Water Saving

SAVE 6.3 Million Litres / 1.7 Million US Gallons of water per pump per year...

...and INCREASE Uptime

- Water, pumps and sustainability
- The problems with packing
- The complete solution
- Target industry case histories

AESSEAL®
ENVIRONMENTAL TECHNOLOGY

Introduction

This paper explains the problems associated with packing, how double mechanical seals with seal support systems solve these problems, and gives examples where double seals with seal support systems have saved billions of gallons of water.

Water is becoming more scarce and more expensive. Still, large quantities of water are essential in many industrial processes. Accurate water-balance planning and reduction of overall water consumption are critical. This document presents a technology that is proven to save millions of gallons of water per pump per year, while also increasing the MTBR (Mean Time Between Repairs) of the equipment with an ROI (Return on Investment) that is typically 6 months or less. The case histories show examples across several industries where savings have been achieved:

- Elimination of 154 million gallons of wasted water per year
- Savings of $30 million per year of product losses
- Increased plant availability through elimination of 28 pump repairs, and
- Three-week ROI for a seal upgrade

Water, Pumps and Sustainability

The growing scarcity of water on a global level and the need to reduce water use has been stated by many experts such as Mohamed ElBoradei (Former head of the IAEA)[1]. For many companies planning, sourcing, permitting, pumping, tracking, reporting and disposing of process water consumes a significant portion of operating budgets, especially those that operate in arid regions of the world. Eliminating water consumption from any part of the process is a worthy consideration for most plant operators. One area to consider for major reductions is the supply of gland water to the packing on process and slurry pumps.

The mining industry is one of the most arduous and expensive industries for the maintenance of rotating equipment. Not only must it deal with abrasive and corrosive applications, but it also has to accommodate historical "run-to-failure" maintenance practices and the difficulty of operating in remote locations. A common mining industry misconception is that the only way to achieve a reliable seal on these tough pumping applications is through the use of gland packing (Figure 1). However, gland packing goes hand in hand with high water consumption, high maintenance costs, poor equipment availability and large production losses.

1 Mohamed ElBaradei, International Atomic Energy Agency: "The simple fact is that there is a limited amount of water on the planet, and we cannot afford to be negligent in its use. We cannot keep treating it as if it will never run out.

Not only do mechanical seals work in the mining industry, they are collectively eliminating billions of gallons of wasted gland water each year, while simultaneously improving the MTBR of the pumps. Thousands of double mechanical seals are now operating successfully around the globe in some of the most remote and difficult phosphate, platinum, gold, potash, copper and other mineral extraction operations. This has been made possible by simply following the golden rule of sealing: "Maintain a stable fluid film".

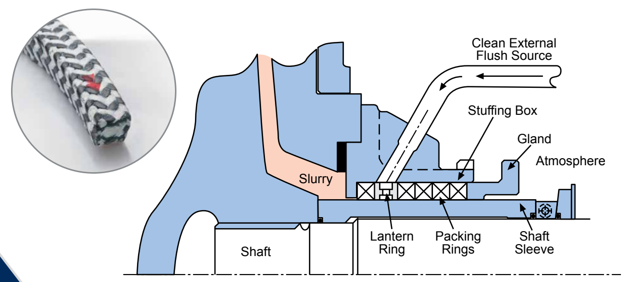


Figure 1.
Gland packing. Typical arrangement of packing in a pump. Inset, photo of braided packing.

The Problems With Packing

Gland packing has been the traditional method of sealing pumps for nearly 100 years.

Packing is generally readily available, relatively low-cost per unit, and most mechanics are familiar with its use. However, there are some inherent drawbacks. Packing:

- Requires large amounts of gland water for cooling and lubrication. A typical slurry pump requires 12 gallons (45 litres) per minute of gland water, which equates to 6 million gallons (22.7 million litres) per year
- Requires more energy (than a mechanical seal) to turn the shaft, since it relies on a friction-fit against both the pump housing and the rotating shaft. A 30hp (22kw) motor can waste $1,700 (£1,270)/year just to overcome the friction of the packing
- Wears quickly and requires a high level of maintenance for adjustment and re-packing
- Damages the shaft sleeve, due to the friction, requiring frequent sleeve replacement
- Sprays gland water or process liquids directly onto the pump's bearing housing when it leaks, resulting in premature bearing failures
- Puts about half of the gland water onto the ground (Figure 2), and the other half into the process. Both of these outcomes can have negative consequences
- Creates housekeeping and safety issues from gland water on the ground around a pump (Figure 2)
- Causes corrosion that requires frequent repainting from gland water leaking on the pump and pump base

Figure 2. Typical mining slurry pump with packing gland water can create a safety hazard and waste water.

AESSEAL® water management systems contribute to water savings of over 95 Billion litres / 25 Billion Gallons per year!

A Partial Solution: Single Mechanical Seals

The key to successful sealing is to maintain a cool, clean and stable fluid film between the faces. When a single mechanical seal is used, the process fluid becomes the fluid film (Figure 3). This works fine when this is a clean liquid such as water. However, when it is a slurry, the abrasive nature of the slurry can quickly damage the seal faces and result in component failure .

A single mechanical seal incorporates two flat faces, one stationary and one rotating, running against each other with a fluid film between them providing lubrication. Without a stable fluid film between the faces, they would be in full contact known as "dry running", which would lead to rapid heat buildup and component failure (Figure 4). In this case, an external flush of clean liquid (typically water) can be injected on the process side of the single seal to force the slurry away and surround the seal faces with a cool, clean liquid. The primary drawback of this arrangement, known as API Plan 32, is the injection water into the process at a higher pressure than the stuffing box pressure. This is problematic on tailings pumps in series, where the final discharge pressure can reach several hundred psi, and special pump systems must be installed and maintained just to supply this high pressure flush water.

Typical flush injection can waste several million gallons of clean water per year. If the process is hot and the injected flush water is cool, large amounts of energy must be added to raise the temperature of the flush water. If the process is sensitive to dilution, even more energy must be added to evaporate the flush water from the process.

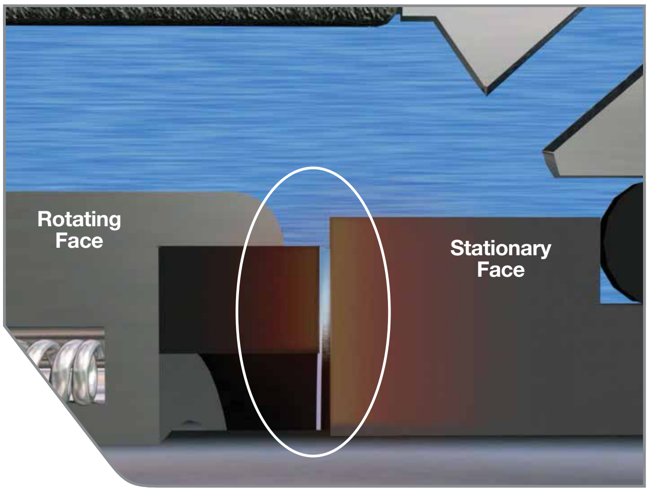


Figure 3 - Mechanical seal faces with a fluid film of fresh, clean water will run cooler and longer.

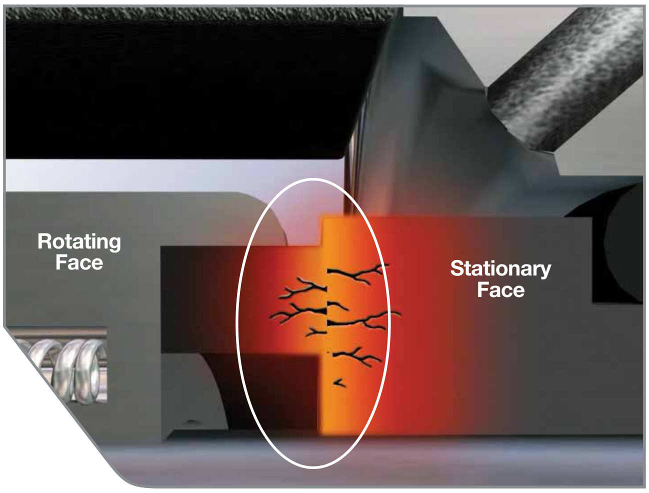


Figure 4 - Dry-running of mechanical seal faces destroys the fluid film, resulting in overheating and failure.

The Complete Solution: Double Mechanical Seal & Support System

All of the drawbacks of both gland packing and single seals described above can be eliminated with a correctly specified double mechanical seal and support system. A double seal has two sets of faces; one set sealing to the process fluid and one set sealing to atmosphere, with a barrier region in between the faces (Figure 5).

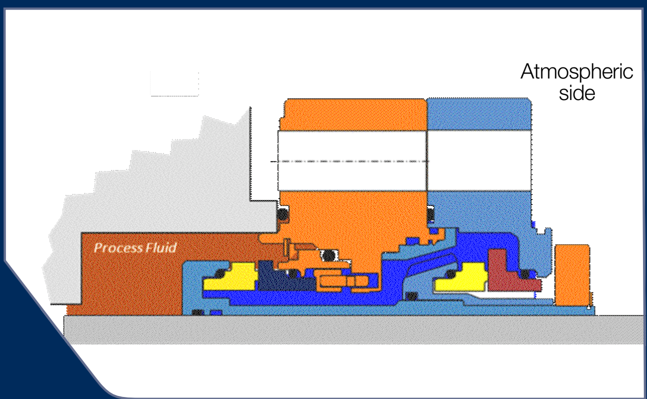
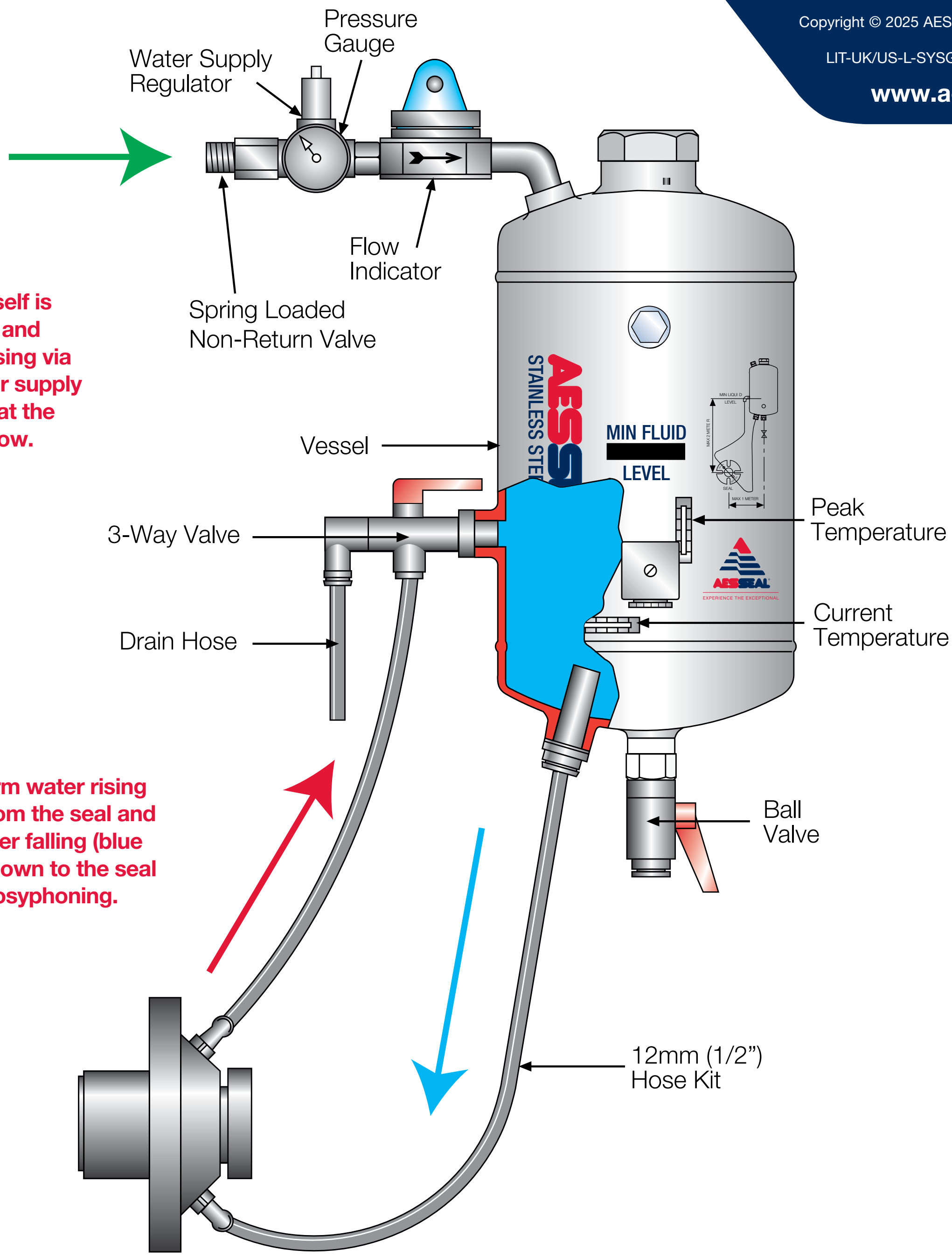


Figure 5. Diagram of a typical double mechanical seal showing inboard seal faces sealing to the process fluid, the outboard seal faces sealing to atmosphere and a (blue) barrier fluid in between.

The tank itself is self-filling and self-pressurising via the plant water supply connected at the green arrow.



Note the warm water rising (red arrow) from the seal and the cool water falling (blue arrow) back down to the seal via thermosyphoning.

Figure 6. Overview of a tank support system, connected to a mechanical seal.

A properly-designed seal support system (tank or "seal pot", see Figure 6) supplies a clean, cool liquid (usually water) to the barrier space between the seals, at a higher pressure than the process fluid in the pump. Thus there is a pressure differential which forces the clean barrier fluid across the faces, forming a stable fluid film.

As the mechanical seal faces generate heat, the hot water in the barrier zone of the seal rises to the tank. The tank radiates heat to the atmosphere, and the cooler, denser water sinks back down to the seal. This process is known as a "thermosyphon", and it enables the tank to provide the mechanical seal with a constant supply of fresh, cool, clean, pressurised water for the fluid film, with no moving parts!

In addition to maintaining a stable fluid film on the seal faces, it is useful to control the design of the seal chamber to promote maximum seal life. Many slurry pumps utilize an open throat seal chamber as shown in Figure 7 on the next page. This design can lead to erosion of the seal gland caused by the velocity of the slurry around the seal. The conventional remedy is to use flow modifiers (ridges or "speed bumps") machined into the ID of the seal chamber.

A better seal chamber design is shown in Figure 8, where the slurry velocity is interrupted by the closed frame plate between the impeller and the seal chamber. There is still a large cavity around the seal which promotes the flow of liquid to cool the seal. So that standard, off-the-shelf seals can be used, the seal mounts to a seal back plate,

The piping plan for connecting multiple pumps / seals / support systems plant-wide in a modified API Plan 53A is shown in Figure 9. Each mechanical seal has its own support tank with pressure regulator, to provide clean barrier water at the appropriate pressure for each pump (typically 15 to 30 psi over the pressure in each stuffing box or seal chamber). Each tank is fitted with a non-return valve so that reverse-contamination of the plant water system is not possible. Even if the plant water pressure should fail for a short time, the non-return valves keep each tank at the proper pressure so as to maintain the important fluid film.

A well-engineered solution will cut seal water consumption (per pump) from an estimated six million gallons of water per year with a traditional flushed seal or packing, to less than 10 gallons per year, for a 99.999% reduction in seal water usage.

Note that there is ZERO wasted water going to drain with the modified API Plan 53A shown in Figure 9.

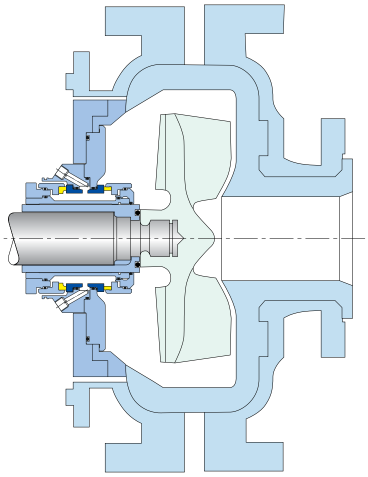


Figure 7. Diagram of a conventional "open throat seal chamber", which exposes the seal to the full velocity of the slurry.

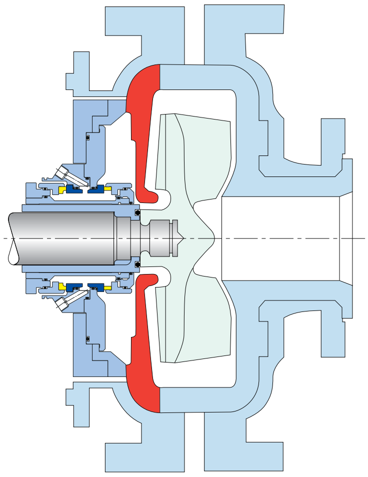


Figure 8. Alternate "closed frame plate" pump design, which hides the seal from the full velocity of the slurry, thus reducing the need for expensive, exotic metallurgy for the seal components. These closed frame plates are available from most pump OEMs on request.

> "ZERO wasted water going to drain with the modified API Plan 53A"

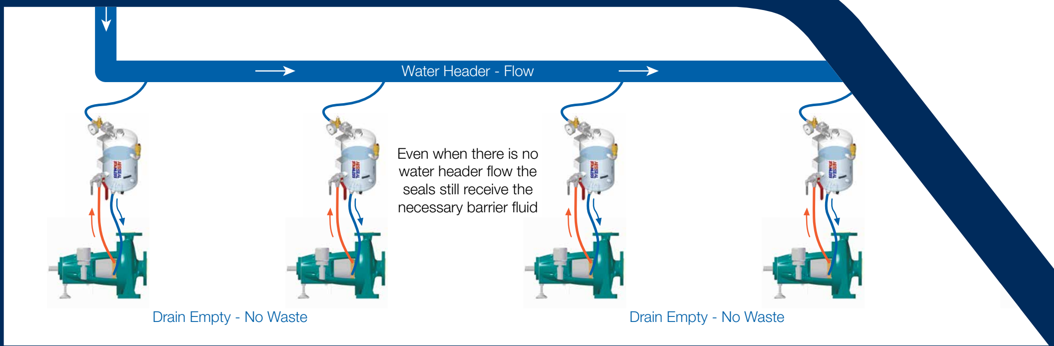


Figure 9. Double mechanical seals and seal pots on a Modified API Plan 53A system. An unlimited number of process pumps can be individually sealed with no cross-contamination and no wasted water to drain.

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Case History #1

Diamond mine, Botswana, Africa: "1 billion gallons of water saved"

Figure 10. Debswana – Orapa diamond mine, Botswana

The Debswana Orapa mine is the largest diamond mine in the world (Figure 10). The mine is located in an extremely arid region of Africa, where water is at a premium. Large Warman® F-frame pumps were sealed with gland packing which required 19 gallons per minute (gpm) of gland water per pump. To reduce water consumption, double mechanical seals and tank systems were fitted to 18 Warman® 6X4 E-frame, and 12X10 F-frame slurry pumps at Plant #2. Currently, these 18 seals are running fine with reported total savings of 1.1 billion gallons of water with a value (in this desert country) of $3.9 million.

FLOWTRUE® — Water Flow Control System

Case History #2

Mineral sands mine, South Australia: "3-week payback / roi"

A large Warman® 14/12 GAH pump was pumping a mineral sand slurry and was leaking excessive packing gland water, creating excessive mud on site (Figure 11). This pump required 9 gallons per minute (gpm) of gland water on the packing for proper operation. The packing was replaced with a double mechanical seal and tank system, reducing the leakage to zero. The improvement in the physical condition of the pump area is obvious from the image in Figure 12, as the double seal resulted in zero leakage to the environment. In addition, the mine operator found that, with the elimination of the gland packing water going into the product, he could actually pump more product and less water. The entire seal upgrade paid for itself in only 3 weeks and a total of 24 pumps have been upgraded to double seals on this site.

DMSF™ — Double Monolithic Stationary Flow

Figure 11. Warman® GAH slurry pump with leaking gland packing water, BEFORE installation of mechanical seals.

Figure 12. Same Warman® slurry pump as above, AFTER installation of double mechanical seal and tank system (circled).

Case History #3

Sludge dewatering operation, Wisconsin, USA: “improved uptime”

The Fox River in Green Bay, Wisconsin, is currently undergoing a $1 billion, ten-year campaign to dredge 15 miles and millions of cubic yards of PCB-contaminated sludge from the bottom of the river and bay (Figure 13). For more information, see **www.foxrivercleanup.com/**

The slurry is pumped to a plant where the treated solids are separated from the water with eight of the world’s largest filter presses, which are fed by 16 Warman® 4X3 DAH slurry pumps (Figure 14). These pumps are challenging to seal, as they ramp up from near-zero pressure and high flow, to 130 psi and no flow, with each cycle. The filter press manufacturer selected mechanical seals over packing to seal the pumps, because the addition of gland packing water at the filter presses would increase both the cycle time and the cost to de-water the slurry. The mechanical seals were originally installed as double mechanical seals with unpressurised barrier tanks. This design, unfortunately, does not promote a stable fluid film for the seal faces. During a two year period, there were 28 seals replaced on these 16 pumps, causing significant down time.

Following this, during their winter shutdown, the plant operator requested help to re-design the sealing system. Dual mechanical seals with patented pumping rings were selected, each serviced by a 25-litre barrier tank which thermosyphons the heat away from the seals (Figure 15). Most importantly, to supply the barrier fluid with clean water at 150 psi to control and maintain a stable fluid film on the seal faces, a self-contained pumping skid was utilized, which supplies all 16 pumps, tanks and seals (see the diagram in Figure 16 below). The pumping skid consists of a 50-gallon water tank, a multi-stage centrifugal pump (with in-line spare), and an accumulator which holds pressurised water and cycles the pump on / off as required.

SP Range — Gas Pressurised Barrier Fluid Systems

CDPH™ — Double Seal for Heavy-Duty Slurries

Figure 14. Warman® slurry pump showing double mechanical seal and white tank.

Figure 15. Four of the sixteen Warman® pumps serviced by the pressurisation skid in the background.

Figure 13. Dredge operating on the Fox River in Wisconsin

Using the new pressurised barrier system, there were ZERO seal failures during the 2011 and 2012 operating seasons. This compares with 28 seal failures the previous two years with an unpressurised barrier system.

A digital flowmeter installed on the pressurisation skid (Figure 17) showed that the system consumed only 25 gallons of water per year in total, or less than 2 gallons of water per pump per year.

On this project, the double mechanical seals, tank system, and water pressurisation skid have eliminated the down time and costs associated with mechanical seal failures, while at the same time providing a safe and reliable sealing method that does not require any gland packing water that would dilute the de-watering process.

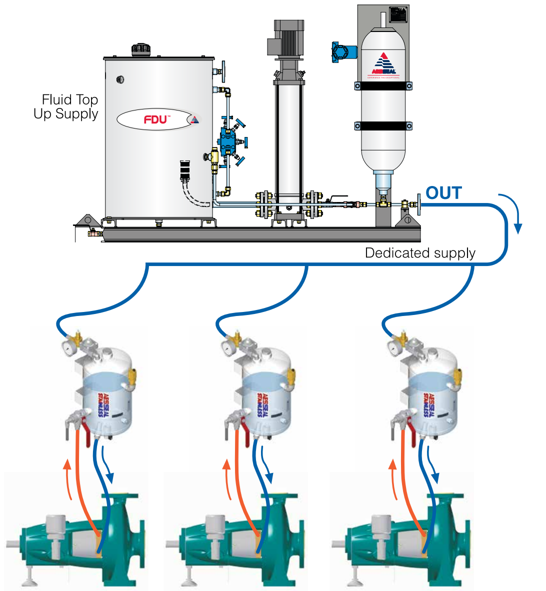


Figure 16. Typical arrangement of pumps, seals, and tanks that are serviced by a single self-contained water pressurisation skid. At the Fox River project, 16 Warman® pumps are serviced by one pressurisation skid.

Figure 17. Skid-mounted FDU unit with digital flow meter (arrow) provides pressurised water for seal barrier fluid.

Case History #4

Potash mine, Canada: "$30 million product savings"

The potash refining process uses a working fluid of saturated brine to process the crushed ore through a series of scrubbers and flotation steps to remove insoluble minerals and unwanted salts. Saturated brine is used because it will not dissolve the potash solids. Introduction of any fresh water at this stage will dissolve potash solids and reduce the potash yield.

One gallon of fresh water will dissolve about one pound of potash crystals. The slurry pumps on the scrubbers and flotation circuits have OEM-recommended water flush to the packing of 14 to 16 gpm. Conservatively, 1/3 of this gland water enters the potash process, resulting in the loss (by dissolving) of 1,314 tons of potash, worth more than $600,000 per pump per year.

A potash mine in Canada recognized this loss and has begun to convert their slurry pumps from packing to double mechanical seals and tank systems. The first mechanical seal was installed on a froth feed pump which historically leaked gland water on the ground, as well as consumed potash solids due to plant water being injected into the process.

With the 50 new pumps fully operational, it is estimated that as much as $30 million in potash product per year could be saved, as it will no longer be dissolved in the injected gland water.

SW Range™ Water Management System

CDSA™ Double Mechanical Seal

Figure 18. Warman® AH-F Froth feed pump, fitted with double mechanical seal and tank system.

Case History #5

Chemical industry, UK: "AESSEAL® helps global industry save over 25 Billion US gallons of water per annum"

Saving water, the environment and our customers money. A chemical manufacturer in the UK was using 2,000 cubic meters of water per year in an API Plan 54 system on a reflux pump, at an annual cost of around £1,700.

With a need to reduce costs, and lessen the environmental impact of their process, they turned to AESSEAL® and the environmentally friendly SW water management range.

The AESSEAL® solution was a contained API Plan 53a where the seal barrier fluid is circulated via a unique, bi-directional, integral pumping ring that delivers high volumes of barrier fluid to the seal faces, greatly reducing the chances of seal failure and reducing water waste.

The cost of upgrading the system was paid back within 10 months and is anticipated to save the customer over £3,500 in 3 years. The actual water cost savings amount to £1,740 per annum, without taking into account the environmental impact of saving over 2,000 cubic meters of water every year.

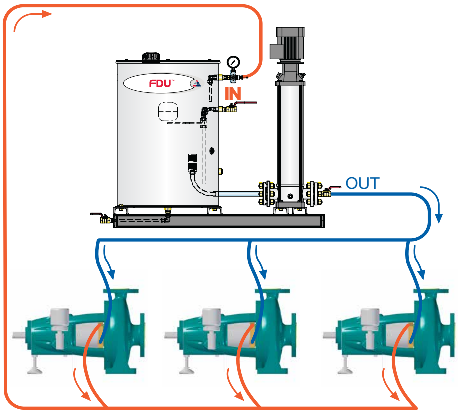
Case History #6

Food & Beverage, UK:
"£47,000 a year cost saving"

Saving water, energy and £47,000 a year. A UK based food and beverage company was running 16 pumps, with a quench to drain seal support system.

This was costing the company over £47,000 per year in energy and effluent disposal, without taking into account the environmental cost of the wasted water. The old system was costing over £27,000 a year in energy costs alone, just heating the water that was then being quenched to drain.

AESSEAL® installed a Fluid Distribution Unit (FDU), and TO1F component seals specifically designed for use with Fristam pumps. The FDU unit, which is capable of supporting the seals on multiple pumps operates in a closed loop API Plan 54 environment offering significant water savings over a quench to drain system.



The FDU system since installation has decreased energy costs by over 900% and decreased effluent disposal by over 1,500%. This has contributed to a £47,000 per year cost saving and a considerable reduction in water wastage.

Case History #7

Chemical plant, UK:
"Saving £11,800 & 18 million litres of water a year"

Upgrading from packing reduces water usage and operating costs. A chemical plant in the UK was using packing to seal 12 waste water pumps around the facility. The packed pumps were consuming 18 million litres of water a year in a flush to drain configuration.

AESSEAL® replaced the packing with a Convertor II™ mechanical seal on all 12 pumps. The Convertor II™ is a simple to install cartridge seal, specifically designed to replace packing and is ideally suited for use on applications with limited space. The seal eliminated the need for a water flush saving in total over 18 million litres of water per year plus £11,800 per year in operating costs. The total cost to upgrade was paid back in 4 months of operation.

Case History #8

Pulp & Paper, North America:
"Savings of more than one million dollars per year "

AESSEAL® undertook a seal energy audit where the energy used by the seal and seal support system of each pump is measured. The audit recommended upgrading a number of pumps with the latest technology dual mechanical seal and water management systems. This was to have the benefit of reducing water and energy usage, while improving pump reliability.

AESSEAL® installed the first upgrades in January 2013 on three chemical mixers. With the upgrades installed reliability of the three chemical mixers was improved significantly. Three effect pumps were also upgraded in 2013 and these have given energy savings of $30,000 per year amounting to $85,000 since installation.

In 2014, 14 pumps were upgraded which have given additional energy savings of over $400,000 per year ,and in 2015 a further 25 pump sealing system upgrades gave an additional $455,000 in energy savings and almost $100,000 per year in maintenance cost reduction. In 2016, by eliminating the need to reheat and evaporate injected water the company are saving a total of over $900,000 in energy costs per annum, in addition improved reliability has reduced maintenance expenditure by $130,000 per year.

Since AESSEAL® started working with the company in January 2013, the latest technology dual mechanical seals and seal support systems have been installed on numerous plant locations in the USA. One facility has over 70 dual seal and support systems in operation. Over this period the company has saved over $880,000 on maintenance and almost $1,500,000 in energy costs, through upgrading pumps that were sealed with packing or single mechanical seals to dual mechanical seals and systems.

Case History #9

Sugar Refinery, Netherlands:
"Reducing Energy Usage and improving reliability"

Suiker Unie were using packing to seal juice circulation pumps at their Dinteloord sugar refinery. Typically after 3 campaigns the packing on these pumps needed replacing. Additionally as a result of wear caused by the packing, the shaft sleeves also had to be replaced.

In addition water used to maximize the life of the packing leaked into the product and needed to be removed by evaporation. For Netherlands based sugar producer Suiker Unie saving energy is a key element of its sustainability program and have a goal to cut energy consumption by 50% by 2030 relative to 2005. Removing the need to evaporate off seal water from the product has the potential to save energy.

In order to address the leakage and shaft wear issues, AESSEAL® recommended replacing the packing with a CDSA dual seal along with a SW2 seal support system on twelve pumps coupled with a single FDU installation. Changing from packing to a dual mechanical seal eliminated shaft wear and after 6 years of operation (approximately 7 campaigns) the system is operating without failure.

The change from packing to double seals with support system has resulted in Suiker Unie receiving tax benefits from the government for saving both water and energy. In order to qualify for this tax benefit; the company must achieve an energy saving of between 0.6 and 1.5Nm^3 Natural gas equivalent per invested Euro.

Water savings: With packing, water usage was measured to be 48 litres/hour per pump, giving water usage per campaign to be:

12 pumps x 48 Litres x 24 hours x 120 days campaign = 1,658m^3.

1,658m^3 is 1,658 tonne return flow. To evaporate 1 tonne of water requires approximately 100m^3 of gas. Total gas usage to evaporate the injected seal water is therefore 165,888m^3.

Changing to dual seals with support systems has resulted in no significant leakage of water and therefore saved energy as there is now no requirement to evaporate off seal water.

As a result of the excellent performance, the plant has subsequently installed additional seals and support systems replacing packing on 43 pumps.

With the upgrade applied to 43 pumps more than 5,944m^3/year of water will be saved, reducing gas usage by 594,432m^3/year.

This is equivalent to approximately £181,000/year saving*

(* Based on a cost of gas of £0.0274 / kWH)

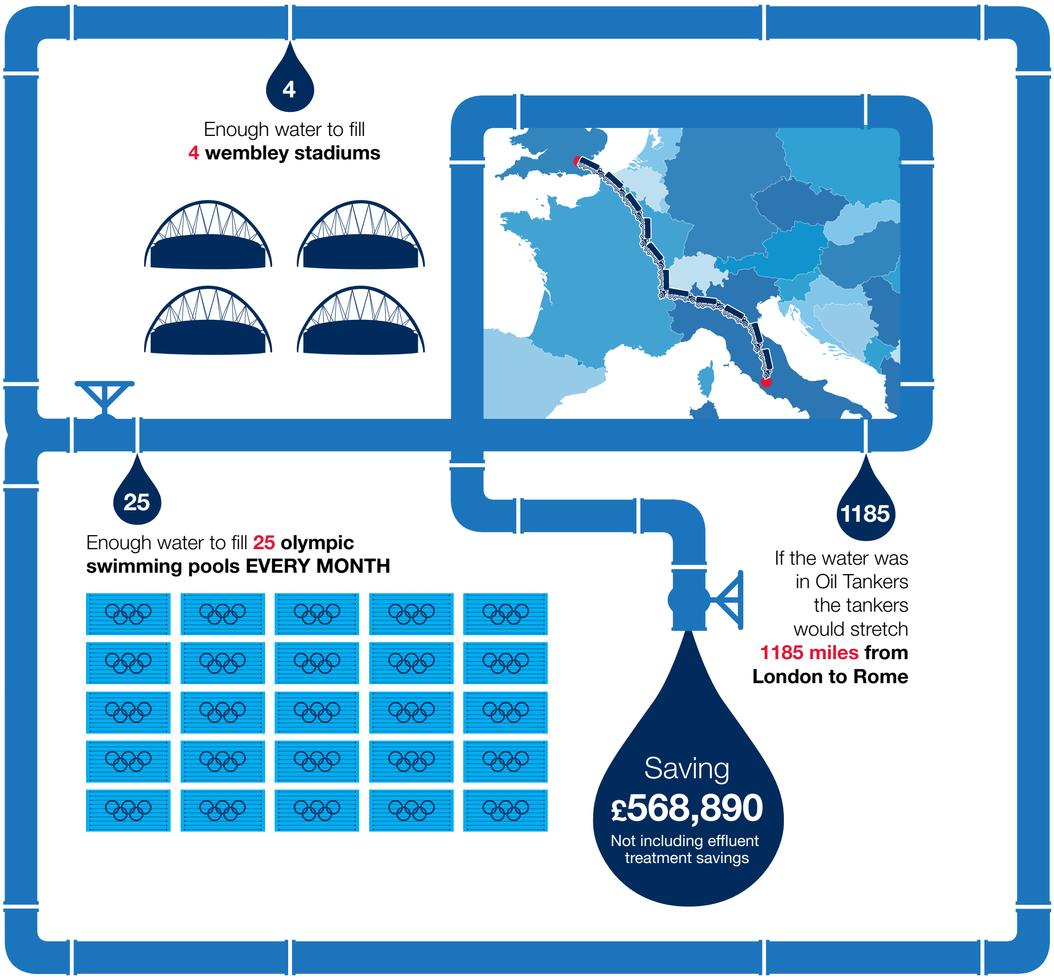
Case History #10

Pulp & Paper, South Africa:
"4.5 Billion litres of water will be saved in the next 6 years"

Reducing water usage and increasing MTBF. International packaging and paper group Mondi is replacing quench-to-drain flushing and lubricating systems fitted to mechanical seals at its Richards Bay mill with AESSEAL® systems incorporating a continuous loop water management design. The AESSEAL® systems will cut water usage at the plant by more than 60,000 kilolitres per month, helping to conserve scarce water resources in northern KwaZulu-Natal.

Mondi placed its order for replacement systems in February on fluid sealing and wear resistance company Easy Coat, the AESSEAL® agent for Richards Bay. The order provides for 167 AESSEAL® type-SW2 and SW3 water management systems that will use recycled water to cool, lubricate and flush mechanical seals in the Richards Bay plant. They will replace a competitor's once-through flushing designs that need a constant supply of fresh water.

The 167 competitor cooling and lubrication systems to be replaced are consuming an average of 63,210 kilolitres of water every month. The new AESSEAL® systems will help save Mondi over 4.5 Billion litres of water in the next 6 years.



Summary:

Double mechanical seals reduce water footprint and improve uptime.

Packing has several drawbacks when used to seal rotating shafts on pumps. Perhaps the biggest drawback is the requirement for millions of gallons of gland water per pump per year, for cooling and lubricating the packing.

Double mechanical seals and tank systems eliminate all of the problems associated with packing and can greatly reduce water footprint, while also reducing the manpower required to care for the packing and increasing the uptime / availability of the equipment. In those cases where the process is sensitive to dilution, double mechanical seals can save millions of dollars per year in lost product.

Not just any mechanical seal arrangement will accomplish the above goals. The pump owner must select a robust double mechanical seal and then maintain a clean, stable fluid film across the seal faces. This is accomplished by the use of a self-filling, maintenance-free tank support system which maintains the seal barrier fluid pressure at 15 to 30psi over the pump fluid pressure.

Water Savings Conclusion

AESSEAL plc have sold thousands of water management systems, in combination with a double seal. The systems are maintenance friendly, requiring no external compressed air or gas pressurisation. They are also largely self-regulating and self-operating and do not require any manual intervention for refilling.

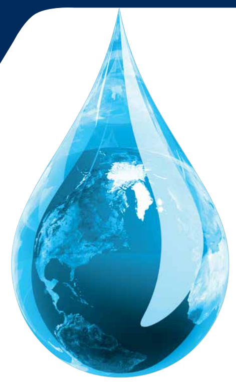
The total annual operating cost of a CDSA™ seal and SW2™ water management system would give a typical return on investment of around 200 days.

In considering all of the above seal support arrangements, we can clearly see that in each case, water consumption at the rate of between 6-18 litres per minute (1.59 - 4.76 gallons per minute) per seal was the previously accepted norm. This allows for a conservative estimate of an average of 12 litres per minute (3.17 gallons per minute) water consumption to be applied to all pumps run in this manner. Therefore in continuous 24 hour, running one pump uses 6,307,200 litres per year (1.7 million gallons per year). By retrofitting a water management system (which uses only 32 litres / 8.45 gallons per year) to each of these applications we are saving 6,307,168 litres / 1,666,178 gallons per year for every water management system.

With in excess of 15,000 systems running globally AESSEAL® water management systems contribute to water savings of over 95 Billion litres / 25 Billion Gallons per year!

Note: 1 billion, as used in this article, refers to one thousand million, or 10^9.

AESSEAL® estimates that our tank support systems installed on pumps around the world save **more than 25 billion US gallons (95 billion litres) of water per year.**



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THE QUEEN'S AWARDS FOR ENTERPRISE: INNOVATION 2021

THE QUEEN'S AWARDS FOR ENTERPRISE: SUSTAINABLE DEVELOPMENT 2022

AESSEAL plc is certified to:

ISO 9001, ISO 14001, ISO/IEC 20000, ISO/IEC 27001, ISO/TS 29001, ISO 37001, ISO 45001 & ISO 50001

Use double mechanical seals with hazardous products.

Always take safety precautions:

WARNING

- **Guard your equipment**
- **Wear protective clothing**

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