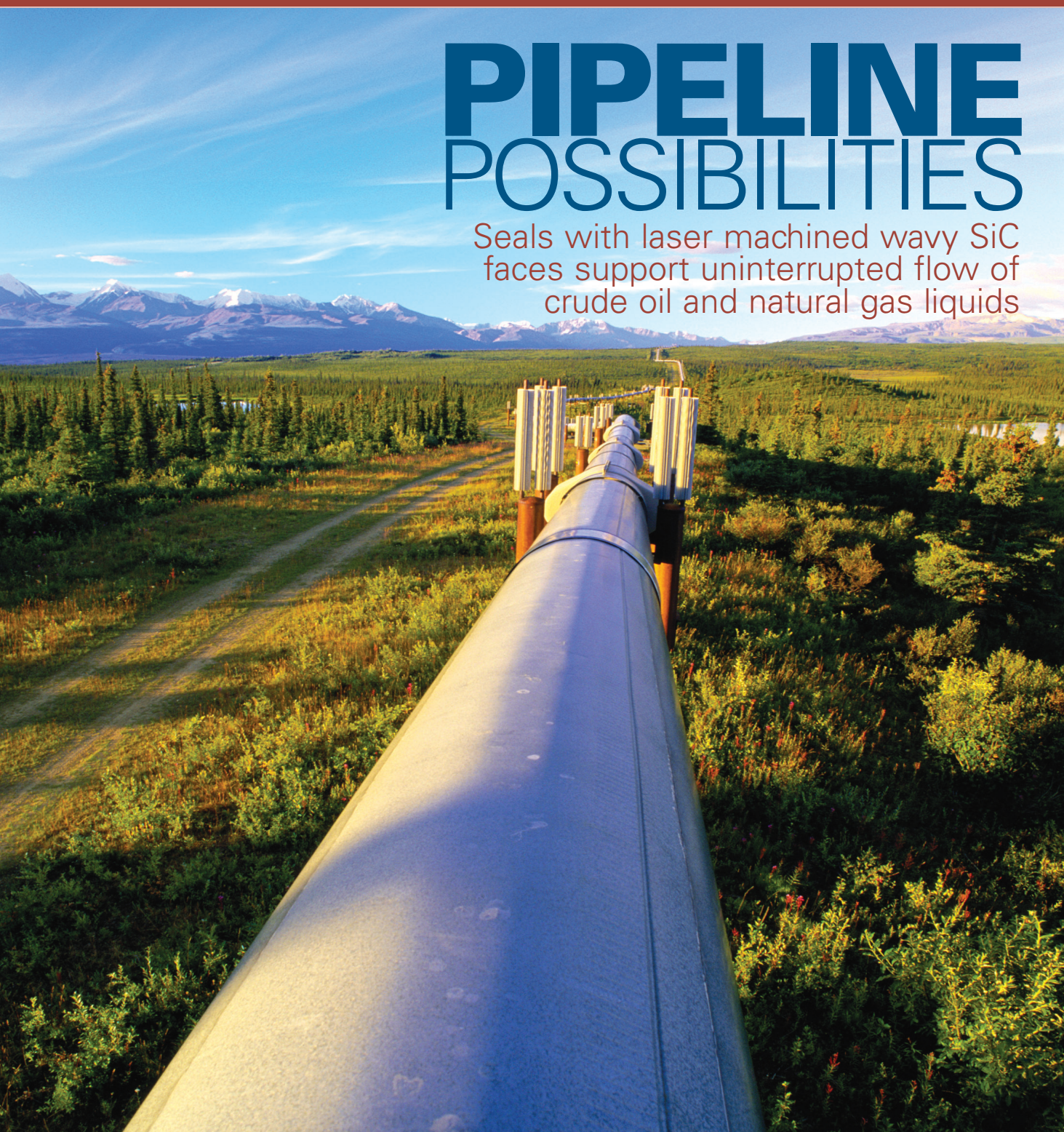
FLOWSERVE

Face to Face

Vol. 15 No. 2

THE SEALING TECHNOLOGY MAGAZINE



PIPELINE POSSIBILITIES

Seals with laser machined wavy SiC faces support uninterrupted flow of crude oil and natural gas liquids

PIPELINE POSSIBILITIES

Mechanical seals equipped with wavy silicon carbide faces make possible uninterrupted pipeline flow for crude oil and natural gas liquids.

Natural gas liquids (NGLs) and crude oil are pumped in batch mode, so seal pressure varies over a wide range and the pumps are subjected to vigorous start/stop operation. The presence of abrasive pipe rouge (iron fines) is a further complication. Mechanical seals were developed to perform in such demanding pipeline applications.

Flowserve engineers used state-of-the art technology to design seals for this difficult application, and verify seal performance in laboratory tests. Mechanical seals incorporating laser machined wavy silicon carbide (SiC) faces have been running in the field since September 2000, with great success.

Pipeline pump stations are spaced about 30 to 40 miles apart. Each station uses three or four pumps in series. One to four pumps are active at the same time. The third or fourth pump experiences a wide range in suction (seal) pressure. To determine seal operating conditions, the fourth pump at one station was monitored using instrumentation hardwired to a computer in the station control room.

A modem was used to access performance in real time and download data. This information

A mechanical seal incorporating laser machined wavy silicon carbide faces can perform successfully in demanding NGL/crude oil pipeline applications.

Laser Machining **Solves Pipeline Problems Fast**

The Flowserve-designed laser micro-machining process has been used to solve other pipeline application problems.

Laser technology produces very uniform patterns, improves surface finish and allows more complex patterns to be made and tested more quickly. "The time needed to move from pattern concept to prototype is much shorter," says Lionel Young, specialized technology manager at Flowserve's Temecula, Calif., facility. "Before, the process could take weeks. Now we can make new patterns within minutes."

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In a Canadian pipeline application that runs a crude oil/ethane batch, the seals endured abrasive conditions and pressures ranging from 400 to 1,000 psi. A special problem, however, was the specific gravity, which ranged widely from 0.85 to 0.44. "Ethane is hard to seal because it tends to go into a gaseous form between the faces," says Young. "When this happens, the pumped fluid no longer provided lubricity."

Laser machined waves on the stationary face of the Flowserve HDHW 5500 seal (which features silicon carbide against silicon carbide) coupled with a GSL 5250 backup provided the solution. "After pulling out one set of seals after 5,000 hours of operation, the faces [were] in excellent condition," says Young.

Multiphase pumping applications in Venezuela are a good example of where laser machined wavy faces have helped solve a tough sealing condition. These applications pump crude oil directly from the ground. The process temperature on the twin screw pump – 90 to 125 degrees F – wasn't that bad, and the shaft speed was a low 900 rpm. But the problem was the pressure, particularly the 750 psi start up pressure, compared to the steady-state pressure of 90 psi. The crude oil also is extremely viscous, and it contains gas, water and sand, which makes it hard to pump and hard to seal. Laser machined wavy faces solved the problem.

revealed that seal chamber pressure varied from about 150 psi to more than 1,300 psi. In addition, the data showed seal pressure spikes of 350 psi (up or down) when a pump 1, 2 or 3 was turned on or off.

The dual mechanical seal arrangement consists of an HDHW primary seal that handles full system pressure drop and a dry running GSL containment seal (see Figure 1). The primary seal is designed to handle NGL and crude oil at pressures as high as 1,500 psig. The containment seal minimizes product release to the environment in the event of a primary seal failure; it features a bi-directional wavy lift-off face for long life and low wear. This tandem seal arrangement with a dry running secondary seal is easy to maintain, as it doesn't require a liquid buffer fluid support system.

Special analysis software was used to design seal faces to handle the range of operating conditions. Seal faces distort (cone) as a result of pressure and thermal loading. To ensure long life and low leak rate, net face deflection coning must be less than about 1/400 the thickness of a sheet of paper. The final seal design was

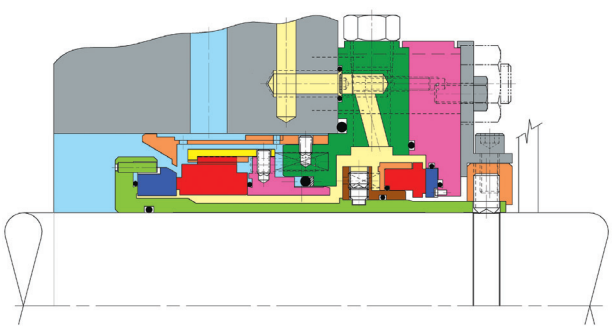


Fig. 1 The dual mechanical seal arrangement consists of an HDHW primary seal that handles full system pressure drop and a dry running GSL containment seal.

The wavy SiC seals are achieving significantly longer life compared to conventional seals using non-featured faces of carbon against silicon carbide.

computed to distort less than half that amount when operating on propane (NGL) at 1,200 psi.

Laboratory tests were conducted with the seals running on propane. Seals that performed well on the test stand were installed in the field. Initial seals used conventional face materials: a carbon face running against a silicon carbide face. The original seals tended to have limited life, particularly in the higher pressure pumps.

Improved lubricity and abrasion-resistant faces were required. Using SiC against SiC faces virtually eliminated wear from pipe rouge. Furthermore, SiC is about 15 times stiffer than carbon and, thus, much less sensitive to pressure-induced distortions. Laser micro-machining, a Flowserve innovation, was used to manufacture a smooth wave pattern in one SiC face (see Figure 2).

The laser process allows complete control of waviness amplitude, seal dam location and number of waves. The wave pattern enhances lubricity. Wave amplitude is small, on the order of 2.5 to 10 microns, depending on operating conditions. The radial taper aspect of the wave valley provides load support under any operating condition, while circumferential waviness provides hydrodynamic load support during shaft rotation. The seal dam resists leakage and the wave pattern is resistant to contamination. Other advantages to this wavy shape include bi-directionality, high fluid film stiffness, long life and high reliability.

Laboratory tests on propane proved that wavy SiC face seals could handle pressure spikes in excess of 400 psi and operating pressure to 1,300 psi. There was no measurable face wear in tests running as long as 140 hours.

The first two wavy SiC seals were installed in September 2000. As of December 2003, wavy face SiC seals have been installed in 67 pumps (134 seals). Only four NGL primary seals failed with high leakage. Three had faces in excellent condition (1,037, 2,149 and 4,276 operating hours). The fourth failure had heavily damaged SiC faces (1,697 hours). Figure 2 shows the excellent condition of the wavy face that ran 4,276 hours. The cause of these failures is undetermined.

Extensive analysis, laboratory testing and field experience has shown that a mechanical seal incorporating laser machined wavy silicon carbide faces can perform successfully in demanding NGL/crude oil pipeline applications. The wavy SiC seals are achieving significantly longer life compared to conventional seals using non-featured faces of carbon against silicon carbide.

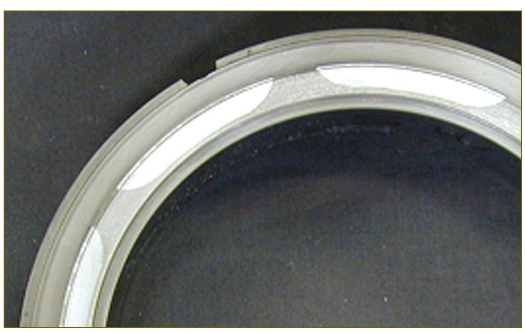


Fig. 2 Laser micro-machining, a Flowserve innovation, was used to manufacture a smooth wave pattern in one silicon carbide face.

The Benefits of the EMBEDDED ENGINEER

Flowserve's Alliance Program supports the Marathon Ashland Petroleum refinery to reduce pump failures and improve equipment reliability.

Like the "embedded journalists" interested in getting the best possible story from the warfront, embedded engineers from Flowserve Flow Solutions Division get up close and personal with customer pump systems in order to improve equipment reliability. These on-site Application Engineers (AEs) are Flowserve employees who work exclusively for a specific customer, such as Marathon Ashland Petroleum (MAP).

Flowserve did not have to look far to find an AE for the MAP refinery in Robinson, Ill. Ted Stone knows the Robinson plant better than just about anyone–because he was a MAP employee for 32 years. Stone had already been part of the MAP-Robinson Seal Improvement Team and, after he retired, he joined up with Flowserve.

MAP is a member of Flowserve's Alliance Program, in which the two companies work toward a common goal of reducing pump failures and improving equipment reliability at MAP refineries. MAP-Robinson signed its first five-year agreement with Flowserve in September 1998, and another just last year.

"We're like one of their employees," explains Flowserve District Sales Manager Brian Bradley. "It's a team. We're all part of the same team."

Although all seven MAP refineries participate in fixed-fee contracts, the arrangement works particularly well at the Robinson facility, which is far from any major highway or Flowserve QRC facility.

The centerpiece of the alliance is the embedded on-site AE. They are tasked with executing the Alliance and managing the overall program on a daily basis. This includes performing a review of all failed equipment and suggesting solutions that help improve overall reliability. Rather than MAP having to call for services every time something breaks down, the on-site application engineer can make equipment upgrades quickly. This helps keep the costs for such maintenance consistent – no budget surprises, and no delays for funding to be approved.

"With the agreement, we are not concerned as much about trying to justify upgrades as they come along," says Kent Paschen, who has worked closely with Flowserve as a member of MAP-Robinson's Reliability Department since 2000. Paschen says the agreement eliminates the need for MAP to spend time on assessment each time an engineer requests an equipment upgrade.

The Alliance Program also facilitates continuous quality improvement through regular monitoring of equipment performance. "It's a continuing, ongoing project," Stone says. "You look at every aspect of the pump and try to make it work better." In addition to Stone, the MAP-Robinson Seal Improvement Team consists of the plant's craft supervisor, reliability supervisor, machine shop foreman, a rotating equipment engineer and someone from the purchasing side of the business. The group meets monthly to discuss the concerns of each department and share advice on improving plant operations.

Flowserve's equipment database, Flowstar.net, is also used by MAP-Robinson. Flowstar.net keeps an inventory of all pumps in the program and a record of past equipment failures so engineers can avoid the same problems in the future.

> 'You look at every aspect of the pump and try to make it work better.' – Ted Stone

Stone raves about the operator training course developed by the Seal Improvement Team — including an online version created by Paschen. The course shows MAP technicians the proper ways to operate and maintain equipment.

At MAP-Robinson, the teamwork that arises from the Alliance program has led to an improvement in MTBF from 24 to 70 months in five years. This results in an annual savings of over $1.4 million dollars to MAP-Robinson. While all customers may not achieve such tremendous results so quickly or enjoy such extensive, site-specific experience from a Flowserve on-site engineer like Stone, they can expect the same level of attention, cost-savings and continuous improvement from every Flowserve AE as part of Flowserve's Alliance program.

GRAND RE-OPENING OF GERMAN TEST LAB

Every two years in Dortmund, Germany, Flowserve's Flow Solutions Division customers attend a Technical Forum to learn about the latest technical advances. In Spring 2004, the Technical Forum coincided with the re-opening of the FSD test lab, which added additional compressor seal test capability.

Key European customers toured the facility in which offices were moved to create a customer monitoring area. Test data streamed live onto LCD monitors in a quiet room away from the testers that kept customers safe from test pressures up to 450 bar (6,500 psi).

Flowserve FSD President Andy Beall, who was in Dortmund for the grand re-opening, said, "This state-of-the-art test facility in Dortmund is yet another example of our commitment to providing our customers with excellent capability and service."

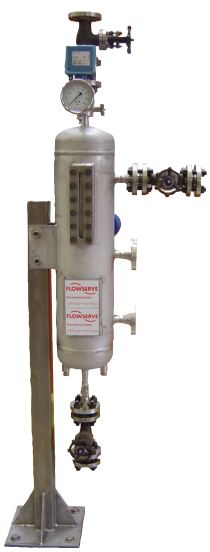
During the forum presentations, the Circpac LO was introduced. As the newest solution for reducing nitrogen consumption as a separation seal in compressors, this carbon ring seal is in contact with the shaft during static conditions, but lifts once the shaft starts to rotate. This allows for low leakage rates both statically and dynamically, and eliminates carbon wear and contamination from the rings.

European customers recently attended presentations at Flowserve FSD's biennual Technical Forum in Dortmund, Germany, (above right), and toured the test lab (above), which added additional compressor seal test capability.

FAST DELIVERY FOR STANDARD RESERVOIRS

A correctly specified seal support system contributes significantly to the durability and correct function of pumping systems. Seal support systems provide fluid at the right temperature and pressure to keep the mechanical seal properly lubricated. This helps achieve maximum safety and maximum useful life with minimum leakage.

Flowserve Flow Solutions has standard API plan 52 or plan 53A reservoirs in stock and ready for fast delivery. These reservoirs satisfy the API 682 guidelines and are designed to ASME VIII div 1 standards, in accordance with the Pressure Equipment Directive (P.E.D.).



Both the first and second edition of API 682 contain clear design guidelines for reservoirs that are to be used for API plan 52 or 53A configurations. API plan 52 calls for the use of buffer fluids for "dual unpressurized seals." In this design, an unpressurized buffer fluid in the reservoir acts as a receptacle for primary seal leakage. For volatile liquids, any leakage evaporates and is vented through an orifice in a controlled fashion. For non volatile liquids, the primary seal leakage is dissolved into the buffer fluid, which needs to be replaced periodically.

API plan 53A calls for "dual pressurized seals," in which a pressurized barrier fluid fills the cavity between the two seals. Because the pressure in the barrier system is higher than the seal chamber pressure, pump product is prevented from leaking to the atmosphere.

Connections are present on the Flowserve Flow Solutions reservoirs for the most commonly used components, such as level switches, pressure switches and pressure gauges. Both Flowserve standard components and customer-specific components can be supplied. The standard specification includes a cooling water element, so an extra cooler is not normally required.

API Plan 52 **and** Plan 53A **Reservoirs**

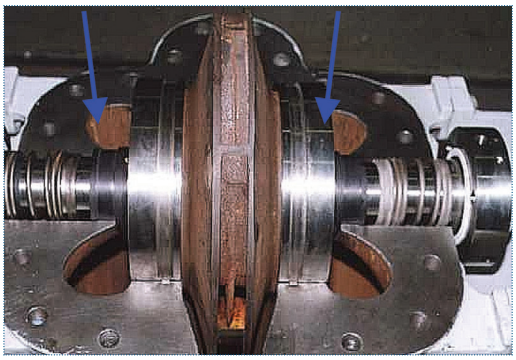
Design pressure: dependent on temperature, from 58 to 77 Barg (840 to 1117 psig)
Total volume: 27 liters / 7 gallons
Normal working volume:
6.4 liters / 1.7 gallons
Material: stainless steel AISI 316L
Connections: 3/4" 600# flanges
More information: www.flowserve.com/seals

WR, AR MATERIALS **DISTRIBUTION AGREEMENT**

Flowserve BV, Flow Solutions Division, has signed an agreement to distribute in Europe high-quality thermoplastic pump components from Greene, Tweed & Co. The five-year agreement covers Greene Tweed's WR® and AR™ materials.

The WR material, which consists of long-carbon-fiber-reinforced thermoplastic composite, is intended for use in rings, bushings, seals and wear plates in a variety of pumps used in the refining, chemical and petrochemical industries. It is an alternative for metal, carbon and graphite pump elements.

WR material has very high resistance to wear and good self-lubricating properties under almost all circumstances. It also has a low coefficient of expansion, so that it is possible to work with much smaller tolerances. It reduces internal leakages losses, which results in increased pump efficiency and reduced vibrations.



Wear on the bushings is negligible when using WR300 material.

The AR material is a composite specially developed for bushings, bearings and wear rings in pumps moving abrasive and erosive substances. The material is also highly resistant to thermal shock and very impact-resistant. This makes it a good alternative to traditional rubber and bronze material.

Ben van Eyndhoven, director of EMA sales for Flowserve Flow Solutions, says, "We have extensively tested the WR and AR materials from Greene Tweed and these tests confirmed what we believed. Pumps run more efficiently when these high-quality composite pump elements are used. This is good news for our clients in the chemical and petrochemical industries."

Says Robert van de Velde, general manager of Greene, Tweed & Co. Holdings International BV, "We are very pleased with the deal with Flowserve. Worldwide, the company has a great reputation in the field of producing and maintaining mechanical seals for pumps in the process industry. Our WR and AR materials fit well with the high quality products and service offered by Flowserve."

Greene, Tweed & Co. Benelux BV, based in Halsteren, in the Netherlands, is a subsidiary of Greene, Tweed & Co., Kulpsville, Pa.

The best little reference guide in the business

The Flowserve Piping Plan Flip Book

a durable, compact reference book provides concise summaries of the essential piping plans used successfully in today's process plants

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