufacture, assembly and testing of all equipment supplied.

Flowserve developed product specifications for review, coordinated design exchange between designers and PDO engineers, produced the inspection plans, and provided quality-assurance for all documents, including testing, commis-

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Are you ready?

Compressor seal inventory management and maintenance program eliminates customer pain point

The long life of a gas compressor seal frequently causes improper planning for routine replacement and maintenance during inventory management programs. A spare compressor seal might be in storage for five years because of the effectiveness of seals already in use.

A warehouse can lose or misplace spare seals. Routine upkeep likely has been ignored, so the seals require time to clean and repair before installing. O-rings often harden and lose their elasticity. End-users frequently waste time and money on these and other replaceable components.

Such problems and concerns represent a “pain point” for most end-users. But Flowserve has developed an inventory and maintenance program called ReadySeal™ to provide customers with a cost-effective, comprehensive solution for inventory management, repair and eventual replacement of gas compressor seals.

Being ready

The ReadySeal inventory and maintenance program meets customer demand for greater cost control, as well as fast and reliable seal replacement. ReadySeal not only ensures rapid replacement of seals when needed, but also eliminates the need for extensive

investment in seal inventory, repair and storage.

The program levels customer cash flow over the life of the seals included in the program, with no required capital investment for spares. This means participants realize a high rate of return compared with traditional compressor seal purchases.

“With the ReadySeal program, Flowserve completely manages customers’ gas compressor seal inventory and associated costs,” says Mark Fallek, vice president of marketing, Flow Solutions division. “This ensures minimal downtime and budget impact, while eliminating problems with compressor seal storage and availability.”

In addition to managing field-ready seals to minimize downtime, Flowserve takes responsibility for storage and regularly inspects and confirms seal quality and integrity prior to installation.

ReadySeal advantages

Flowserve assumes warranty risk and liability with ReadySeal through warranty extensions on compressor seals in use, as well as on competitor’s seals in a customer’s inventory.

ReadySeal guarantees seal and spare parts shipment from a Flowserve facility within 24-hours of receiving a request. The ReadySeal program uses a network of regional Flowserve facilities around the world. Facilities are located in the United States, Germany and Singapore, with additional locations planned for the Middle East, Asia and South America.

ReadySeal advantages extend to expert consultation and support. Specially trained compressor seal specialists work directly with end-users to proactively address application and other issues.

“Consultation regarding technology upgrades that can further increase the reliability of the compressor is offered to customers as part of the ReadySeal program,” adds Fallek. “This is part of the entire value-added program we’re confident customers will find beneficial.”



Customized for a perfect fit

Coordination makes it possible to switch from packings to mechanical seals in record time

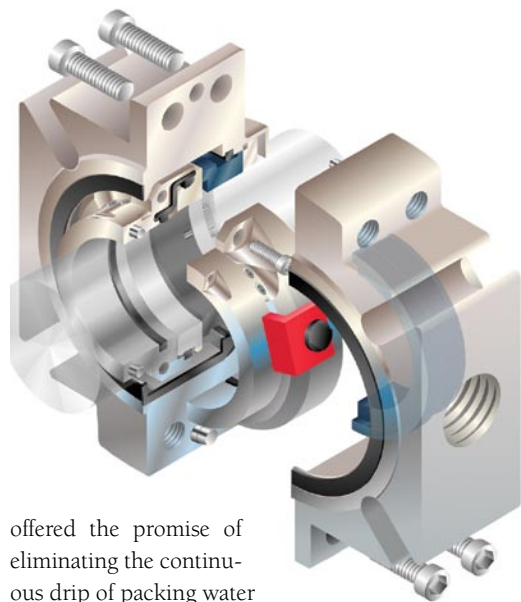
There was a time when a plant had no choice but to tolerate the drip, drip, drip of water from the packings on its pumps. But plant engineering and maintenance departments gained access to precision technologies that make a process plant a real showcase for cleanliness. This is particularly true for a paper manufacturer in North Carolina that produces fluff pulp, which is shipped to manufacturers who convert it into diapers, tissues and other absorbent paper products.

The fiber line is where log chips are cooked in a digester, screened to size, bleached and washed before being dried. The fiber line has split-case pumps, which are used for dilution, a process that controls consistency as pulp moves through the line. Thanks to a dedicated team of maintenance mechanics in the predictive/preventive maintenance group, more than 700 pumps in the facility are still operating like new.

Looking for reliability

Each pump has two stuffing boxes originally designed for packings. The facility experimented with a variety of packings, including ring packings and waterless packings, but none proved satisfying. Preserving pump seal reliability using packings was too maintenance-intensive for the lean staffing that is an integral part of the plant's culture. Also, several pumps are in tight locations, where limited access makes packing replacement difficult.

A few years ago, the paper mill began exploring the idea of switching the pumps to mechanical seals. The motivation, of course, was improved reliability that, in theory, also would reduce maintenance. A side benefit was housekeeping. Mechanical seals



offered the promise of eliminating the continuous drip of packing water that formed small rivers on the plant floor. During warm months, this unnecessarily wet environment fostered algae blooms. During cold months, it led to frozen slip/fall hazards.

The project involved at least two seal vendors who attempted to apply proprietary split-seal technologies to address the plant's concerns. Neither were entirely successful and the root cause, they realized, was that the vendors tried to adapt standard catalog offerings to the pumps. Because the catalog seals wouldn't fit quite right, the vendors expected the mill to design and manufacture adapters that would connect the seals to the pumps. This factor made the installed cost prohibitive. Even if the seals could be installed, when they failed, the plant would have to devote even more time to reinstalling packings to get the process back on line.

Rapid non-catalog answer

The project team would not be denied their desire for a better way. In 2005, they contacted Greg Leach, Flowserve senior sales manager for eastern North Carolina. Leach listened and learned and took a different approach to the sealing problem.

First, Leach carefully measured the packing gland and shaft geometry on the pumps. Then, backed by Flowserve engineering expertise, he returned three weeks later with an answer – in this case, a mechanical seal custom-designed for the pumps. The PSS-II and PSS-III split seals, therefore, fit the pumps perfectly, right out of the box.

“The Flowserve seals are split,” says Leach, “so you can put them on without dismantling the pump. You don’t use the worn or grooved part of the sleeve and the Flowserve seal installs outside the stuffing box. We engineered them and made them fit.”

But merely fitting the old pumps with new seals wasn’t sufficient proof of reliability.

“We thought that if we could get a run time of one year, we would be doing well,” says Leach. “It took the facility six months to acknowledge that the seals worked. And those early seals are still operating.”

So far, that represents two-year reliability. It’s clear that the Flowserve PSS-II and PSS-III split seals exceeded expectations at the plant, especially considering their experience with the catalog-bound seals the plant had tried.

“Split seals on a split-case pump – they had never done this before, and it’s successful,” says Leach. “We have 25 seals on their pumps so far.”

There’s no doubt that this North Carolina facility is gaining reliability in spades. That’s what you get when Flowserve turns a custom seal into a standard product.

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sioning and installation procedures. Flowserve provided complete dry seal and system integration information, along with detailed designs and drawings for all equipment, components and systems. The company also completed all PLC and controls programming, conventionally left for sub-vendors or the end-user on this type of project. Project management and technical coordination for the execution of the project has included extensive onsite visits.

On a fast track to satisfy the customer

Flowserve fast-tracked the entire process to meet the tight timeline, beginning by building the control panels at the company’s Calgary, Canada engineering facilities, and continuing with the complete Gaspac seal

retrofit and compressor re-wheeling. The company’s Dortmund, Germany manufacturing facility supplied the Gaspac dry gas seals. A fully equipped workshop was also located in the city of Muscat, near the power plant, where the compressor buildups and dry gas seal installations were done.

By December 2005, and well ahead of schedule, three compressors were fully upgraded, with dry gas seals installed and re-wheeling completed. The compressors underwent 300-hour test runs, satisfying a long series of specifications laid out by PDO engineers.

“PDO was so satisfied after the revamp of the first compressor that they agreed to turn over both remaining compressors for rework instead of only one agreed earlier,” says Ramachandra. “It was an outstanding success.”



A global leader in fluid motion and control

Flowserve products and solutions are well recognized and play key roles in the oil, gas, chemical and power markets.

A wealth of products, systems, solutions and services

The Flowserve reputation is based on experience to deliver industrial and highly engineered pumps, precision mechanical seals, and various control valves and valve actuators.

That reputation is by delivering life cycle management services and a full range of training and engineering solutions.

Unmatched global reach with a truly local presence

Flowserve people, processes and experience help leading companies in more than 70 countries worldwide.

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