THE SEALING TECHNOLOGY MAGAZINE

Making waves for the power industry

They improve efficiency and reliability of boiler service

We need more power! This yell is being heard around the world as the electronic revolution continues. To help the power generation industry squeeze more efficiency out of existing systems and improve reliability of rotating equipment, Flowserve Seals is making waves...faces, that is.

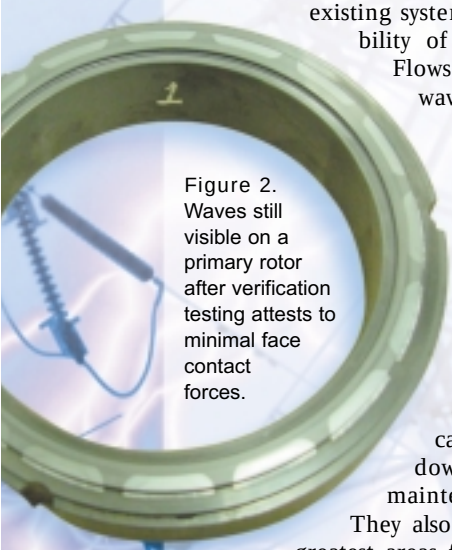


Figure 2. Waves still visible on a primary rotor after verification testing attests to minimal face contact forces.

Boiler circulating pumps are critical equipment in steam power generation plants, as they circulate boiler water at pressures approaching 3,000 psi and temperatures of 600 to 700° F. Under these extremes, the pumps can be a source of costly downtime and frequent maintenance requirements. They also represent one of the greatest areas for efficiency improvements within the steam-electricity generation cycle.

History reveals that advances in generation efficiency and equipment reliability have directly translated into life cycle cost savings. It also explains why applying the latest technology available today—wave face mechanical seals—is important.

A costly proposition

Boiler feed pumps commonly discharge water at 350° F. Each gallon carries a heat content—enthalpy—of 2,240 BTU. Traditionally, feed water also cools braided packing and mechanical seals used in boiler circulating pumps. Simply put, each gpm of feed water used for cooling can represent a waste of 2,240 BTU / min. (0.039374 MWe) that can't be used to make electricity. While that doesn't sound like much, a single gpm represents 1.2 trillion BTU per year (21,000 MWe) of wasted energy. It's equivalent to 3.21 railroad cars of coal or 9,748 gallons of gasoline wasted annually.

Packing

In the 1960s and 1970s, braided packing sealed most rotating pump shafts. A series of close-clearance floating rings and leak off ports were used to reduce the discharge pressure down to an acceptable level needed in the packing box of a vertical boiler circulating pump. This allows valuable steam energy to escape the system and not be used for electricity generation. Between 100 and 200 gpm of 350° F boiler feed water must be injected to prevent steam flashing as the boiler circulating water pressure drops from discharge to that created in the packing box. A single boiler circulating pump can represent the equivalent of 642 railroad cars of coal, 2 million gallons of gasoline or more than 4 million MWe of wasted energy annually.

Additionally, costly purified, deaerated make-up water must be added to account for water losses. Rotational wear, fouling by oxides and hydraulic system upsets can require constant adjustment and frequent packing replacement. This obviously adds to maintenance costs, but most importantly, it reduces generation capacity as equipment is taken offline for repair.

Single mechanical seals

In the late 1970s and early 1980s, single mechanical end-face seals gained popularity over braided packing as a way to reduce maintenance costs and improve uptime. Close-clearance carbon graphite bushings reduce the circulating pump discharge pressure to 300 psi in the seal chamber. As with packing, boiler feed water injection is still needed to prevent flashing, often at a rate of 25 to 50 gpm. This flow represents 160 coal cars, 0.5 million gallons of gasoline or more than 1 million MWe of wasted electricity in a year.

Payback periods easily justify using single mechanical seals instead of braided packing.

Seals are more efficient because they operate at higher pressures, which minimizes lost heat and make-up water costs. But, boiler feed water pumps or separate dedicated booster pumps used to provide the needed cooling water injection must be brought online first and remain operational when the circulation pumps operate.

It is common for the single Flowserve D seal fitted with API Piping Plan 23 to achieve three years or more of continuous service in boiler circulation pumps. This reliability and uptime is several orders of magnitude better than for braided packing.

Pressure-staged multiseals

Pressure-staged multiple mechanical seals can further reduce energy loss and water make-up if boiler feed water is the seal cooling media. Multiple face mechanical seals, such as the Flowserve HS series mechanical seal, have two, three or four sets of faces, or "stages." Each stage takes a fraction of the pressure drop to prevent flashing at any set of faces. The last set can act as a safety back-up. Staged pressure seal technology eliminates the need for injection cooling and associated system make-up water, but it also requires a complicated seal design and a reliable seal support system to function properly. Typically, each stage uses its own dedicated API Plan 23 setup.

The ultimate

Wave face technology makes it possible to seal a 3,000-psi discharge pressure in boiler service using only one set of faces, without pressure staging or injection cooling. These custom-designed seals can feature either a single arrangement or a dual, non-pressurized tandem arrangement in which the secondary set of faces can act as a full safety back-up seal.

Laboratory testing at actual seal chamber operating conditions using API Plan 23 verifies the suitability of the DHTW mechanical seal for a given application. Critical functional parameters are verified against design criteria using a full complement of flowmeters, pressure transducers and thermocouples.

The design

Each seal rotor has an undulating face that was designed using computer code that combines sophisticated fluid mechanics and finite element analysis and then manufactured with precise laser technology incorporating proprietary computer modeling.

To reduce face contact and wear, algorithms determine the amplitude, tilt and number of waves needed to optimize full-surface liquid lubrication down to the sealing dam area (see Figure 1). The wave face design reduces face contact to the point that the shaft can be rotated by hand, even at full system pressure. Figure 2 shows a primary rotor after a series of rotating verification tests. Its pristine condition shows waves still visible to the naked eye, which attests to its minimal face contact forces.

Wave face technology translates to improved reliability in rotating equipment because the seal support systems are less complicated compared with pressure-staged seal designs. DHTW seals maximize the efficiency of steam electricity generation because no boiler feed water is needed as a cooling fluid. As a result, utilities have the potential to save in excess of half a million dollars simply by upgrading conventional single mechanical seals. The limited contact in wave face seals helps to optimize the generating unit uptime and system output. As far as the steam electricity power generation industry is concerned, making waves is a good thing.

Technical details

The DHTW seal is a balanced, stationary multi-spring configuration in a stainless steel cartridge design. The standard unit uses a silicon-carbide rotating face working against a carbon or silicon-carbide stationary face. Other custom combinations are available. The gaskets are made of high-performance elastomers, such as nitrile, fluoroelastomer, perfluoroelastomer or ethylene-propylene. A pumping ring eliminates any need for the injection of cooling water during operation, with stable temperatures maintainable through thermosiphon even in hot stand-by conditions.

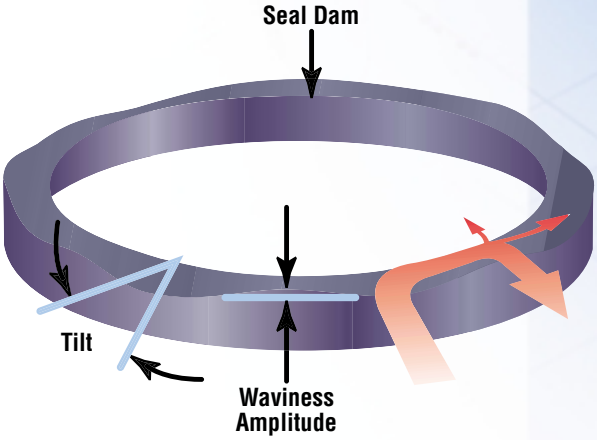


Figure 1. Computers determine the amplitude, tilt and number of waves needed for full-surface lubrication down to the sealing dam area.

The Flowserve DTHW seal is rated to handle pressures to 3,000 psi, temperatures to elastomer limits and speeds to 15,000 feet per minute. It is available to fit shafts from 2.00 to 11.00 in. and can be fitted to most existing seal chamber bores. ●

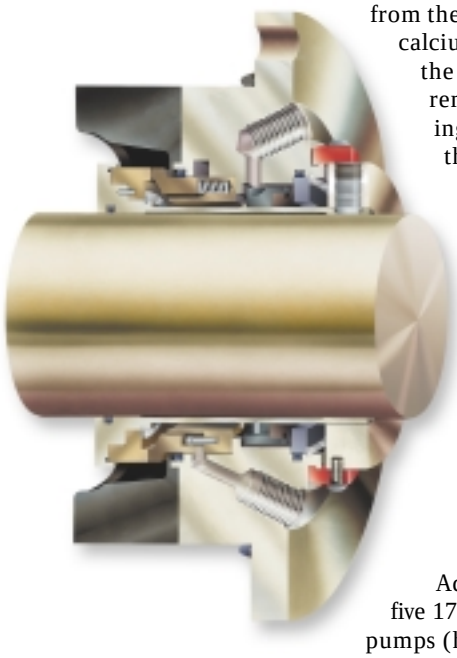
(Based on an article by John Marta, Manager Product Marketing, Flowserve Corp.)

Don't flush your slurry seals

The power industry discovered you don't need to do that

More than half the power generated in the U.S. comes from coal-burning power plants. A byproduct of coal combustion is sulfur dioxide, which combines with moisture found in air to form acid rain. Removing sulfur dioxide before it reaches atmosphere is called flue gas desulfurization, or FGD. Eric Adolfsen, who manages the FGD process at Conectiv's B.L. England Generating Station in southern New Jersey, explains the process. Flue gases are diverted to an absorber vessel, a tank eight stories tall by 33 ft. across. It contains 300,000 gallons of limestone slurry in its base that is circulated through spray headers.

As the flue gas passes through the spray levels, the slurry absorbs sulfur dioxide gas. In the process, the SO_2 reacts with the calcium from the limestone to form calcium sulfate. Once the sulfur dioxide is removed, the remaining gases pass onto the stack.



Adolfsen's plant uses five 17,000-gpm Hazelton pumps (heritage product of the Weir Slurry Group) to recirculate the limestone slurry—which is like "pumping out a residential swimming pool every minute."

The limestone slurry also collects additional abrasives from combustion—fly ash consisting of aluminum oxide and silicon dioxide. "You've got gas temperatures above 200 degrees. You've got chlorides in the coal that end up in solution, so the pH is acidic. It can be a hostile environment for a no-flush mechanical end face seal if you don't know what you're doing," says Barry Hart, Flowserve senior sales engineer for the Conectiv plant.

Flowserve originally designed its RIS (Rubber-In-Shear) seals in the early 1980's specifically for mineral and ore type slurries, like those found with all wet FGD applications. These component seals look similar to and are set manually like a packing gland. Metal components are milled from corrosion and abrasion-resistant alloys and use silicon carbide seal face rings. The faces are lapped to a flatness of one to two light-bands, or 11 to 22 millionths of an inch. That leaves a fluid film gap of approximately three microns—small enough to filter or strain out larger abrasive particles that can wear out the seal faces in a process known as three-body abrasion.

Adolfsen, whose FGD system uses the largest diameter Flowserve RIS 9500 size seals, says, "I don't believe we ever took a pump apart because of a Flowserve mechanical seal. Sometimes we've had to flush and reset them, but I don't remember any seal failures.

New on the horizon

Flowserve has taken things one-step further and introduced the new SLM series cartridge seal to minimize the effects that equipment assembly tolerances, seal installation setting variances, and impeller adjustments can introduce. "The SLM seals are designed using proven flat face criteria and manufactured to survive the same slurry equipment tolerances as the RIS units, but are offered in a cartridge design," explains John Marta, Flowserve's manager of product marketing in Littleton, Colo. "We use power plant fly ash to make a 20-percent slurry at our test facility located in Temecula, Calif. to verify our no-flush slurry seal designs."

According to Marta, Flowserve isn't necessarily emphasizing the repair market for the SLM line. Many power plants have gotten five to 10 years' service out of their RIS seals, and most plants have spares in inventory. The SLM may better suit the new generation of FGD systems. "It's a good fit with modern slurry equipment," Marta says. "It's precision-set at the factory. It's verified using the same parameters we used in our previous no-flush slurry seal designs, and it uses the same flat face design criteria that we've always had."

The new SLM seal also has an expanded pressure/temperature capacity to meet any future needs of an evolving FGD industry. This coincidentally expands the scope of the SLM to be able to be applied in other demanding slurry applications like found with the new millennium of mineral and ore processes as compared with those from just 20 years ago. The SLM seal has a higher capability than its predecessor.

"Flowserve will support its installed base of RIS seals," Marta says, "and continues to stock parts for them. But if you're looking at a new FGD installation, why not use the latest and greatest sealing technology available today?"

Simple, but effective

A single seal takes abuse and solves problems

The Conectiv B.L. England Generating Station in Beesleys Point, N.J., provides electrical power to the grid serving a part of New England. It operates two 155-megawatt generators (one coal, one oil) and one 129-MW coal-fired generator for a peak capacity of 439 megawatts.

A dedicated 1,800-psi boiler serves each turbine. Each boiler uses twin feed pumps operating at about 1,480 gpm at 2,750 psi. These ten-stage barrel pumps feed 326° F water to the boilers.

When one boiler feed pump is down, the best its twin can do is provide feed water for only about 60 percent of the turbine's capacity. Any downtime is a graphic demonstration of "time is money."

Eliminating maintenance

Sealing high-pressure pumps can be problematic. For years, Conectiv's B.L. England station used braided plastic/lead packing to seal its boiler feed pumps. And for years, the station tolerated a continuous maintenance program with these pumps. After a while, the packings would leak. A few turns of a wrench would tighten the gland enough to stop the leak. But sooner or later, they would leak again. This regimen carried the risk of over-tightening and scoring the pump shaft/sleeve, which would require taking the pump offline. There also came a time when continued tightening was simply impossible. As a result, the pump had to be taken offline to be repacked completely. This happened about four times a year.

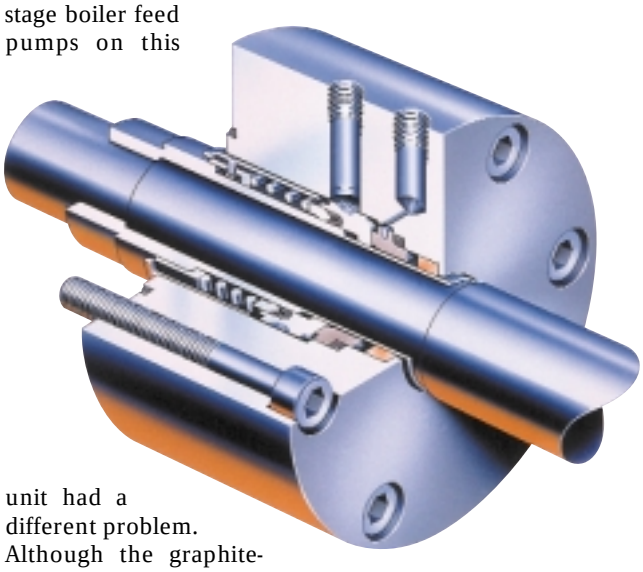
Seeking better options

In 1994, the station gave Flowserve Corp. an opportunity to improve this situation. Flowserve's solution was to replace the packing with the D seal—a single mechanical seal designed for high-temperature, high-pressure boiler feed pumps. The installation relied on API Plan 23 piping to cool the seal.

The bulk of the changeover was painless. "The retrofit required no modifications to the stuffing box on Unit 2 boiler feed pumps," says Charles Ash, project engineer at the Conectiv facility. "Flowserve made a new shaft sleeve because the original cross section would not allow installation of a cartridge seal."

According to Barry Hart, Flowserve senior sales engineer, "The design of one of the pumps prevented an easy retrofit. It required reworking the stuffing box so the D seal would fit." This project was handled at Flowserve's Bridgeport N.J. Quick Response Center.

Normally, the oil-fired unit is the last to come online. It handles forecasted peak loads and provides electricity when the spot prices justify the sales. The multi-stage boiler feed pumps on this unit had a different problem. Although the graphite-laminated packing at the low-pressure, inboard end functioned well, the high pressures developed at the outboard end had a tendency to blow out the packing. Besides being a maintenance headache, failed packing allowed water to contaminate the lube oil.



Conectiv asked Flowserve to address this problem. The solution required retrofitting only the outboard end with a D seal. This heterogeneous sealing scheme has worked well.

"Not every pump has been equipped with the D seal yet," says Ash. "We have been making the retrofits kind of piecemeal. When a pump needs rebuilding, we replace the packing with seals. The payback for converting from packing to seals is typically achieved in about 1 year."

When asked about stocking spare seals onsite, Ash says "We don't stock any. If I need one, I can call Flowserve and they'll be here in no time. I don't need a seal onsite because the turnaround is so good."

Learning solutions

How hands-on education at Flowserve's Learning Resource Center can improve your plant's competitive edge

Are nagging maintenance problems in one of your plant's pumping systems causing costly failures and wreaking havoc on your organization's profits? What if you could tear apart an identical system—without affecting your plant's uptime—and effectively diagnose the problem? Or, perhaps you have an idea about how you might be able to improve the functionality and efficiency of your facility's fluid management system, but realize it would be financially impractical to take your system offline and foolhardy to experiment with the system's components.

Created to provide plant professionals with real solutions to these critical issues, Flowserve's Learning Resource Center (LRC) in the Dallas suburb of Irving provides an education-based program that gives students a hands-on opportunity to test their knowledge. The end result is tangible benefit to their employers by improving their organization's productivity.

Flowserve provides users with the knowledge and skills they need to improve the performance and maintenance records of their own organization, allowing companies to get full value from their equipment.

Putting instruction and theory into action, students move from the facility's classroom to its state-of-the-art labs where they can test, disassemble and reassemble more than 100 static pumps and 28 operating pumps that simulate actual working conditions.

Unique learning model

But while it may be common practice to learn through lecture and hands-on methods, the LRC provides an uncommon third educational experience—experimentation. By testing their theories, participants validate past learning and discover what can't be taught in a classroom alone. The LRC's unique three-tiered adult learning model of instruction, implementation and discovery is implemented in three distinct facility areas: the classrooms, the Static Lab, and the Power Lab.

First, students find out the "why" through classroom instruction that introduces theory and references needed to get the most from future hands-on experience. Next, students move to the implementation phase of their learning by working in the LRC's Static Lab. In the 2,300-square-foot Static Lab, students work on current equipment from around the world, including a wide range of pumps, valves and seals that give students the chance to work with the equipment they encounter in their everyday work environment.

In the LRC's four 900-square-foot Power Labs, students work with innovative see-through training aids such as glass flowmeters, transparent plastic suction lines, extensive gauges, thermocouples, vibration monitoring equipment and unique clear acrylic pumps that allow students a look into the working mechanisms of the equipment. In the Power Lab, pumping systems operate as they do in plants around the world, but many of these pumps have been modified to allow students to compare maintenance methods, and some have been altered to simulate real life failures for the purpose of diagnosis.

What really closes the loop to complete this learning experience is the experimental or discovery phase. These hands-on experiments give participants the answers to "what if" scenarios. During discovery, students recognize they have the skills to solve the very same problems back home. The opportunity to experiment and

change the flow characteristics of these pumping applications allows students to see what will happen if they put their solution ideas into action. Previous to the development of this innovative approach, maintenance engineers could only talk about what might happen. Flowserve provides the opportunity to be creative in the learning and problem solving process.

Companies that have sent employees through the program remark at how extraordinary Flowserve's LRC is. Said Shawn Bassiri, Process Area Specialist at DuPont's La Porte, Texas facility: "It's great because the programs provide an overview of the principles of pumps and hydraulics, and show participants how seals really work. They start at the basics and then go into more advanced applications. It's the combination of classroom instruction and hands on lab experience that makes Flowserve so unique."

This learning philosophy is best reflected in the LRC, where clear epoxy casings on pumps allow students to see exactly what happens when they experiment with seals. For example, they are able to see the immediate effects from temperature changes on pumps and the effect on the resultant life of the seals.

Interactive training

Flowserve also takes training to the next level through its Educational Services Certified Training program, an interactive competence-based equipment-intensive certification program for pump, mechanical seal, and systems engineers and specialists. Students are certified on the standards required by OSHA that meet a specified body of knowledge in areas such as pump assembly and disassembly, proper mechanical seal installation, calibration and repair and control valve position.

The program's goal is to provide participants with two primary, yet essential tools: knowledge and skill. Certification includes complete documentation of a student's skill level, allowing organizations to see the tangible difference Flowserve has made

One phase of the training is preparing an "On The Job Checklist" that includes researching and documenting the critical reliability measures and issues used in their organization. Students return home to their plant, examine their equipment, evaluate their procedures, develop an improvement strategy, and prepare a reliability self-audit.

While many of the students are maintenance engineers or operators who have dealt with the product, they often are not involved in the product's original selection. Upon returning to their organizations, students are now better equipped to understand the installed base by going through the questions and becoming familiar with their own situation. In terms of reliability, they can look at worst performance over time, perform a case study, identify commonalities of failure, and make corrections that improve their system's reliability.

Flowserve seeks to establish long-term learning alliances with companies so that skill improvement doesn't end once a student completes the program. As in any profession, maintaining and upgrading skills are essential to remaining relevant, and profitable.

Positive return on investment

Flowserve looks at learning from a customer's perspective, which is why students always come away with the skills needed to increase their company's competitive position. When an employee is empowered to identify a glitch in his system back at home, and implement a response to correct the problem, the return on investment is nothing but positive. The LRC's competency-based training includes instruction, implementation and experimentation, ensuring that students return to their organizations equipped to increase uptime, decrease equipment failures, and realize real dollar savings. The result is increased earnings for the organization.

Lab equipment features a full array of instrumentation.

And because pump seals are a major portion of a plant's maintenance budget, the potential for savings is significant. Avoiding seal problems frees up labor, improves uptime, and eliminates contamination on the path, which can have costly environmental ramifications.

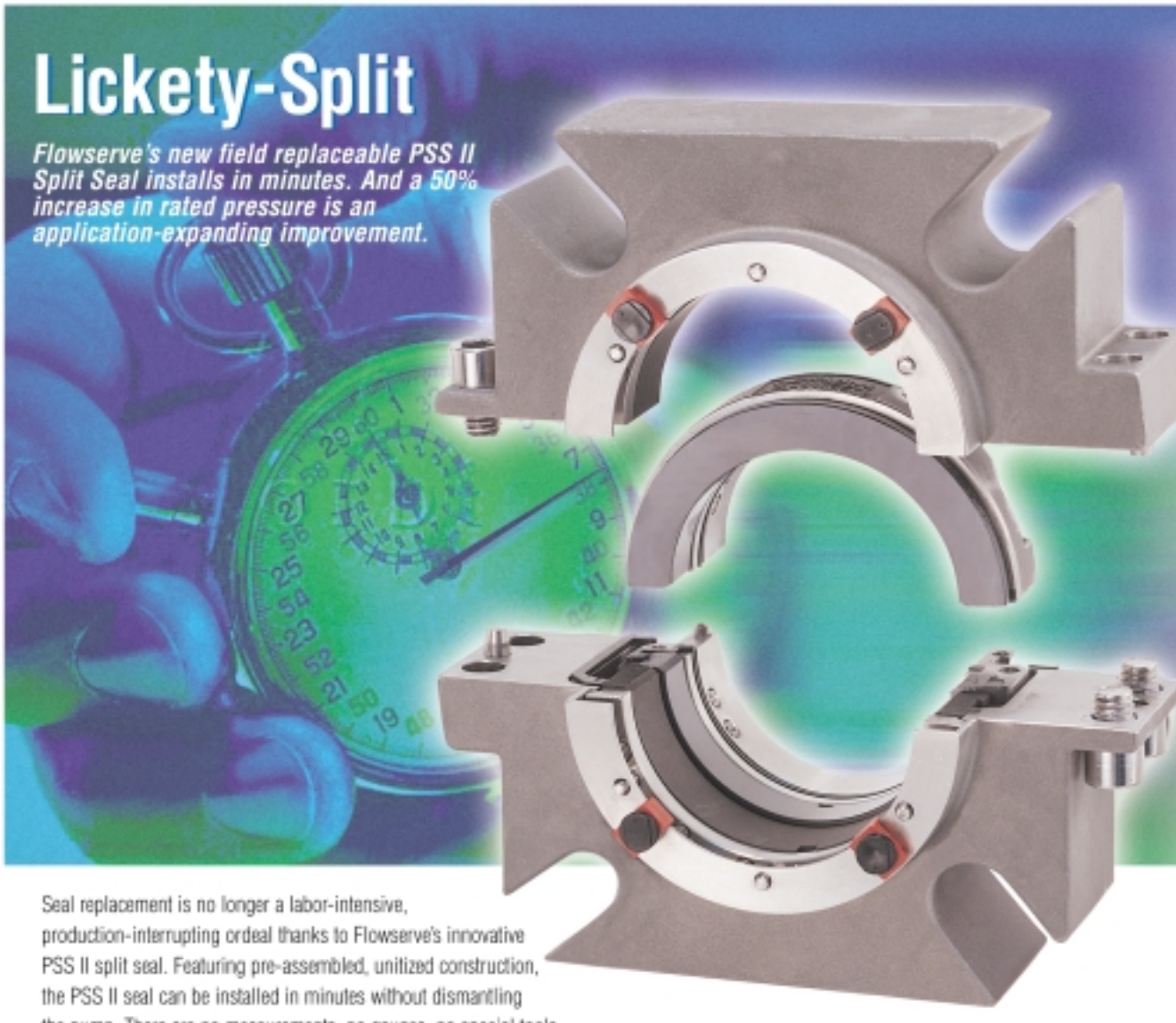
But for most companies, the real payoff comes through a more focused eye on the future. Eliminating seal problems frees human resources to address long-term strategies and moves the organization away from working in a reactionary mode.

It's all fostered by Flowserve's belief that in order to leap forward you first need to be standing on solid ground.

For more information about the programs at Flowserve's Learning Resource Center, please send an E-mail inquiry to ESG@flowserve.com or through the company's Web site at www.flowserve.com. Flowserve's Educational Services Group also can be reached at (800) 446-0401.

Lickety-Split

Flowserve's new field replaceable PSS II Split Seal installs in minutes. And a 50% increase in rated pressure is an application-expanding improvement.



Seal replacement is no longer a labor-intensive, production-interrupting ordeal thanks to Flowserve's innovative PSS II split seal. Featuring pre-assembled, unitized construction, the PSS II seal can be installed in minutes without dismantling the pump. There are no measurements, no gauges, no special tools, no problems.

Ideal for use in unspared process pumps, PSS II seals are commonly applied in water and oil applications in pulp & paper, municipal water, power generation and non-hazardous chemicals. Upgrade leaky packing with mechanical seal reliability. Popular sizes may be obtained off-the-shelf while custom designs can be engineered for special equipment.

PSS II seals are rugged, too. A balanced seal with OD product, it has a pressure rating to 150 psi (10 bar). It accommodates runout of 0.060 in (1.5 mm) TIR while the springs and pins are isolated from the medium. Ultimately, the simplified installation promotes robust performance.

For more information about PSS II Split Seals, contact your Flowserve sales representative or authorized stocking distributor today.

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