ENVIRONMENTAL TECHNOLOGY

Sealing Off/Onshore Exploration Slurries

Introduction

Increased water cuts and higher drawdown rates from mature oil exploration fields have resulted in increased sand production across many global offshore production platforms.

Down hole sand control is usually prohibitive on cost grounds and if implemented this usually reduces the well productivity and ultimate recovery of reserves. Therefore the amount of sand present within tanks, pumps, valves and separators is commonly reviewed by upstream oil and gas companies.

If left un-monitored and not addressed, the effects of the presence of sand include:

- Poor oil and water separation
- Pipe and equipment blockages
- Pipe and valve wear from high sand velocities
- Process control upsets due to blocked instruments
- Sand build up in separation tanks and closed drains
- Increase in downtime and maintenance costs
- Reduced life of mechanical seals and pumping equipment

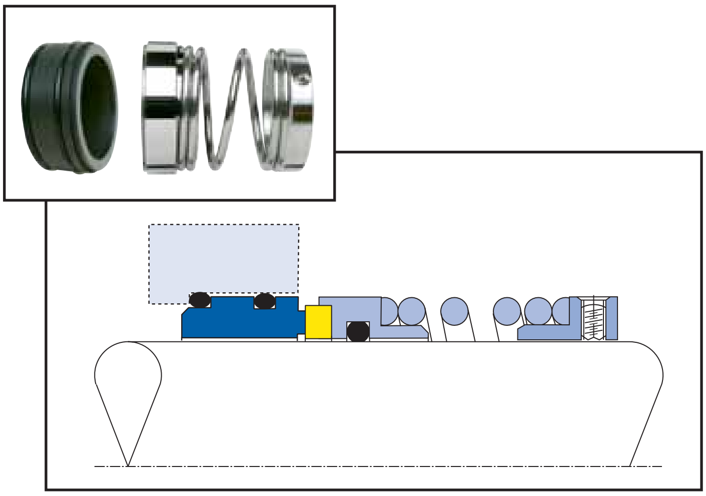
There are of course, many other associated issues with sand, however for the purpose of this document we will be focusing on pumping equipment and the mechanical seals fitted to them.

Traditionally offshore production platforms installed on new fields process clean, relatively solid free, hydrocarbon and non-hydrocarbon based liquids.

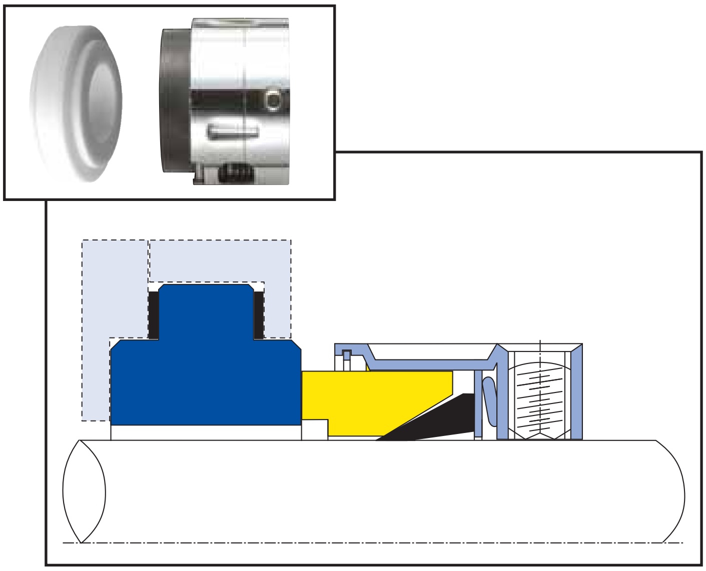
Therefore nearly every platform built in the late 1960's and early 1970's was furnished with traditional centrifugal pumping equipment, which runs typically at minimum speeds of 3,000rpm. This keeps the pumps small and compact given the space and weight constraints offshore.

Typical pump layout in an Offshore platform where physical space is limited.

Due to this fact, mechanical seals furnished with pumps such as the Main Oils Line Pump (MOL), Sea Water Injection (SWI), Closed Drains, Test Separators and Flare Drums were of the single helical coil spring design or multi-spring seal design, where the springs are located within the process fluid, as shown below.



Component seal with single coil spring



Component seal with multiple springs

For many years these seal designs have proven successful in operation and have been the backbone of the oil and gas mechanical seal industry.

However, as oil wells deplete, sand is now becoming more common place. These traditional seal and pump designs are now proving problematic forcing engineers to consider alternatives to the norm.

Traditional Seal Problems

With the ever increasing levels of sand in the exploration operations, traditional seal technologies are unsuitable as both the seal springs and drive mechanisms are clogged with sand causing the seal faces to hang up.

Furthermore, the tight radial clearances between the seal faces and the rotating equipment shaft / shaft sleeve is yet a further area which is prone to clogging, and will ultimately lead to seal face hang up and leakage.

Many of the non-AESSEAL® API type cartridge seals are derived around this traditional 'component seal' format, whereby the component seal is screwed onto a cartridge sleeve, as shown below.

This design therefore also offers little or no improvement in terms of its clogging and seal face hang up resistance, as experienced by many of the global off/onshore oil and gas North Sea operators.

Furthermore, API 682 widely promotes the use of hydraulically balanced seal faces.

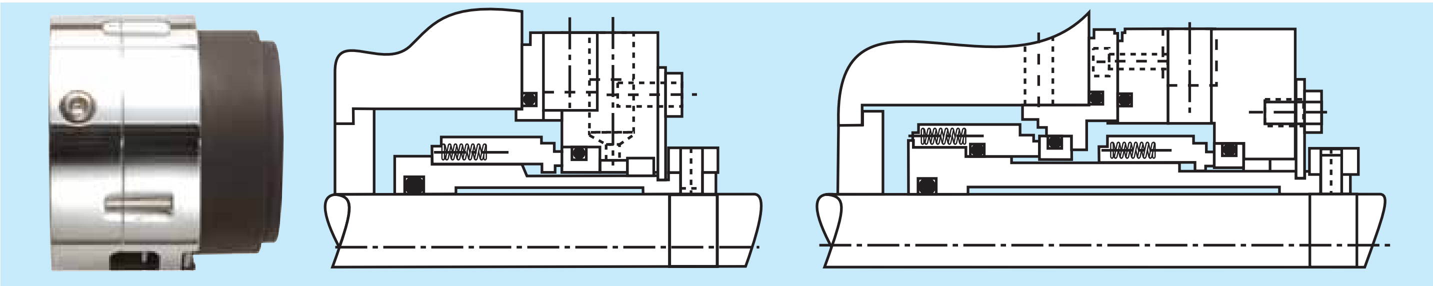
In order to achieve hydraulically balanced seal faces, the non-AESSEAL® cartridge sleeve, shown below, has incorporated radial step.

This means that the radial space of the equipment must be large enough to accommodate the rotary component seal and a stepped cartridge sleeve.

Unfortunately, the issue is exasperated by the fact that offshore platforms need to meet very stringent emission legislation. This means that they need to upgrade many assets to use dual mechanical seals to prevent hydrocarbon release to atmosphere.

In the case of a traditional, non-AESSEAL® API 682 dual seal, two radial steps are required in the cartridge sleeve meaning an even larger inboard rotary component seal has to be employed.

Since the major seal manufacturers cannot fit 'stepped' seal face technology onto a cartridge and into 0.500"(12mm) radial space as found on mature assets, they elect to offer different cartridge technology, which has not passed the rigorous endorsement and emission criteria of the API 682 qualification test program.



Non-AES API 682 Single & Dual seal configuration with multiple springs positioned in the process media.

Traditional Seal Face Drive Problems

Often the weakest aspect of a slurry seal with monolithic seal faces is the seal face drive design.

The size of the drive pin examined on a non-AESSEAL® 100mm (4.000") API design, shown below, was 2mm (0.075"). This feature is a potential weakness in slurry, sticky and high viscous process fluids, particularly on equipment start up.

Small round drive pin.

Above: Example of one type of rotary seal face drive.
Rejected for use in AESSEAL® monolithic seal designs.

Some non-AESSEAL® seal designs use round drive pins to drive monolithic seal faces. This design can lead to spawling on the Silicon Carbide from pin contact.

Crack propagation generally starts from the drive slots, placing adverse stresses on the material which leads to catastrophic seal failure.

Above: Example of one type of rotary seal face drive.
Rejected for use in AESSEAL® designs

Centrifugal Pump Problems

Main Oil Line (MOL) Pumps have been one of the main sources of problems with sand. Due to the criticality of these units they are one of the premier concerns for the major oil operators.

These issues have mainly been due to the speed of the unit and also the close tolerances required on wear rings, which do not take too long to wear out leading to a severe drop in performance.

The MOL booster pumps feeding the MOL pumps have not escaped the attention of the sand either. The sand also causes considerable erosion damage to the pump components.

In certain applications, pump casings can wear away to the extent that hydrocarbon media is released to atmosphere. Clearly, this is undesirable and examples of such wear are shown below.

There are other applications such as Closed Drains, Flare Drum, Test Separator, Surge Drum, Produced Water and Recovered Oil Pumps which are also prone to suffer from severe sand erosion damage.

Damage to the stuffing box of a multistage centrifugal MOL Pump

A worn volute casing caused by sand erosion on an API 610 OH2 MOL booster pump

Traditional Slurry Pump Solutions

Hard wearing, ultra heavy duty slurry pumps were introduced into the market in the mid 1990's and are becoming more of a necessity on assets producing oil in mature fields. These pump units generally run slower than a conventional clear liquid centrifugal pumps and the materials they are manufactured from are extremely specialist.

Weir Minerals Europe have been active in the marketplace and supplied a number of units worldwide to both mature and new assets. The new assets have learnt from years of experience of extraction in mature fields that sand will eventually become a problem and by using hard wearing slurry pumping equipment, they can engineer out the problems at the initial stages rather than waiting for the problems to occur.

Where slurry pumps cannot be utilised due to pressure and flow restraints, pump manufacturers are investing heavily in coatings technology where High Velocity Oxygen Fuel (HVOF) spraying has been used extensively, together with Tungsten Carbide and Silicon Carbide materials to try and prevent erosion and corrosion taking place to prolong the life of rotating equipment.

Single Seals & Plan 31 Separators

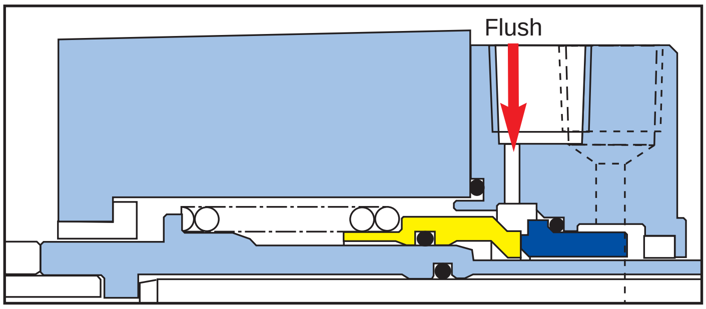
Single mechanical seals are typically favoured by operators as the supporting system. Pipework/instrumentation and operation of them is far less complicated than that of dual seals.

However, single seals rely on the process fluid to lubricate the seal faces. Sand unfortunately is not a good lubricant!

In an attempt to improve the sealing conditions at the seal faces of a slurry process application, cyclone separators have traditionally been recommended.

Cyclone separators, used in Plan 31 arrangements, are designed to separate solids from the process fluid. The separated clean fluid is then used as the flush media over the mechanical seal faces. However, cyclone separators have drawbacks.

- Separators will only operate successfully if the particles being filtered are sufficiently heavier than the mother liquor and a constant pressure drop is maintained across the unit. This poses a problem for some of the heavy crudes extracted around the globe. This means that there will always be some degree of carry over of abrasive particles, which are injected into the sealing chamber. If the percentage of particles in the liquor exceeds 10% this leads to a heavily contaminated fluid, which is injected into the seal chamber.
- As the viscosity of the fluid increases this impairs the ability of the cyclone to remove solids.
- Cyclones are often retro-fitted after problems with sand have occurred. As a consequence of this, the gland plate design of the mechanical seal will have the flush port directly over the mechanical seal faces, as shown below. Whilst this is a mandatory requirement for seals operating with a clean injected fluid, contaminated fluids will "shot blast" the seal faces, inevitably resulting in premature failure of the mechanical seal.

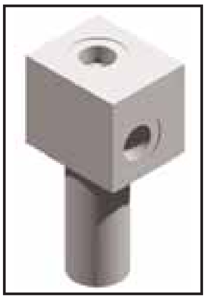


Non-AES Single Seal Design with flush port directly over the seal faces

AESSEAL® have supplied cyclone separators for use with single seals in slurry applications, dating back to the late 1990's.

By way of example, the VS1.0, shown above (AZA5810) is a heavy duty separator installed in a UK Power station, to separate the solids from the river water in the raw water pumps.

These devices have performed well, however AESSEAL® generally avoids the use of such, specifically in aggressively abrasive applications, as sand erosion shows little preference as to which parts it erodes in operation.

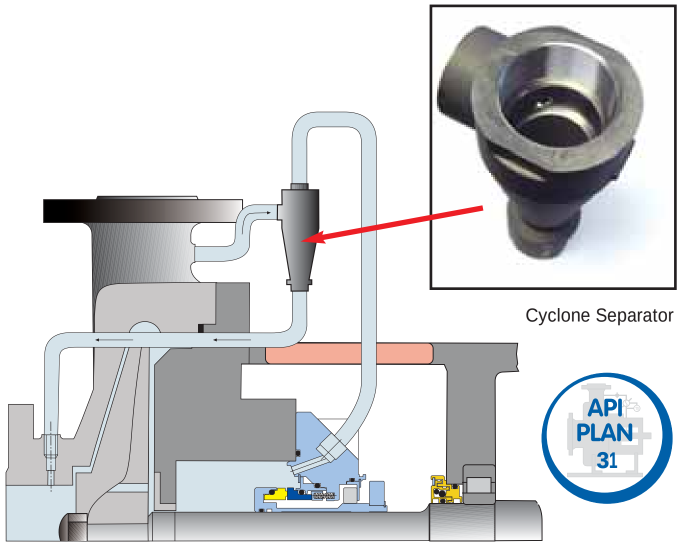


AESSEAL® VS1.0 Vortex Separator (AZA5810)

A typical concern for plant engineers using cyclone separators in Plan 31 arrangements is the issue of internal wear on the separator body.

Clearly, by selecting suitable materials of construction for internal parts of the cyclone separator, one can reduce and minimise the erosion wear potential. However, this wear issue remains a concern given the failure mode of the unit is catastrophic once the wall thickness of the separator is no longer thick enough to withstand the internal operating pressure of the system.

As cyclones are treated as part of the flush recirculation pipework, traditionally there has been no way of an operator detecting how much wear has taken place over a period of time. The normal practice found within the marketplace is to replace the cyclone on a regular basis which is expensive, or to trend the failure rates of seals which provides an indication to wear. The latter being even more expensive when the cost of seals is factored in. Wherever possible, AESSEAL® prefers to promote double seals for abrasive applications as discussed overleaf.



Cyclone Separator

API PLAN 31

Case References

1474, 2299, 2414, 2534, 3191

Dual Seals & Plan 53/54 Systems

Designs for restricted Offshore spaces

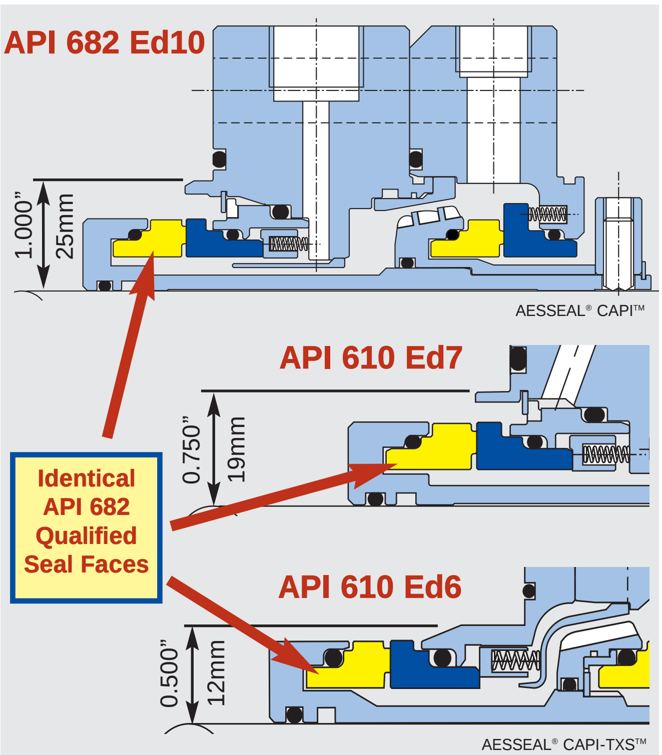
AESSEAL® took a different approach when it created it’s CAPI™ (Cartridge API) range. This range of API 682 qualified mechanical seals, both pusher and bellows, was designed with specific consideration for both new and old equipment.

The CAPI™ range has the same qualified seal face technology for API 610 Ed10 pumps as well as the API 610 Ed5 pumps, and ALL the pump specification variants in between spanning more than four decades.

This means that mature equipment, as found on Off/Onshore platforms, designed in the 1970s and 1980s can be retro-fitted with 21st century API 682 qualification tested seal face technology, without the need for equipment modification.

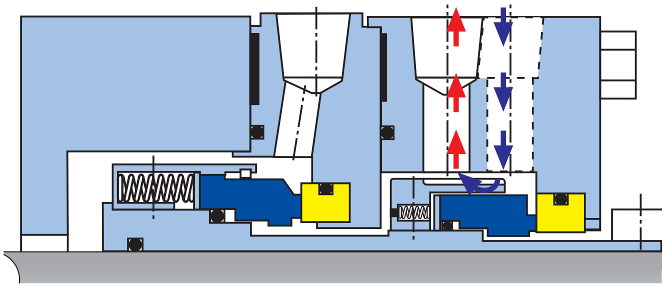
This has clear benefits for the engineers responsible for making plant equipment conform to local and government emission criteria, whilst at the same time operating in the real world with a finite capital budget.

The AESSEAL® CAPI-TXS™ (Thin Cross Section) range comprises of API 682 Category I, cartridge single and dual seals, which use qualification tested API 682 technology. As such, AESSEAL® is believed to be the only major global mechanical seal supplier that provides the end user with a viable alternative to the very costly and time consuming pump modification or replacement option.



Barrier fluid flow to optimise cooling

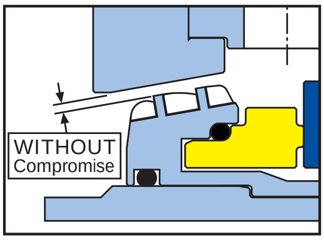
Traditional API 682 dual seal designs (shown below) only attempt to circulate barrier fluid around the outboard seal faces, as the ‘screwed component seal on sleeve’ design leaves no physical space to do anything different.



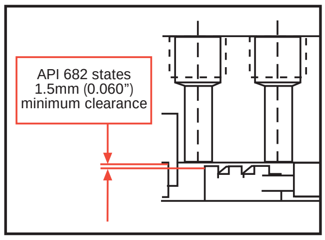
Non-AES seal design with a “Parallel Slot” Circulating Device.

The UHDDS™ (shown below) has an integral Plan 53 barrier fluid circulation system which efficiently circulates volumes of cool barrier fluid to both sets of seal faces, irrespective of the direction of shaft rotation.

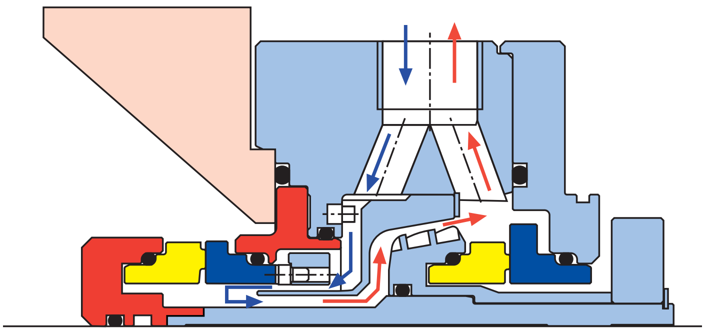
Furthermore, the UHDDS™ design fully conforms to the API 682 1.5mm (0.060”) recommended radial clearances between the pumping ring rotor and stator, something that ALL other suppliers designs are unable to achieve without a substantial drop off in flow/head performance.



AES CAPI™ Circulating Device.



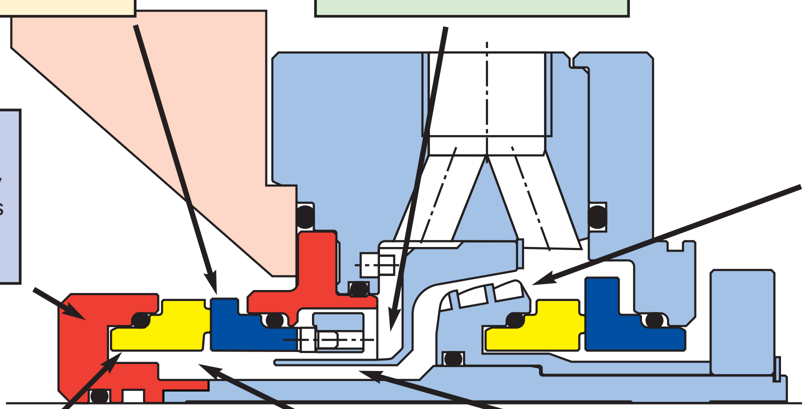
Parallel Helical Vane (Screw) Circulating Device.



UHDDS™ Tapered Vane Circulating Device.

Ultra Heavy Duty Double Seal (UHDDS™)

AESSEAL® have adapted their CAPI™ design to suit the specific application requirements of the Off/Onshore exploration industry by providing a Ultra Heavy Duty Double Seal (UHDDS™) design as follows;



Hybrid Plan 53/54 Offshore Seal Support System

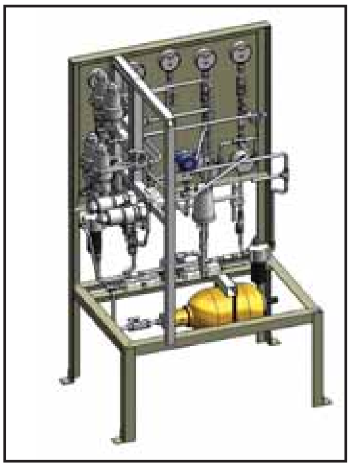
In 2004, four CAPI™ A1 dual cartridge seals were installed in CPC vertical inline API 610 process pumps, sealing natural gas liquid on an offshore platform in Alaska, USA. The seals replaced John Crane type 48MP/48LP which had a mean time between failure of 6 weeks.

The CAPI™ seals were installed in an API Plan 53 modified arrangement, employing an innovative stand mounted support system. The hybrid Plan 53/54 system had a small footprint, therefore ideal for restricted offshore space (as shown below).

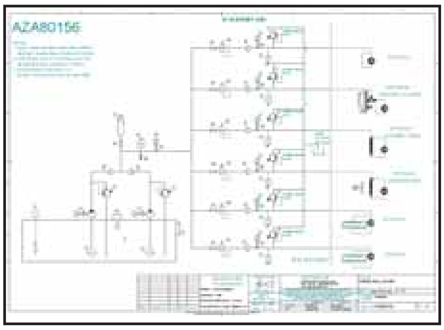
By 2007 the seals had operated for over three years without failure, increasing the equipment mean time between failure of the pump by over 24 fold.

In 2007 the savings for this application was over $200k (£100k) based on compilation of repair costs, prior to the CAPI™ and system installation. These saving clearly exclude the significant gains the platform made to production efficiencies using the AESSEAL® solution.

For further information on the above application see GA's 7134128 and 8007759.



The AESSEAL® hybrid Plan 53/54 System



- Small footprint for multiple systems (700mm(L) x 1000mm(W) x 1600mm(H))
- Lightweight
- Large barrier fluid storage capacity
- Typical Plan 54 flow rates with new Plan 53 technology pumping scroll
- One point atmospheric top up
- One point level monitoring
- Reduce man-management required
- Intermittent running of driver (only for top up)
- Greatly reduced purchase cost on multiple dual seal pump purchases or conversions

Case References

3444

Defracking

The Defracking process is employed to increase the offshores well yield. Pearlite balls are injected into the offshore oil well to block up all the gaps in the periphery of the well to increase the well's yield. Seawater is then injected through the PWI pumps into the well to push the oil to the surface. At the surface, the oil is entrained with seawater, sand and some of the pearlite balls, which can break away from the periphery of the well.

The oil is then sent through scrubbers and other equipment to clean up the produced water for re-injection back into the well. However some sand and pearlite balls still come through the filters and can wear out standard non slurry pumps in a matter of days. AESSEAL® have installed seals on the defracking process since 1998.

Case References: 1282, 2236

Mud Pumps

Applications such as mud mixing and mud charge have been serviced by rotating equipment manufacturers such as Mission Magnum Pumps and Halco, (now National Oilwell Varco) for many decades.

These pumps have been extensively used since the early 1970's and have been the pumps of choice due to their hard wearing characteristics, low cost and modularity of drive trains.

Traditionally, mud pumps were fitted with either gland packing or single spring component seals mounted directly behind the impeller, however due to environmental changes in the market place and the cost of the special drilling mud, the use of dual mechanical seals has become more popular.

Over and above the clear sealing advantages of dual mechanical seals in such slurry conditions, dual mechanical seals permit the mud storage tanks to be completely evacuated of their contents. This is a significant advantage given packing and single mechanical seals are often damaged during this process.

Since 2002, AESSEAL® have supplied dual cartridge seals and oiler systems to the OEM for installation into new equipment. This has improved the reliability in terms of the sealing aspect of the pump, but also has lead to drilling operators being more competitive in the market place.

In addition to this, AESSEAL® has seen a distinct change in the philosophy of 'throw away pumps'.

Manufacturers such as Weir Minerals and Discflo Corporation have been actively promoting slurry pumps on drilling fluid applications based on improvements in reliability and a lower cost of ownership.

In conjunction with some of the major drilling operators, AESSEAL® have helped seal such mud pumps with the latest CAPI™ sealing technology and Water Management Systems.

Case References: 1671, 1672, 2232, 3434

Sand Jetting Pumps

All producer wells have downhole sand production control. Flowing hydrocarbons almost certainly carry sand to the platform topsides which accumulates in the process equipment such as separators, the produced water degasser drum and the closed drains drum.

To eliminate sand accumulation, sand jetting equipment is used, the removed sand being usually directed to a dedicated sand separation package via dedicated sandwash piping.

CAPI A1 Dual seal on a Warman Slurry pump

High pressure heavy duty slurry pumps with de-aerated seawater or produced water are increasingly being used for jetting applications due to the difficult nature of the application.

The sand slurry pumping application poses a difficult challenge for the mechanical seal due to the speed, pressure and often temperature of the processes.

AESSEAL® has supplied seals for sand jetting applications across the globe, in places such as the North Sea and Azerbaijan.

Case References: 2383, 2562

Test Separator

A test separator is commonly referred to as a well tester or well checker, and is essentially a vessel or drum which is used to separate and meter quantities of oil and gas.

Test separators can be two or three phase depending on well producing. They can also be permanent or portable depending on the site conditions and location i.e. offshore or onshore. The test separator provides the requirements for well clean up, well kick off and well testing and is generally periodically used while work or testing of a well is undertaken. However, it is very common for the test separator to operate as a production separator in the event that a production train is unavailable. Due to this fact alone, it is imperative that the pumping equipment fitted to the test separator is in good condition and can be made available at short notice.

There are generally no emissions to atmosphere or to sea permitted as a result of the test separator being used as hydrocarbon products are contained within the process train.

Typical seal component fitted to test separator pump in the North Sea, showing signs of sand wear.

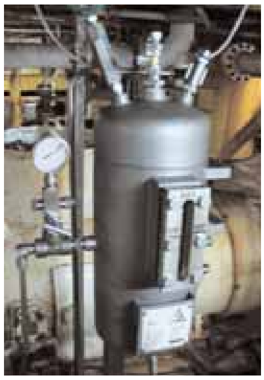
Traditionally, test separators were fitted with single stage overhung centrifugal pumps or vertical inline units, used for the movement and extraction of fluids from the test separator. In most cases the pumps employed single mechanical seals or containment seals. However, as wells are depleting, more sand is encountered within wells.

This has a detrimental effect on the pumping and sealing equipment. One particular offshore operator reported that the single mechanical seals lasted no more than 24 hours before leaking.

AESSEAL® has installed DMSF™ dual seals and pressurised systems to the test separator pumps since 2001. This has resulted in extended life of mechanical seals, in some cases a seal life which exceeds the life of the pump casings.

The seal to the right in the photo above has run for 18 months in conjunction with the pressurised seal support system (right) on a test separator pump duty in the North Sea.

New and previously installed AESSEAL® design.



North Sea Separator System.

Case References: 2095

Clean-Up Seal & System Package

In 2006 a clean-up package, comprising a frame mounted system and CAPI™ A1 dual seal, (Ref: AZA10060013P) was installed on a new North Sea offshore platform.

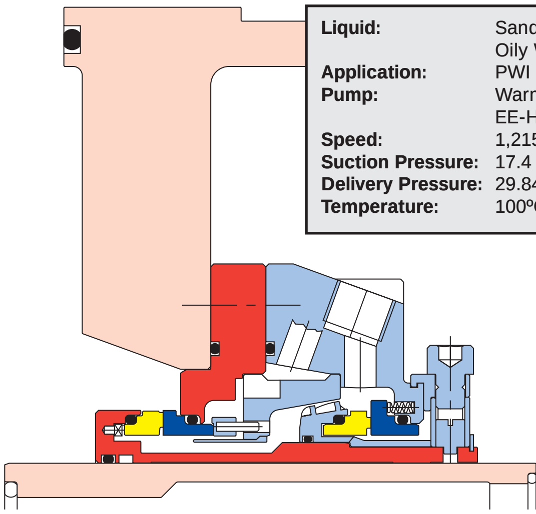
The system operates with a (50/50) ethylene glycol/water mix at 24-27 barg (390 psi), using nitrogen as its pressure source and plant water supplied at 21°C (70ºF) and 10 barg (145 psi) pressure. The full seal and system was classified under ATEX and was fitted with suitable hazardous area instrumentation, specified in conjunction with the purchaser.

AESSEAL® Plan 53B System

The clean-up package processes pressurised batches of solids and associated oily water, which are separated from the produced water treatment package and de-sanding cyclones. Jet washed material from the process separators, test separators, second stage oil separator and degasser surge drum is also routed to the clean-up system.

This self-contained package, installed on the process module level 1 deck in a Zone 1 hazardous area, represents one of the many bespoke, turnkey solutions executed by AESSEAL®.

Liquid:	Sand, Soilds and Oily Water
Application:	PWI
Pump:	Warman 4x3 EE-HH
Speed:	1,215 rpm
Suction Pressure:	17.4 barg (252 psi)
Delivery Pressure:	29.84 barg (433 psi)
Temperature:	100ºC (212ºF) Max



100mm CAPI A1 Dual Exotic Seal Arrangement (AZA10060) to suit 4x3 EE-HH Warman Pump

Case References: 1445, 1447, 1452, 1454, 1480

Main Oil Line Pumps

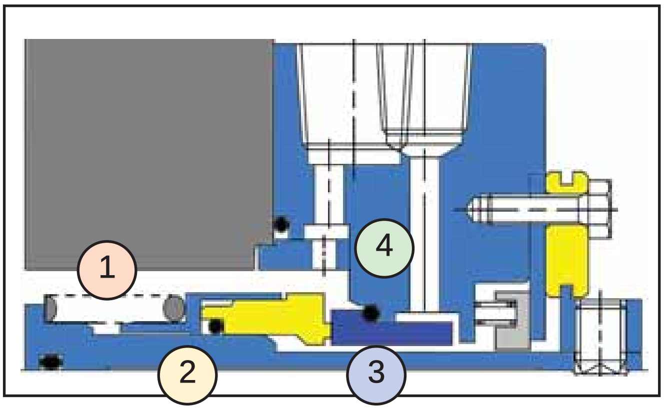
During 2001 a major oil operator in Nigeria was experiencing a number of issues with their Main Oil Line Pumps.

Over 100 pumps installed at the customer's flowstation were suffering from severe sand accumulation which was resulting in excessive wear, mechanical seal failure and expensive downtime and maintenance.

The various service providers with differing mechanical seal designs upgraded eight of the pumps. One of the companies chose to use AESSEAL plc as the supplier of the mechanical seals.

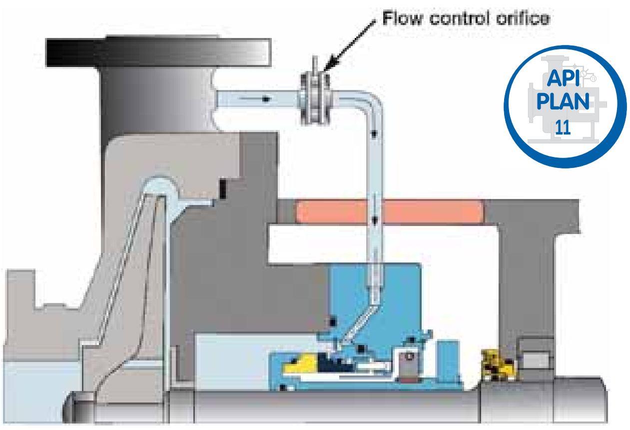
The existing units were fitted with traditional single helical coil spring cartridge seals (shown right), which may have operated successfully on clean crude oil, however the sand content was causing severe problems for the seals for a number of reasons as discussed below.

Application problem: Traditional seal



Typical seal installed with the problem areas highlighted

Sulzer MSD 4x8x10.5 bottom half casing showing severe sand accumulation



1) The rotating spring creates a velocity in the stuffing box which centrifuges solids away. This results in wear taking place on the inside diameter of the bore of the stuffing box and in some instances can wear through towards the O ring gasket on the seal gland plate. This results in a hydrocarbon release to atmosphere which is not acceptable.

2) The sliding dynamic O-ring is rubbing on a surface which is not coated. Most seal manufacturers would stellite or hard chrome plate this area to try and eradicate the effects of fretting. In doing this it adds to the cost of the seal and increases lead time, so some/most avoid doing it.

3) As all mechanical seals have a mean leakage rate, the area under the seal faces over a period of running hours will become filled with process fluid. In the Nigeria application the fluid was crude oil with a high sand content. The crude can also contain submicron fines which permeate the sealing gap and become trapped in this area. This then causes wear on both the mechanical seal sleeve OD and ID of the stationary face. On this specific application the stationary face was manufactured from Carbon. As this is a soft material this will lead to rapid and premature wear and the eventual demise of the mechanical seal.

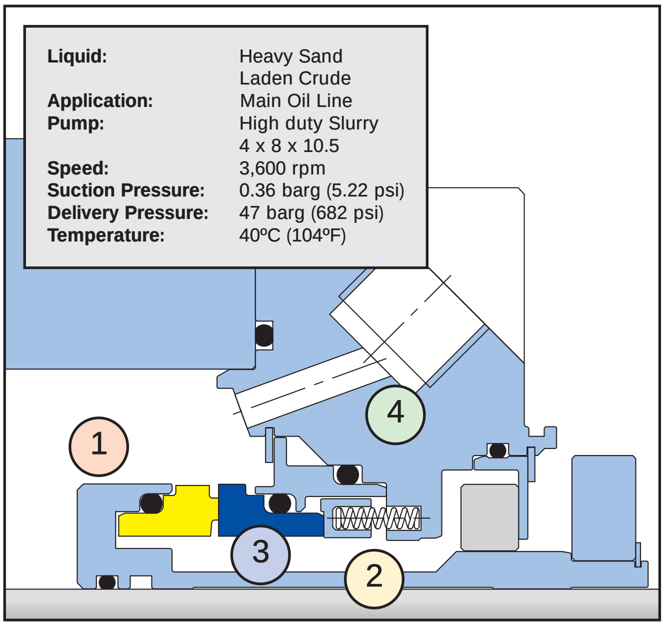
4) These seals were supported with API Plan 11 which is a re-circulation piping plan taking fluid from the discharge of the pump and injecting this into the sealing chamber through a flow control orifice. Under clean pumpage conditions the seal design above would be the correct selection as the flush injection port is directed towards the sealing interface. However as the crude is sand laden, the flush port acts as a 'shot blaster' and at high velocity begins to wear away the soft carbon face and the metal hardware surrounding the area of the faces. Even if a cyclone separator was implemented, turning this into an API Plan 31 arrangement, the potential for solids carry over would have lead to problems later on in the seals life.

Application solution: CAPI™ A1 Single

AESSEAL® have retro-fitted seals from their CAPI™ range of certified API 682 mechanical seals. This modular range of API seals have inherent benefits when compared to the existing seal design. Utilising modern day manufacturing techniques, seal manufacturers can carve and shape materials in far more complex geometries than ever before, giving design engineers more of a ‘free hand’ in the design process.

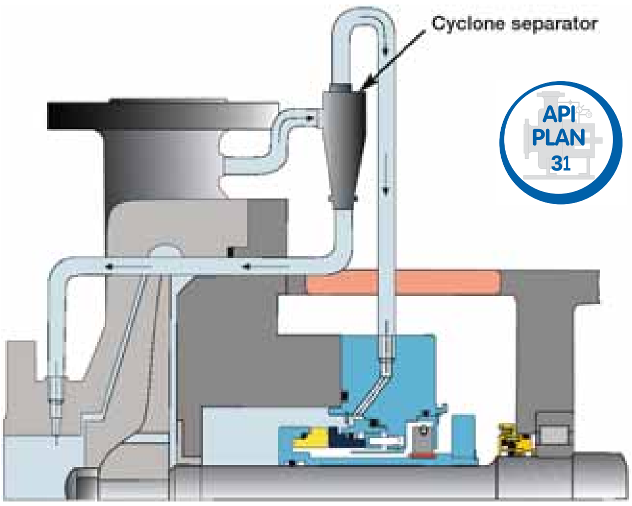
The seals in question for Nigeria were manufactured so that no modifications to the pump and flush plan pipework were required.

The oil company in Nigeria trialled four seals in 2001 in a head-to-head with other seal manufacturers. The AESSEAL® CAPI™ design was successful and far outlasted the competitors, so much so that we have installed another 40 identical seals in 2005 with all 100 pumps (200 seals) being earmarked for upgrade.



2.635” CAPI™ A1 Single Seal fitted to Multi-stage pump in Nigeria

2.635” CAPI™ A1 Single Seal fitted to Multi-stage pump in Nigeria



1) As a multi-spring stationary design, where the springs are isolated from the process fluid, this enables the AESSEAL® CAPI™ to have a smooth profile on the inboard side of the seal. Due to this it creates little or no velocity, resulting in no wear to the stuffing box casing.

2) The dynamic O-rings on the faces are sliding on Silicon Carbide which is many times more wear resistant that stainless steel which has been hard coated with Stellite or Chrome Oxide.

3) The seal faces utilised were two Silicon Carbide rings which offered greater life when compared to Carbon on abrasive services. They are also of a thick cross section design with minimal overhang, which results is more stable fluid film conditions under pressure and temperature excursions.

4) The flush port entry was directed away from the seal faces and seal metal hardware. This removed the potential for ‘shotblasting’ the seal faces and with the port being larger in diameter this lowers the velocity of the abrasive fluid entering the sealing chamber.

Case References

1455, 1458, 1459, 1460, 1465, 1886, 2127, 2389, 2534, 2539, 3191, 3202, 3307

Closed Drains Pumps

Progressing cavity pumps, used on a North Sea platform on closed drains applications, were proving problematic to the platform operators. Firstly, the oil hydrocarbon mixture was causing the rubber stators to swell which either locked up the complete drive train assembly or led to rapid wear on the rotating elements. The original OEM seals were also causing problems as they were subject to the full discharge pressure generated by the pump.

Due to the lack of reliability the oil operator decided that the pumps were too unreliable and another pumping solution was sourced.

A major UK slurry pump manufacturer was called in to offer two replacement pumps and chose to offer AESSEAL® as the sealing solution. AESSEAL® have a mechanical seal supply agreement with the major slurry pump manufacturer and they have made AESSEAL® the preferred seal vendor for the European market.

Non-AES seal gland plate showing signs of sand erosion due to process fluid vortexing

Application solution: Exotic CAPI A1 Dual

Since October 2002, several 85mm CAPI™ A1 dual cartridge seals (Ref: AZA8796) and API 682 (AES 28-SC) systems have been successfully running on Warman 3/2 CC-HH pumps, pumping produced water with methanol, oil and heavy sand content.

The API 682 CAPI™ dual seals were supplied with bespoke backplate and sleeve kits for the slurry pumps.

Two closed drains pumps are used to collect the slops from the drains system on the offshore platform and pump them back into the separation system so that nothing is wasted. Obviously pumping the waster material overboard is not an option.

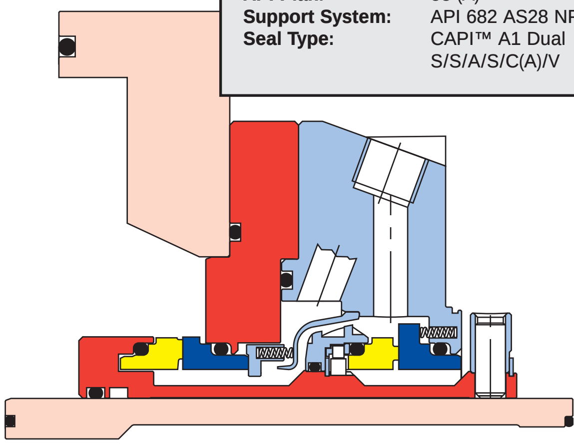
If both of the pumps go out of service, given their criticality, the asset is shut down until they are reinstated.

AESSEAL® had installed seals on similar applications on offshore assets, therefore incorporated various features into the seal holders and advised the pump manufacturer as to the configuration of the sacrificial liners, which make up the pump construction.

AESSEAL® have found on previous applications that sand and abrasive particles contained within the fluid will wear out seal gland plates due to high velocities.

With these problems in mind, AESSEAL® designed bespoke heavy duty seal holders for the pumps with vortex breakers. The plates were made from a hard duplex alloy and have proven to be successful in the field.

Liquid:	Sand, Produced Water, Sand and Oil
Application:	Closed Drains
Pump:	High duty Slurry pump
Speed:	2100 rpm
Delivery Pressure:	16.5 bar (240psig)
Temperature:	70ºC (158ºF)
API Plan:	53 (A)
Support System:	API 682 AS28 NPT
Seal Type:	CAPI™ A1 Dual S/S/A/S/C(A)/V



85mm CAPI A1 Dual Exotic Seal Arrangement (AZA8796) to suit 3/2 DD-HH Warman Pump

Before

Condition of seals before use

By making the seal and seal holder a two piece design, the seal is allowed to float on the shaft. As most of the slurry pumps construction is of a non-machined casting, it is extremely difficult to guarantee the concentricity of the shaft to the housing OD. Therefore, letting the seal float within the seal holder and allowing it to find it own centre can only eradicate the issue of misalignment.

Another reason for the two piece design is weight. One piece seal designs are extremely heavy and due to the design of the pump units, they tend to have to be manhandled in place. This handling can result in damage to the seals and could potentially injure plant personnel.

The pumps and seals on the North Sea asset were commissioned in summer 2002.

As of June 2006, the AESSEAL® CAPI™ seals were still running and had never been out for repair since their installation, despite the severity of the application.

In August 2006 , the oil operator removed one of the pumps due to a leaking casing after 4 years operation. The site engineers stated that, remarkably, the seal had not failed. The pump had gone down because the pump casing had given way. The seals were subsequently returned to AESSEAL® for repair.

The repair team noted that the mechanical seals were still intact and after assessment, they predicted that they would have performed much longer than the 4 years recorded, leak free.

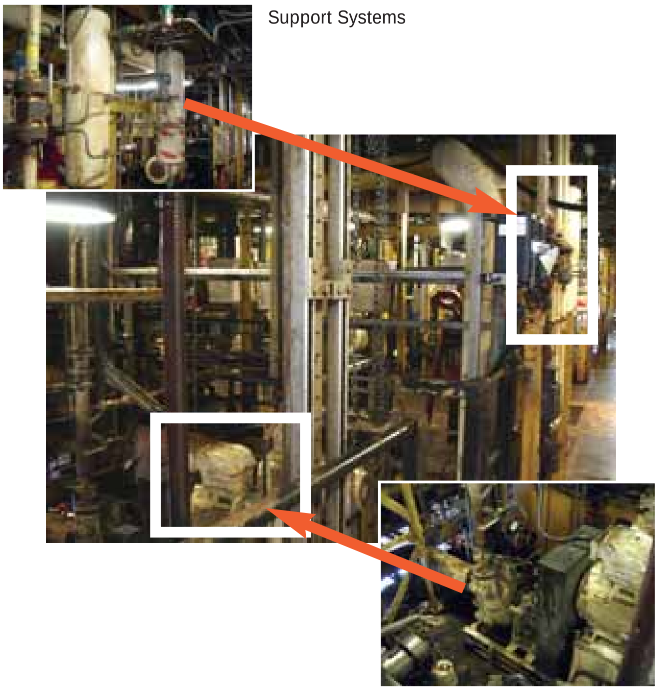
After

Condition of seals after running for 4 years

The seals operated in an API Plan 53 system with a seal chamber pressure at 13 barg (188 psi) and a shaft operating at 2,100 rpm.

The pipework connecting the seal and system measured over 3 meters (10 feet) horizontally and 2 meters (6.5 feet) vertically, with snakes and pipe bends everywhere. This is contrary to every Best Practice text book guideline.

Upon inspection of the application, the engineer realized that part of the seal success was due to the outstanding performance of the CAPI™ integral pumping ring. This incredible bi-directional pumping ring effectively circulated, against all the odds, the barrier fluid to the systems.



Installed CAPI™ Seals (Case ref 1447)

The innovative design of the CAPI™ pumping ring is clearly evident from the recently published graphs, which show a 100mm (4.000") CAPI™ circulates 6.2 litres/min (1.64 gals/hour) of barrier oil at 3,600 rpm.

It is the world leading performance of this AESSEAL® innovation, especially when coupled with an effective heat exchange configuration at the inboard seal faces, which creates the fine line between application sealing success and failure in the real world.

Off the back of this success, AESSEAL® have carried out many more installations in the North Sea and as far as Azerbaijan. AESSEAL® are also actively chasing projects in Russia and Norway due to oil operators and contractors recognising the benefits of slurry pumping equipment on new and mature assets.

Case References

1369, 2220

Bearing Protection

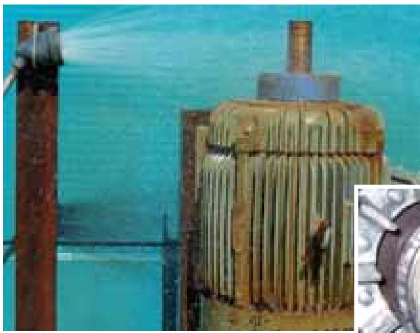
AESSEAL® is the only company which promotes the use of wholly owned and extensively inventoried non-contacting and contacting bearing seal technology for rotating equipment applications around the world. Some examples of installations in the Hydrocarbon Processing Industry include;

Electric Motors: Salt Water Spray Tests

An end user plant in Korea wanted to validate the performance of the MagTecta™ on their grease lubricated electric motors which rotated at 1,800rpm in a salt water spray environment.

The electric motor operates in a humidity/salt water spray fog at 0.01 gpm (0.04 lpm), therefore they performed an accelerated test using a salt water spray at 3.1 gpm (11.7 lpm) for 8 days. After the test, they disassembled the motor found the MagTecta™ had protected the motor perfectly.

The post test results (photo right) were very impressive so they immediately sanctioned the roll out of the 45mm MagTecta™ seals.



Customer Salt Water Spray test (above)

Post test examination of Electric motor

Pump Bearing Chambers

Clearly the reduction of moisture contamination in equipment bearing chambers provides a major reason for rotating engineers to upgrade their bearing seals.

However, in areas that suffer from severe sand storms, such as the oil exploration fields of the Middle East, the elimination of sand and debris accumulation in the equipment bearing chambers provides further reason to upgrade the sealing element.

Typical sand environment in the Oil exploration fields of Oman, Middle East

AESSEAL® have been very successful with the installation of MagTecta™ bearing isolators fitted to screw pumps in PDO. They have now been accepted as the preferred standard for upgrade of such pumps.

Furthermore, MagTecta™ seals have been installed since 2005 on pumps such as Byron Jackson centrifugal pumps and Sulzer MSD multi-stage centrifugal used on water injection in the onshore exploration plants in the Middle East.

AESSEAL VoLee in Indonesia supported by AESSEAL Malaysia have made significant progress in sealing offshore and onshore installations in the Far East, including;

An onshore platform in Thailand has installed over 40 MagTecta™ bearing protectors to seal the bearing chambers of their process pumps.

In May 2007, three 2.625” and one 1.125” MagTecta-OM-AX™ seals (Axial Movement) were installed on a Sulzer MSD2 3x6x9 Model pump operating at 4,600rpm on an off-shore application in Brasil.

No other bearing seal had operated successfully in the application and the MagTecta-OM-AX™ replaced the Inpro Labyrinth seals and other manufacturers Labyrinth seals which did not work to the satisfaction of the operators.

MagTecta-OM-AX™ bearing protectors fitted on a Sluzer MSD2 3x6x9 Model pump.

Case References

2151, 2312, 2313, 2336, 2544, 2545, 2575, 2990, 3192, 3390

Case Histories

The following case histories represent a sample of AESSEAL's experience in sealing slurrious products in the Off/Onshore exploration industry. Many more case references can be found in the APPLICATIONS section of **www.aesseal.com.**

CASE No. 1282J

AESSEAL® installed a number of 85mm (3.346") CURC™ SiC/SiC/V seals with DIN 1.4462 wetted parts on a defracking process on an offshore platform in the North Sea. The seals were installed on Warman 6/4 DAH slurry pumps rotating at 1,750rpm and processing produced water with a solid S.G. of 2.6 and 3-4mm particle size. The seals have operated since January 1998 and only failed after a number of years running due to the dry running of the pump when the inline filter had blocked on the suction.

CASE No. 1369K

Ten 85mm (3.346") CAPI™ A9 dual seals, SiC/SiC inboard faces and containment seal faces outboard were installed on Warman 3x2 DD-HH pumps rotating at 1,480rpm on the Alba Platform in the North Sea in 2002. The seals operated a mixture of closed drains and coalescer duties, sealing produced water with oil and sand, hence were supplied with DIN 1.4462 wetted parts. The AESSEAL® designs (AZA9007) replaced Flexibox FFET/SBOP seals and were supplied with backplate kits to change the seal environment and increase seals life.

CASE No. 1445K

In October 2001, four 48mm (1.890") DMSF™ (API Style) dual cartridge seals, Sic/Sic//Sic/Sic/Aflas® complete with special impeller spacers were installed on Sulzer ZE 100-3315 API 610 pumps for an offshore oil Platform belonging to a major oil exploration company in the North Sea. The seals (AZA8429) at 3,600rpm on a process temperature of 70°C (158°F) in a Plan 53 & 32 arrangement sealing produced water with 1,000ppm oil, H2S (sour water) with a heavy sand content. The dual seals were complemented with fully instrumented AS15-2 systems (AZA8470, AZA8471 & AZA9472).

CASE No. 1447K

In October 2002, three 85mm (3.346") CAPI™ A1 Dual cartridge seals, Sic/Sic//Sic/Car/Aflas® (AZA8796) complete with pump back plate and sleeve kits were installed on Warman 3/2 CC-HH pumps at an off-shore platform in the North Sea. The Plan 53 seals were installed on a produced water with methanol, oil and heavy sand content application, at 70°C (158°F), 13 bar (188 psi) operating at 2,100rpm. An API AS28-SC system with NPT connections and a special paint finish, monel piping and fittings accompanied the seals. This was a new installation to replace PC (progressive cavity) pumps which failed on a fortnightly basis.

CASE No. 1452K

In September 2002, two 60mm (2.362") CAPI™ A2 single cartridge seals, SiC/SiC/Aflas®, were installed on a Warman 4/3 CC-AHE for a new installation on an offshore platform in the North Sea. The seals (AZA8895) were supplied complete with a pump sleeve kit and operated on a produced water with white sand application at 60°C (140°F) and seal design pressure of 17.8 bar (258 psi).

CASE No. 1455K, 1458K, 1459K & 1460K

In August 2002, five 70mm CAPI™ A1 single cartridge seals with DIN 1.4462 (Duplex Steel) wetted parts and four 40mm and 2.250 DMSF™ dual cartridge seals were supplied for a FPSO in the North Sea. All seal face combinations were Ant Car/Sic and/or Sic/Sic with Viton® and EPR o rings. The seals were fitted to a range of Girdlestone 988 API610 centre line mounted pumps and Floway pumps, in plan 11, 61 and 52 arrangements (seal stock codes were AZA8306, AZA8285, AZA8283, and AZA8090).

The product media was sea water and crude oil with a process temperature of 110°C (230°F), and pressures from vacuum to 16 bar (232 psi). Two API 682 AS28-SW fully instrumented systems accompanied the seals together with 2 off modified AS15 fully instrumented and socket welded systems, with a process pressure of 4.1 bar (59 psi) in Plans 11 & 61 arrangement.

CASE No. 1454K

In August 2002, three 70mm (2.756") CAPI™ A1 single cartridge seals, Ant Car/SiC/Viton®, were supplied for an installation on a FSPO (floating production storage and offloading vessel) in the North Sea. The seals, stock code references RA03BS-01A and RA03BS-24P, were fitted to Girdlestone 988 API 610 centre line mounted pumps pumping crude oil, produced water and condensate at 84°C (183°F) with a process pressure of 4.1 bar (59 psi) in Plans 11 & 61 arrangement.

CASE No. 1465K

In December 2002, three 2.250" (57.1mm) DMSF™ (API Style) dual cartridge seals, Ant Car/SiC/V//Ant Car/SiC/V were fitted to a Peabody Floway type 18MKH/N for an offshore oil platform belonging to a major oil exploration company in South America. The seal (AZA8316) operated at 1,800rpm on a process temperature of 70ºC (158ºF), with a Plan 53 system sealing stabilised crude oil with sand. The dual seals were supported with a fully instrumented AS15 special vessel (AZA8351).

CASE No. 1480K

Three standard plus AS15 systems (AZA7824) were supplied to support mechanical seals installed on Weir Pumps, in the summer of 2002. The 15 litre vessels were at atmospheric pressure and were installed on sea water draw pumps in the leg of an offshore platform in the North Sea. They consisted of a weld pad sight gauge, air vent, 2.000" 150 lb flange and a 2.000" Level Transmitter.

CASE No. 1671K & 1672K

In February 2001, two 85mm and four 60mm CURC™ single seals TC/TC/V, with 316L stainless steel product wetted parts were fitted to a Warman type 6/4 DAH pump for an offshore platform in the North Sea. The process media was mud at 25ºC (77ºF) and the seals had a Plan 11 arrangement.

CASE No. 2151L

In June 2003, several Magtectas were installed on centrifugal pumps installed on a offshore platform in the USA. The MagTectas were used to seal the bearing chamber of the pump protecting it from salt water/spray ingress.

CASE No. 2196L

In December 2003, two 2.260" (57.4mm) CAPI™ A1 single seals (Ref. AZA9277BSA01) were fitted to a Bingham pump for an offshore installation in the Cook Inlet off the coast of Alaska. The API 610 radially split barrel casing between bearing pumps (API 610 BB5) sea water injection pumps ran at 5,600rpm, 14 bar (203 psi) seal chamber pressure and employed a Plan 11 and 61 arrangement.

CASE No. 2232L

In February 2001, a 1.875" SCUSI™ single cartridge seal TC/TC/Viton® (Ref. AFTT15V01) was fitted to a Mission mud pump on an offshore oil platform within the North Sea, UK.

CASE No. 2236L

In 2001, two 85mm (3.346") CURC™ single cartridge seals, SiC/SiC/Viton®, (Ref. ABSC0085V14) with DIN 1.4462 wetted parts were fitted to Warman pumps 6/4 D-AH for an offshore platform off the coast of Norway. The feed re-injection pumps processed produced water containing pearlite balls and operated at 1,760 rpm, 8 bar (116 psi) with a Plan 2 arrangement.

CASE No. 2299L

In 2001, five 48mm SMSR™ seals with DIN 1.4462 wetted parts and SiC/SiC seal faces and Viton® elastomers were supplied with impeller spacers for a Sulzer ZE 100 3315 pump. The pump processed produced water with oil and heavy sand at 3,600 rpm, 19 bar (276 psi) and a temperature of 70ºC (158ºF) with a Plan 31 arrangement (cyclone separator system).

CASE No. 2301L

In 2004, three 85mm DMSF™ SIC/SIC//SiC/Car were installed on a Warman 3/2 CCHH with an AS28 NPT standard plus Plan 53 system, sealing produced water with methanol, oil and sand content. The pumps rotated at 2,100 rpm at 16.5 bar (240 psi) with a seal temperature of 70ºC (158ºF).

CASE No. 2383L

In July 2004 a CAPI™ A1 DUAL seal, SiC/SiC//Ant.Car/SiC with Alloy 255 wetted parts (Ref. AZA10060013P) was fitted to a Sand Jet pump application for a offshore oil & gas extraction application in Canada. The Warman 4x3 EE-HH pumps were supported by a Plan 53M arrangement and processed a sand slurry with high chloride content.

CASE No. 2387L

In October 2004 several 100mm CAPI™ A1 dual seals with Alloy 255 wetted parts, SiC/SiC/Ant.Car/SiC faces and Aflas® elastomers (Ref. AZA10060) were installed on Warman 4x3 EE-HH pumps, sealing a sand slurry with high chloride content. The pumps rotated at 1,200 rpm and had a seal chamber pressure of 22 bar (319 psi), with a maximum temperature of 100ºC (212ºF) and operated in a Plan 53M arrangement.

CASE No. 2414L

In January 2005, a 45mm (1.750") CAPI™ A1 single seal with Alloy 255 wetted parts (Ref. AZA10357SS) was fitted to a Amarinth pump C series 80x50x35 for an offshore application on a produced water, oil and sand duty. The seal was supported as per the API Plan 31 configuration.

CASE No. 2544M & 2545M

In April 2005, four 100mm MagTecta's and a 75mm MagTecta™ bearing seal was installed in a Houttuin screw pump in the pumping station of a onshore oil exploration plant. The customer reports excellent performance of the MagTecta™ as the pumps were previously fitted with lip seals, which continuously leaked.

CASE No. 2562M

In August 2005, a CAPI™ A1 dual seal with Alloy 255 wetted parts (Ref. AZA10773013) was installed on a Warman pump for a produced water, oil and sand offshore application in Caspian Sea area. The seal was supported as per the API Plan 54 configuration with a standard plus PUMPPAC™ system (Ref. MZM1222/A).

CASE No. 2575M

In July 2005, two 2.125" (54mm) MagTecta™ bearing seals were installed on a three stage Byron Jackson DVMx4x6x9D pump rotating at 2,950 rpm in an oil splash feed application.

CASE No. 3029N

In August 2005, a AS28-SC instrumented vessel (Ref. AZA10697) was used to support a dual seal on a centrifugal pump for an offshore application in the North Sea, UK.

CASE No. 3191N

In May 2006, eight CAPI™ A1 single seals with Alloy C276 wetted parts (Ref AZA11157BS) were installed on Houttuin pumps for an onshore oil extraction process in Oman. The seals were supported with Plan 32 & 75 arrangements with an AESSEAL® Cyclone (Ref. VAS / CYCLNDXN) and leakage detection vessels (Ref. AZA10993).

CASE No. 3202N & 3203N

In April 2006 several CAPI™ A1 Dual seals with Alloy 255 wetted parts (Ref. AZA11098 / 11094) were fitted to Ingersoll Dresser pumps for an offshore application in the Irish Sea, UK. The seals were supported with 53C arrangements using the OEM's own API Plan 53C system and an AESSEAL® finned cooler assembly (Ref. AZA8003) and sealed produced water with oil and sand content.

CASE No. 3259N

In January 2007, two 100mm DMSC™ (PCP™) dual seals (Ref. AZA11210) were commissioned on Seepex pumps for an offshore oil application in the North Sea. The seals were installed on the LP Flare Drum Pumps sealing hydrocarbons with produced water and supported in a Plan 52 configuration with an AESSEAL® SSE10™ type vessel (Ref. AZA9864).

CASE No. 3412

In August 2007, three off 40mm CAPI™ A1 single seals with Alloy 255 wetted parts (AESSEAL® stock code AZA12084) were fitted to a 900 series Amarinth API 610 (OH2) pump for an offshore application in the North Seal, UK. The pump operated at 3,550 rpm processing hydrocarbons and produced water at an ambient temperature and seal chamber pressure of 5 bar. The seals were supported as per the API Plan 11 configuration.

CASE No. 3435

In 2006 a Hybrid Plan 53/54 seal support system was installed on an offshore platform in Alaska, USA. The system had a small footprint, therefore ideal for restricted offshore space and did not require an electrical supply as the Plan 54 circulation pump was air actuated. Following the success of the first, a second system was ordered in August 2007.

CASE No. 3434

A number of 2.500" and 3.000" DMSF's were supplied to an oil company in the North Sea who were previously using competitors 5620 seals which lasted three months. The customer was also charged by the competitor £3,000 ($6,000) per seal repair. AESSEAL® supplied the DMSF's TC/TC//TC/Car with Aflas® elastomers during 2006 for various mud drilling applications using Discflo slurry pumps model 806-17-2HHD running at 1,780 rpm, 50ºC (122ºF) and 4 bar (58 psi). The DMSF's supplied ran for 18 months before failing and the customer was overjoyed with the performance of these seals and has been considering AESSEAL® for new and repaired seals ever since.

CASE No. 3433

2 off 60mm CAPI™ A1 single seals were supplied in March 2007 under ADM 27660/1 to replace Flexibox RROL/R mechanical seals which were beyond economic repair. The seals were supplied with DIN 1.4462 wetted parts and were fitted to an API 610 Mather and Platt pump, model 8/10 CMEY located on the deaeration towers on a platform in the North Sea. For further information contact Lee Gooch (AESSEAL plc) or see GA 7154722.

CASE No. 3408

2 off 1.375" CDP™ (ANSI+) dual seals (AESSEAL® stock code 3AWCSSC11AV01) were fitted to LF3196 STX Gould pumps with Taper bore for an offshore FPSO application of the coast of Angola. The seals were supported as per the API Plan 53A configuration with an AESSEAL® P2 Thermosyphon vessel (AESSEAL® stock code VSE/SP02). The seals and vessels were supplied in June 2007 and sealed crude oil.

Distributed by:

UK Sales & Technical advice:
AESSEAL plc
Mill Close
Templeborough
Rotherham, S60 1BZ
United Kingdom

Telephone: +44 (0) 1709 369966
Fax: +44 (0) 1709 720788
E-mail: seals@aesseal.com

USA Sales & Technical advice:
AESSEAL Inc.
10231 Cogdill Road
Suite 105
Knoxville, TN 37932
USA

Telephone: +1 865 531 0192
Fax: +1 865 531 0571
E-mail: usa@aesseal.com

Middle East Sales & Technical advice:
AESSEAL Alaa.
Dammam
31423
P.O. Box 9998
Saudi Arabia

Telephone: +966 3 847 0033
Fax: +966 3 847 0077
E-mail: aesseal@afi.com.sa

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