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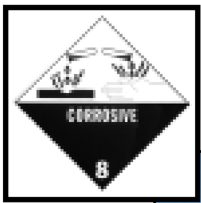
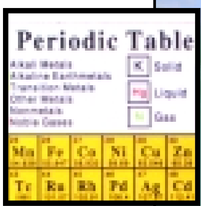
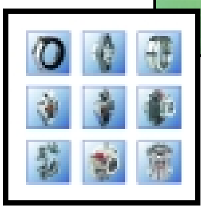
A Guide to Sealing SULPHURIC ACID PLANTS







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A GUIDE TO SEALING SULPHURIC ACID AND SULPHURIC ACID PRODUCTION PLANTS

Introduction

Sulphuric Acid is the highest volume inorganic chemical manufactured world-wide. Approximately 60% of world production is consumed in producing phosphate Fertilizers, the balance being used in literally thousands of other applications including Lead Acid Batteries, the production of other Acids, Pharmaceuticals, Plastics, Dyes & Pigments (e.g. Titanium Dioxide), Electroplating, Explosives, Metals Processing and Petroleum Refining.

Sulphuric Acid is a clear or slightly cloudy, heavy, oily, toxic liquid. Other names used include Oil of Vitriol, ROV (Rectified oil of Vitriol), BOV (Brown Oil of Vitriol) and Battery Acid. At concentrations over 98% it has a pungent smell due to the presence of free Sulphur Trioxide, but below 98% it has little odour. Sulphuric Acid is commercially available in concentrations from 33%, used in storage batteries, up to 100%.

Oleum, or Fuming Sulphuric Acid, is a solution of excess Sulphur Trioxide in anhydrous (100%) Sulphuric Acid. Since Oleum can be diluted with water to produce 100% Sulphuric Acid, the equivalent acid concentration is often used. For example, 66% Oleum is also known as 114.6% Sulphuric Acid.

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SULPHURIC ACID INDUSTRY

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AESSEAL plc wishes to acknowledge the following sources of information and data used in compiling this publication:

Shreve's Chemical Process Industries, fifth edition, by George T. Austin (McGraw Hill)

Selection and Performance of stainless steels and other nickel bearing alloys in Sulphuric Acid, by C.M. Schillmoller, NiDi technical series No 10057.

Product Booklet - Sulphuric Acid, Hays Chemical Distribution Ltd

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Safety & Environmental Issues

Whenever dealing with Sulphuric Acid remember to wear protective clothing. Concentrated Sulphuric Acid is extremely corrosive, causing severe damage to all body tissues. Suitable eye protection and protective clothing must be worn when handling Sulphuric Acid. Skin contact will result in itchiness and digestion could be lethal. Loss of vision can result from contact with the eyes. If there is danger of significant leakage or spillage, a full PVC suit is needed. Full B.A. (breathing air) equipment is required where there is risk of exposure to a Sulphuric Acid mist.

Reaction with ignition can occur when concentrated Sulphuric Acid comes into contact with metallic powders, Nitrates, Chlorates and some Carbides. Although the acid is not in itself flammable, it attacks most metals with the evolution of Hydrogen gas, which forms an explosive mixture with air. There is hence a risk of an explosive atmosphere in tanks, etc, and a flammable gas test is required as part of the entry procedure. Flammable gas may also escape from tank vents.

Much heat is generated when water is added to concentrated Sulphuric Acid. To dilute concentrated acid, the acid should be slowly added to water with plenty of cooling and continuous stirring. The heat can be sufficient for the mixture to reach boiling point. Water should never be added to acid, as spattering of hot acid may result. This must be borne in mind when dealing with any spillages. Acid can be neutralized by the slow addition of Hydrated Lime or Soda Ash. Strong Alkalies such as Caustic Soda should not be used.

Manufacturing Processes

Over the last decades the ‘Contact’ process has been used to produce Sulphuric Acid, replacing the traditional ‘Lead Chamber’ process dating back to the 18th Century.
In the Contact process, Sulphur is burnt in the presence of air to produce Sulphur Dioxide (SO_2), which is then oxidized to Sulphur Trioxide (SO_3) at high temperature in the presence of a Vanadium catalyst. The SO_3 is absorbed into 98% to 99% Sulphuric Acid, increasing its concentration. Water is added to maintain the acid concentration, and the excess produced is drawn-off as product acid.

Sulphur and Sulphur Dioxide are by-products of other industrial processes such as Metals Smelting, Oil & Natural Gas Desulphurization, and Flue Gas Desulphurization from Power Generation. Increasing legislation and awareness of environmental effects have led to the local construction of Sulphuric Acid plants to utilize these sources and hence reduce SO_2 emissions.

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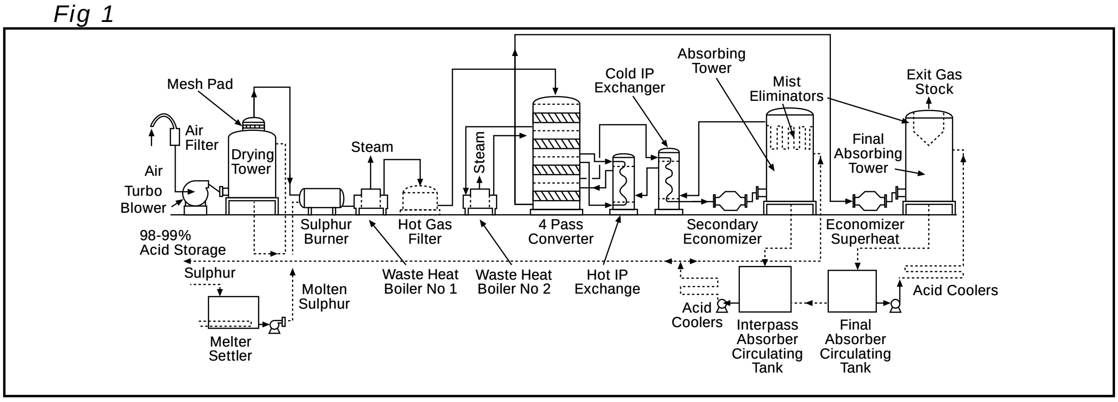
A General Overview of the Contact Process

Fig 1



As energy prices have risen in recent decades, the valuable energy generated during the Sulphuric Acid production process has become a valuable commodity. Major changes have been made in process and plant design to maximize energy recovery and then use this heat to generate high-pressure steam and/or electricity. This secondary function complicates the plant and it's operation, but sharply reduces the cost of the acid produced. A modern Sulphuric Acid plant has extensive boiler and steam systems in addition to the acid streams. Process economics and legislation reducing allowable SO_2 emissions have resulted in more complex plants with higher conversion efficiencies. The older 'single absorption' process has been largely replaced by the 'double absorption' process (also called 'double catalyst') which increases yield of acid and reduces emissions. A modern Sulphur burning plant may achieve conversion efficiencies of 99.7% or better, and plants using smelter gases 99.5%.

A typical flowchart for a Sulphur burning double absorption Sulphuric Acid plant is shown in Figure 1. Molten Sulphur is pumped (using a heated pump and lines) to burners in a furnace, where it meets dried air from the Turbo-blower (fan). Where roasted Sulphur ores are used rather than elemental Sulphur, fluidized beds or rotary roasters are used in the furnace. Spent Sulphuric Acid from other production processes may also be decomposed to provide SO_2 gas.

The gas produced (containing around 11% or so of SO_2) is passed through a heat recovery boiler then filtered before being passed to the converter. Vanadium catalyst beds in the converter encourage the reaction of SO_2 with Oxygen to produce SO_3 (Sulphur Trioxide). The reaction is exothermic, and the gas passes through several heat exchangers as it makes its way down the converter, controlling the temperatures at each catalyst bed to obtain optimum speed and efficiency of the conversion. The converter operates at temperatures over 400°C (750°F), and is usually brick-lined. In the double absorption process, gas from part-way down the converter is cooled, then passes through an inter-pass absorber before being reheated and sent back to the final stage of the converter. After the final stage, the gas passes through another heat recovery exchanger then to a final absorber.

In the absorbers the SO_3 laden gas is passed through 98% to 99% Sulphuric Acid, increasing the concentration of the acid. The acid circulates back to a tank, where it is diluted with water (or dilute acid) then the excess drawn off as product. The process is again exothermic, and the acid is cooled as it circulates. Absorbers are usually lined with acid-resistant brick.

In some plants the gas passes through an Oleum tower before going to the absorber, where 98% to 99% acid is added to the circulating acid instead of water. Oleum is then produced and drawn off as product. Product acid may be pumped to stock tanks, and then to road or rail tankers.

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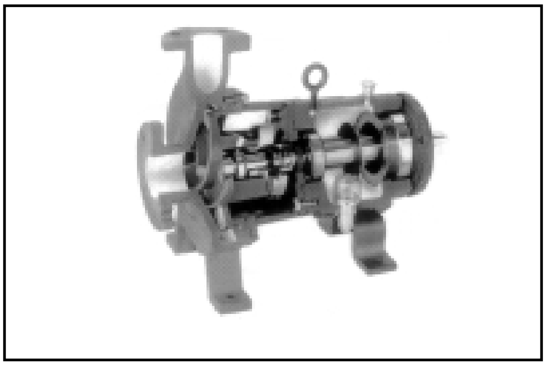
Pumps Used on Sulphuric Acid Plants

Conventional Horizontal Process Pumps



In storage and loading areas the Sulphuric Acid is cool and concentrated, and conventional horizontal process pumps are used. These are often constructed in 316L Alloy, although other materials may be specified according to local preference. A ‘seal friendly’ back-plate with an enlarged seal chamber is greatly preferred, since this will help prevent temperatures rising locally to the seal. A discharge flush (API Plan 11, see page 21) can also be used to aid venting and cooling.

Horizontal process pumps are used on water and condensate duties and may also be found on Molten Sulphur duty, for which they must be steam jacketed.

Fig 3

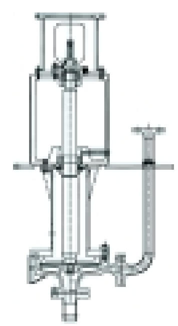
BFW Pump

Boiler Feed and Circulation Pumps

Boiler Feed pumps are usually multi-impeller designs to generate the high pressures required. These are almost always double-ended, with a seal at each end. Most designs are either ‘double-suction’ or include an internal ‘balance’ facility to reduce the load on the thrust bearing. An added benefit is that the seals on both ends see pressures close to suction rather than delivery, and these pumps are not as difficult to seal as they may first appear. Boiler Circulation pumps present more complex problems, as the seal(s) often see full boiler pressure and temperature.

Vertical Spindle (Cantilever shafted) Pumps

Fig 4



This type of pump uses an impeller mounted at the bottom of a hollow tube, with the motor and bearing frame at the top. They will usually be of the ‘cantilever-shafted’ type, with no bearing in the process fluid. Manufacturers such as Lewis Pumps, Ensival and others have developed heavy duty pumps, particularly for use in acid production plants. The sealing area is out of the liquid, and sees only product vapours in normal operation. A variety of techniques are used for sealing, including labyrinth seals, lip seals and packing. Any vapour leakage past these can lead to corrosion of the bearing frame, motor and supporting structure.

Materials of Construction for Mechanical Seals

Metallurgy:

Sulphuric Acid is most corrosive to most metals in the 65% to 80% concentration range. In most cases the corrosion rate increases as temperature increases. The acid changes from being a reducing agent to an oxidising agent at concentrations between 65% and 85%, depending on temperature. Impurities in the acid, such as ferric or cupric ions which may arise from corrosion of other system components, can aid the formation of a passivation layer on the surface of stainless steels such as AISI 304 and 316. The overall picture is complex, and local experiences may vary.

Plant equipment handling cool concentrated Sulphuric Acid (over 80%) is often constructed from Carbon steel, with cast iron or cast steel pipe-work. A Ferrous Sulphate layer is formed on the surface of the metal, protecting the material underneath. However this layer is easily stripped off by increases in temperature or by any turbulence in the flow. Once it is removed then rapid corrosion occurs. Carbon steel cannot therefore be considered a suitable material for mechanical seal construction. 316L is only suitable for use at very low (below 10%) and very high (90% to 100%) concentrations, in both cases at temperatures below 50°C. Excursions outside these conditions may cause rapid corrosion. The design of mechanical seals is such that little corrosion allowance can be made, and 316L is best avoided.

The design of modern Sulphuric Acid plants makes use of Alloys 904L, 904hMo, 28, 625 and others. These have good corrosion resistance when appropriately applied. Variations in impurities and plant conditions mean that local experience should always be considered when specifying seal materials.

In general, Alloy 276 is suitable for use at all concentrations from 0% to 114% at temperatures up to 60°C (140ºF). Alloy 20 is suitable for most concentrations over the same temperature range, but its use should be avoided between 65% and 80%. Hastelloy B–3 may be used for higher temperatures (up to 100ºC (212ºF)) at concentrations between 70% and 100%, but its use at 50% to 70% concentrations should be avoided. Any contaminants present can dramatically affect the corrosion rates at higher temperatures, and selection must be confirmed with plant personnel. It has also been reported that Alloy 20 may be preferred to Alloy 276 if the acid is aerated, for example during agitation.

AESSEAL® has extensive stock of material and components in Alloys 20 and C-276. These Alloys should be considered first in specifying any AESSEAL®. Alloys 904L and 28, Hastelloy B-3 and others can be specified where local conditions demand, but will result in increased cost and delivery lead time.

N.B. 904L in particular has been widely adopted due to its cost advantage over Alloy 20 when purchased in larger quantities for the construction of process plant, but this cost advantage disappears when only smaller quantities are required. An AESSEAL® in 904L would be a ‘special’ and would be more expensive than the same seal in Alloy 20 or C-276.

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Generic Name	Trade Name	UNS	EN	ACI
Alloy 20	**Carpenter 20**	**N08020**	**2.4660**	
Alloy 20 (cast)	**Durimet 20, Alloyco 20**			**CN-7M**
904hMo	**Avesta 254SMo**	**N08925**	**1.4547**	
904L	**Uranus B6, 2RK65**	**N08904**	**1.4539**	
C-276	**Alloy 276**	**N10276**	**2.4819**	
B-3	**Hastelloy B-3**	**N10675**		
625	**Inconel 625**	**N06625**	**2.4856**	
825	**Inconel 825**	**N08825**		
28	**Sanicro 28**	**N08028**	**1.4563**	
316L		**S31603**	**1.4404**	**CF-3M**
316		**S31600**	**1.4401**	**CF-8M, CF-12M**
318		**S32205**	**1.4462**	

Table 1 Alloys used on Sulphuric Acid Plants

Elastomers:

Viton® has excellent acid resistance, and can be considered a general purpose elastomer for Sulphuric Acid duties. Problems can sometimes be experienced with Viton® in hot acids due to its limited resistance to hot water & steam, and in these cases Aflas® or Kalrez® 6375 can be used to advantage.

AESSEAL® keep extensive stocks of O rings in Viton®, Aflas® and Kalrez®.

Seal Face Materials:

Carbon is suitable for use at acid concentrations below 65%. Between 65% and 80% (dependant upon temperature) the acid changes to an oxidising agent, and this can attack the resin impregnants used. Sintered Silicon Carbide (SiC) has excellent resistance to Sulphuric Acid at all concentrations. There are reports that concentrated acid can attack the free silicon in some grades of Reaction-bonded SiC, but the grade used by AESSEAL® does not suffer from this effect. SiC/SiC (reaction bonded vs sinted) faces are the optimum choice for higher concentrations and temperatures, and wherever abrasives are present in the product. Tungsten Carbide or Chrome Oxide faces should not be used in contact with Sulphuric Acid.

External seals with Glass-Filled PTFE vs Alumina Ceramic faces can be used on cooler duties where no abrasives are expected. This option does have several disadvantages. When leakage occurs, acid will be sprayed directly from the faces. The pump bearing frame ‘arms’ can be severely corroded over time by even minor seal leakage. The PTFE face is easily damaged by abrasives. Both PTFE and Alumina Ceramic faces deteriorate rapidly if exposed to short periods of dry or partially dry-running.

With double seals the choice of outboard face combinations is wider, as these only provide sealing for the barrier fluid in normal operation. It is usual to have one Carbon face, as the use of two hard faces externally risks vapourising the barrier fluid inside the seal cavity. The hard face should be chosen to allow sufficient time for planned action and minimal product loss in the event of failure of the inboard faces, and hence it is usual to use the same face as used on the inboard seal. Outboard faces will hence usually use Carbon/Silicon Carbide, but Carbon/Chrome Oxide or Carbon/Alumina Ceramic can be used to reduce seal cost where appropriate (particularly on larger seals). N.B. Carbon/Crome Oxide outboard faces should not be used with an oil barrier fluid.

Gaskets:

Glass-filled PTFE (also known as GFT) gasketing has good acid resistance, and can be used as a ‘general-purpose’ gasket on Sulphuric Acid duties.

The ‘AF1’ gasket supplied as standard by AESSEAL® should not be used on Sulphuric Acid applications.

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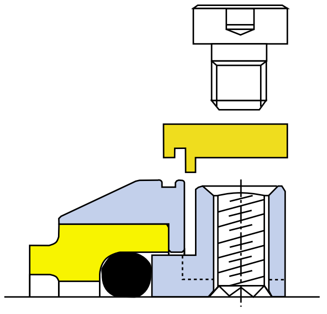
AESSEAL® Mechanical Seals

Extensive use is made of modular design and construction throughout the AESEAL® range to allow delivery lead times to be kept short and prices competitive.
Only a small selection of the AESSEAL® range is shown below. For further details please refer to the product range brochure.

In addition to the standard seal glands shown below, all seals are available with fully-machined glands to suit particular equipment. Glands are available from stock to suit many Progressing Cavity Pump types.

Fig 5



CS™ External Seal

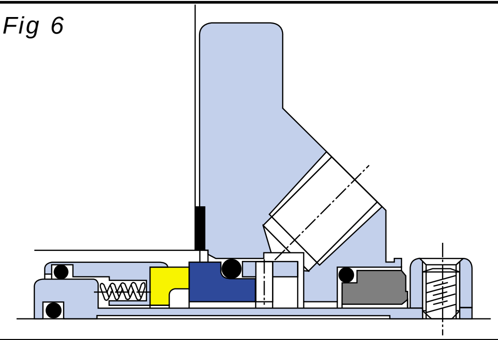
CS™

A 'component' seal available with Carbon or Glass-Filled PTFE rotary face. A range of Alumina Ceramic stationary seats is available to suit most pumps.

CURC™

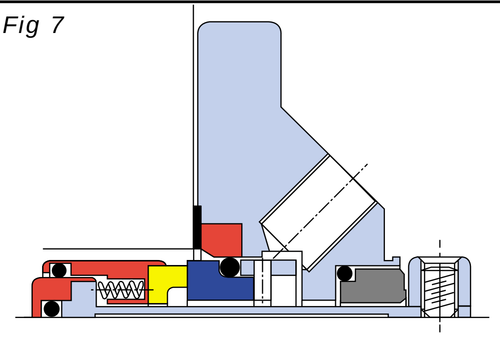
A robust, general purpose single cartridge seal with integral flush, quench and drain connections, available in a wide variety of seal face and elastomer combinations. All metallic components are manufactured in 316L (cast glands from 316) with Alloy 276 springs. In the BI-Metal CURC™ design the product-wetted components are available in Alloy 276, Alloy 20, Titanium or other materials to suit particularly aggressive applications. A Carbon Restriction Bush is standard to limit leakage in the event of seal failure.

Fig 6



CURC™

Fig 7



Bi-Metal CURC™

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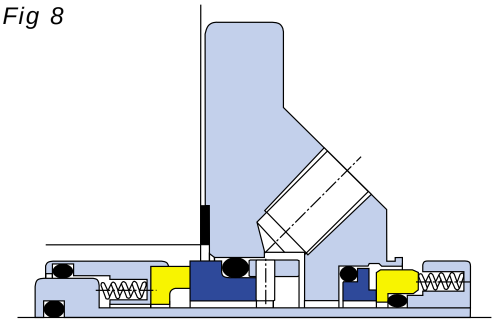
CURE™

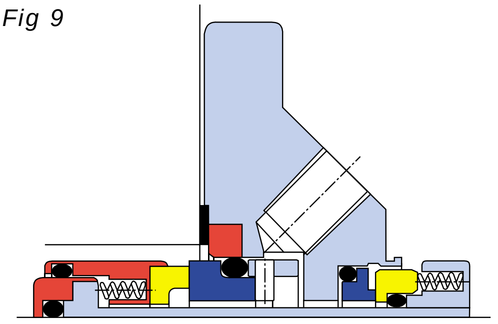
The inclusion of a space-effective set of outboard seal faces allows the use of a low-pressure or un-pressurized barrier fluid for face cooling on moderately hot applications, dry-running protection or prevention of crystallization on the inboard seal faces. The short overall length of the CURE™ allows its use where space is limited.
Due to the use of Carbon/Chrome Oxide outboard faces, the CURE™ seal should not be used with an oil barrier fluid.

Fig 8



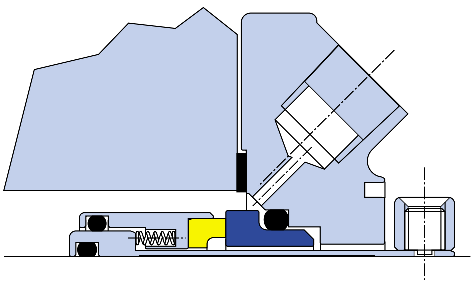
CURE™

Fig 9



Bi-Metal CURE™

Fig 10



SEH1

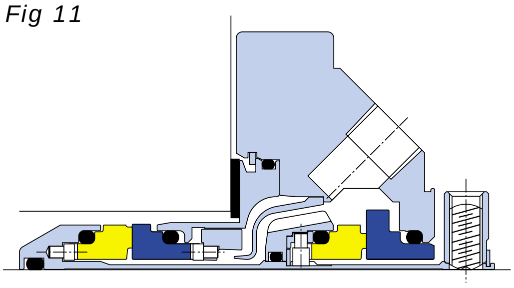
SEH1™ (Alloy 276), SEA2™ (Alloy 20)

Sharing the basic design and many components with the CURC™ seal, the SEH1 features cartridge sleeve and gland manufactured in solid Alloy 276, Alloy 20 or Titanium. This allows the inclusion of a seal flush port.

DMSF™

'Monolithic' wide faces and sprung stationary faces provide ultimate sealing performance across a wide range of shaft speeds and product pressures. Again manufactured in 316/316L as standard with Alloy 276 springs, with BI-Metal version in a full range of materials. The DMSF™ incorporates an extremely effective pumping device with internal flow guides to ensure the faces are properly cooled and flushed by the barrier fluid.

Fig 11



DMSF™

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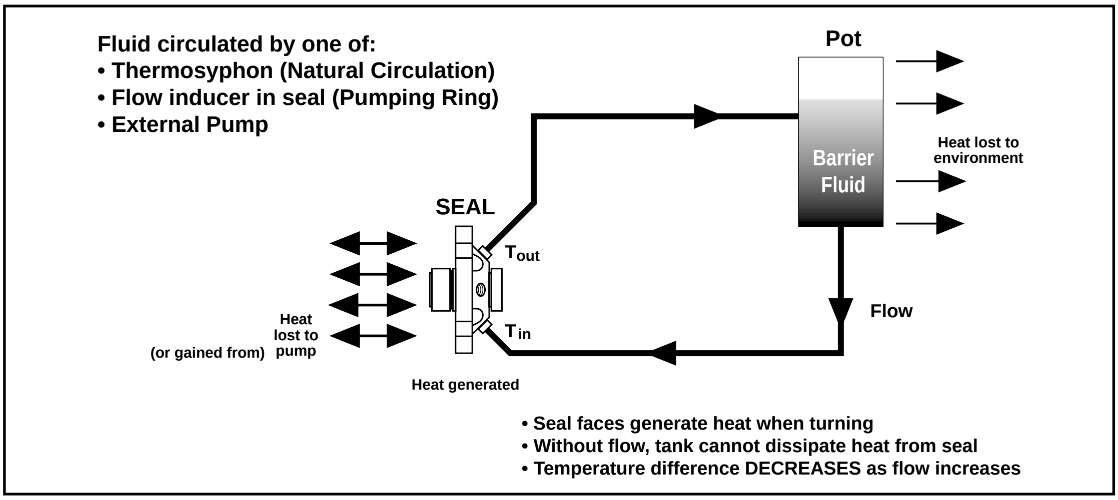
Barrier Systems for Double Seals

A double seal has an inboard and an outboard seal, with a cavity between which is filled with cool, clean barrier fluid. A pressurized barrier fluid serves two purposes. Firstly it prevents the abrasive particles in a slurry from entering between and damaging the seal faces, and secondly it cools the outboard seal faces during operation. A double seal also provides an additional safety shield in that a pressurized barrier system, properly monitored, will give an indication of seal deterioration before there is any product loss. An un-pressurized barrier system can provide cooling and prevent product crystallization on the seal faces, but cannot prevent damage of the inboard faces from abrasives in the product, nor can it provide a positive safety barrier.

The double seal is often connected to a local barrier fluid reservoir ('pot'). Two pipes must be used, to allow a flow through the seal and back to the pot for cooling purposes. The seal can incorporate a pumping device (e.g. the AESSEAL® DMSF™ seal). On cooler or slower duties a 'thermosyphon' can be used. Here the warm fluid in the seal rises by natural convection up to the pot, where it cools before returning to the seal.



Fluid flow in Double Seal Barrier System

Fig 12

The barrier system can be pressurized by running Nitrogen to the pot via a pressure regulator. The Nitrogen may be already piped around the plant, or bottled gas can be used. Plant compressed air can be used to pressurize systems using aqueous barrier fluids on aqueous products, but should never be used with oil or organic barrier fluids or products due to the possible risk of explosion. A sight glass allows the liquid level in the pot to be monitored, backed-up by a level switch if appropriate. Some small leakage of barrier fluid into the product is inevitable; the rate will vary with seal size, speed, pressure across the faces, seal wear, temperature, vibration, etc. Provision must be made to regularly check the level in the pot and top-up if necessary.

The AESSEAL® Water Management System can provide an easy-to-operate, pressurized barrier wherever a suitable plant water supply exists. The pot is fitted with an automatic air vent valve, and the water supply piped into the pot via a pressure regulator and a flow indicator and/or sensor. On commissioning the water supply fills the pot, then once the air vent valve closes the supply pressurizes the pot and flow ceases. In operation the water supply maintains the pressure in the pot and makes good any small loss of barrier fluid. The flow indicator and/or sensor are used to detect seal problems leading to excessive barrier fluid loss. When water is mixed with concentrated Sulphuric Acid, heat is evolved and the acid is diluted. AESSEAL® Water Management Systems should never be used with concentrated Sulphuric Acid (above 60%) due to the potential for larger volumes of water to be added into the acid stream in the event of complete inboard seal failure.

Where the function of the barrier system is purely to provide moderate seal face cooling and/or dry-running protection, an un-pressurized Buffer Pot may be used.

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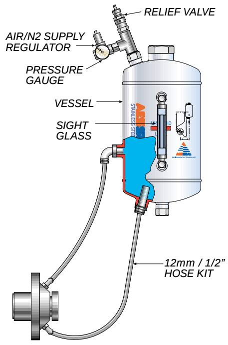
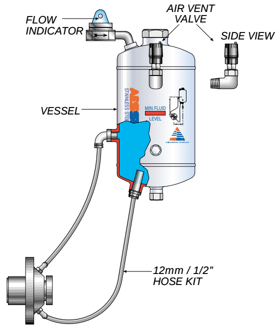
Fig 13



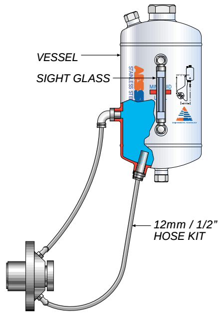
Air/Nitrogen Pressurized Barrier System SSE10™ P2

Fig 14



Water Management System SSE10™ W1
Do Not Use with Concentrated Sulphuric Acid

Fig 15



Buffer Pot System SSE10™ P1

The pressure in a pressurized barrier system should be set to 1 to 2 bars (15 to 30 psi) above the maximum seal chamber pressure likely to be encountered in operation. A pressure gauge should always be fitted to the pot to allow this pressure to be monitored; a pressure switch can also be fitted on critical applications.
For higher temperature applications, finned heat-exchange tubing can be fitted into the pipework, and/or pots fitted with internal water cooling coils. A full modular range of barrier fluid systems is available from stock.

Care is required when choosing a barrier fluid for use with Sulphuric Acid. Water is not ideal for use with concentrated acid, due to the exothermic reaction which occurs when the two mix. Many oils may also suffer a reaction with Sulphuric Acid, and solids may form which can build up between the seal faces and prevent proper sealing. Another factor to consider is contamination of the acid in the event of seal failure, when the contents of the seal pot may escape into the product. In practice, water may be acceptable for use with acid of 60% concentration and below, when the temperature rise from the mixing of acid and water is not likely to be excessive. Seal pot pH must be regularly monitored to ensure acid is not contaminating the barrier fluid, leading to corrosive conditions in the pot. For more concentrated acids Thermotec 15 oil (available from AESSEAL®) may be an acceptable solution. Selection must be discussed and agreed with the end-user. AESSEAL® Technical Dept will be pleased to advise on a suitable selection; the contact numbers are listed on the back page.

N.B. Extreme care must be taken with any double seal on a vertical shaft application to ensure that the seal is properly purged of air on installation. AESSEAL® will be pleased to advise on how this is best achieved.

There are many variations in the ‘environmental controls’ which can be used with mechanical seals. These are often defined by an ‘API plan number’ as shown in the diagrams at the end of this guide.

With the exception of the hard piping option all SSE10™ systems are supplied complete with all fittings and accessories.

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Sulphuric Acid Plant Seal Locations

A. Molten Sulphur Pumps

Elemental Sulphur must be pumped in the molten amorphous state. Sulphur melts at 119°C (246°F); at 158°C (316°F) it undergoes a phase change called 'Caramelization' when viscosity increases by a factor of 14,000. Normal pumping temperatures are in the range of 135°C-150°C (275°F-302°F).

Pumps must be heated, usually by a steam jacket. Where conventional horizontal process pumps are used it is vital that the volute chamber and seal are thoroughly warmed before pumping starts. A single seal is used here, with a low pressure steam quench to the outboard side of the faces. The steam flow should be set to minimize escape past the seal's restriction bush, and the pump must be appropriately guarded to prevent injury. Successful operation depends on fastidious warming of the pump and seal prior to use. Vertical spindle pumps are often used; these have the advantage that the sealing area is not in contact with the Sulphur.

Vertical Spindle Pumps	
Seal Type	Cartridge Double Seal
Metal Parts	316L
Design	CDM™
Inboard Faces	Tungsten Carbide/Tungsten Carbide
Outboard Faces	Tungsten Carbide/Carbon
Elastomer	Aflas®
Gasket	GFT
Drawing	API Plan 53, SSE10™ P2

With any vertical shaft application extreme care must be taken on installation to ensure the seal is fully purged of air.

Horizontal Process Pumps		
Option	Minimum Required	Best Available Option - Over 75mm (2.875")
Seal Type	Cartridge Single Seal	Cartridge Single Seal
Metal Parts	316L	316L
Design	CURC™	SMSS™
Inboard Faces	Tungsten Carbide/Tungsten Carbide	Tungsten Carbide/Tungsten Carbide
Elastomer	Aflas®	Aflas®
Gasket	GFT	GFT
Drawing	API Plan 62	API Plan 62

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B. Absorber Circulating Tank Pumps

These pumps circulate hot, concentrated acid from the tank back to the absorber towers. A proportion of the flow is taken off as product acid. These will usually be vertical spindle pumps mounted directly into the top of the circulating tanks themselves.

Vertical Spindle Pumps	
Seal Type	Cartridge Double Seal
Design	BI-Metal CDM™
Metal Parts	Alloy 276 or Alloy 20
Inboard Faces	Silicon Carbide/Silicon Carbide
Outboard Faces	Silicon Carbide/Carbon
Elastomer	Viton®
Gasket	GFT
System	API Plan 53, SSE10™ P2

With any vertical shaft application extreme care must be taken on installation to ensure the seal is fully purged of air.

C. Circulating Tank Drainage Pumps

Provision is often made to drain the circulating tanks by means of a horizontal process pump. These normally see only occasional use. A single external seal may be used if the pumps are only to be used on cold acid, but if provision is to be made to pump the acid hot then a double seal is needed to cool the faces and to provide a safety barrier.

Circulating Tank Drainage Pumps		
Option	Minimum Required	Best Available Option
Seal Type	External Single Seal	Cartridge Double Seal
Design	CS™ + Stationary	DMSF™
Metal Parts		Alloy 276
Inboard Faces	GFT/Alumina Ceramic	Silicon Carbide/Silicon Carbide
Outboard Faces	N/A	Silicon Carbide/Carbon
Elastomer	Viton®	Viton®
Gasket	GFT	GFT
System		API Plan 53, SSE10™ P2

D. Storage and Tanker Loading Pumps

A number of horizontal pumps are provided to transfer cold concentrated acid between storage tanks and into road and rail tankers. Single seals are often used on older plants, but on more recent plants and installations safety and reliability considerations may require the use of double seals.
The freezing point of concentrated acid can be as high as 10°C (50°F), Oleum as high as 35°C (95°F). Trace heating may be required.

Storage and Tanker Loading Pumps		
Option	Minimum Required	Best Available Option
Seal Type	External Single Seal	Cartridge Double Seal
Design	CS™ + Stationary	BI-Metal CDSA™
Metal Parts		Alloy 276 or Alloy 20
Inboard Faces	GFT/Alumina Ceramic	Silicon Carbide/Silicon Carbide
Outboard Faces	N/A	Silicon Carbide/Carbon
Elastomer	Viton®	Viton®
Gasket	GFT	GFT

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E. Boiler Feed Pumps

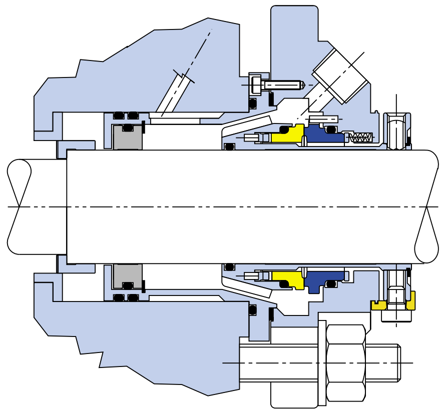
As covered earlier, seals on boiler feed pumps will usually see suction rather than delivery pressure. Single seals can be used at temperatures up to 70°C (160°F) in the seal chamber. For intermediate temperatures (70°C to 120°C (160°F to 250°F)) a double seal can be used to provide the required face cooling. For high feed water temperatures the SMSS23™ single seal circulates the seal chamber contents through an external cooler (API plan 23) to maintain a controlled environment for the seal faces. The seal includes an integral pumping device and adaptor plate with restriction bushing, and is designed for easy installation on a wide range of equipment. A range of coolers is available to suit various application conditions.

Consideration must be given to possible thermal expansion of the shaft. Another factor is radial and axial shaft motion due to play or wear of the thrust/radial bearings.

Boiler feed pumps come in a wide range of sizes, and may be driven at high shaft speeds by steam turbines. For larger and/or higher speed machines, the seal face PV (pressure x velocity) limits must be checked. Please refer to AESSEAL® Technical Department for advice; the contact numbers are listed on the back page.

Fig 16

SMSS23™



SMSS23™ Cross Section

F. Boiler Circulation Pumps.

Due to the high pressures and temperatures often encountered on these pumps, please consult AESSEAL® Technical Department for specific advice. The contact numbers are listed on the back page.

G. Condensate Pumps

Condensate is collected and recycled back to the boilers. The temperatures may be as high as 95°C to 105°C (200°F to 220°F). Careful consideration of the condensate removal system must be made, as they will vary considerably between plants. Contamination can occur, for example due to leaking heat exchanger tubes, and the pH may be monitored. Condensate with an unacceptable pH is often sent to a caustic dosing tank, where caustic is added until the pH is acceptable. Treated condensate cannot be sent back to the boilers. In some locations steam may on occasions blow through into the condensate recovery system.

Conditions are such that a single seal is unlikely to give reliable service due to vaporization ('flashing-off') between the faces. The CURE™ seal with an un-pressurized barrier provides cooling to the faces to prevent this vaporization, and also protects the seal from dry-running. This is suitable for use on condensate at temperatures up to 105°C (225 ºF); higher temperature condensate will require the use of a CDSA™ seal with a pressurized barrier.

Condensate Pumps	
Seal Type	Cartridge Double Seal
Design	CURE™
Metal Parts	316L
Inboard Faces	Carbon (Antim)/Tungsten Carbide
Outboard Faces	CrO_2/Carbon
Elastomer	Aflas®
Gasket	AF1
Drawing	API Plan 52, Buffer Reservoir or SSE10™ P1

H. Water

Plant water quality can vary enormously. Clean cool water is easily sealed using a Carbon/Chrome Oxide single seal, but if solids are present then the Carbon face can suffer rapid wear and a hard face pair is needed. A Tungsten Carbide/Tungsten Carbide face combination is tough and robust. Silicon Carbide/Silicon Carbide may be needed where acid contamination is expected. With any single seal, care must be taken to avoid dry-running in operation.

Water Pumps		
Option	Minimum Required	Where solids/acids present
Seal Type	Cartridge Single Seal	Cartridge Single Seal
Design	CURC™	CURC™
Metal Parts	316L	316L
Inboard Faces	Carbon/CrO_2	Silicon Carbide/Silicon Carbide
Elastomer	Viton®	Viton®
Gasket	AF1	AF1

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Other Sulphuric Acid Applications

I. Phosphoric Acid Production

Concentrated Sulphuric Acid reacts with Phosphate Rock Slurry to form Phosphoric Acid and Gypsum Slurry. The Sulphuric Acid is often mixed with re-circulated, warm Phosphoric Acid in a pre-diluter to provide better control of the exothermic reaction and to reduce the corrosivity of the reactor contents.
For further details of Phosphoric Acid production see the AESSEAL® Publication 'A Guide to Sealing Phosphoric Acid Plants'.

Concentrated Sulphuric Acid Pumps		
Option	Minimum Required	Best Available Option
Seal Type	External Single Seal	Cartridge Double Seal
Design	CS™ + Stationary	BI-Metal CDSA™
Metal Parts		Alloy 276 or Alloy 20
Inboard Faces	GFT/Alumina Ceramic	Silicon Carbide/Silicon Carbide
Outboard Faces	N/A	Silicon Carbide/Carbon
Elastomer	Viton®	Viton®
Gasket	GFT	GFT
System		API Plan 53, SSE10™ P2

Diluted Acid Pumps (Sulphuric, Recycled Phosphoric Acid)	
Seal Type	Cartridge Double Seal
Design	BI-Metal CDSA™
Metal Parts	Alloy 20 or 904L
Inboard Faces	Silicon Carbide/Silicon Carbide
Outboard Faces	Silicon Carbide/Carbon or CrO_2/Carbon
Elastomer	Viton®
Gasket	GFT
Drawing	API Plan 53, SSE10™ SW02

J. Acid Pickling

Sulphuric Acid at 5% to 15% concentration and temperatures up to 95°C (200°F) is used to remove oxide scale from forged, hot-rolled and heat-treated steel parts. The metal parts may be immersed in acid, or a spray process may be used. The reactions involved consume any dissolved oxygen, and hydrogen evolved from the action of acid upon the metal maintains the acid in a reducing condition. Inhibitors or accelerators may be added to control the process. Alloy 400 has traditionally been the material of construction for the plant, but Alloys 825 and 20 are now also used. Alloy 20 or Alloy 276 may be used for a mechanical seal.

Copper, Copper Alloy and Brass parts are also pickled to remove oxide layers. The seal selections are as below. Hard faces are used due to the presence of solids in the acid, removed from the metal surfaces.

Hydrochloric Acid and Mixed Acid solutions have replaced Sulphuric Acid in some processes. The seal selections below are not intended to cover these applications.

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Sulphuric Acid Pickling Solution Pumps		
Option	Below 60°C (140°F)	Above 60°C (140°F)
Seal Type	Cartridge Single Seal	Cartridge Double Seal
Design	BI-Metal CURC™	BI-Metal CDSA™
Metal Parts	Alloy 276 or Alloy 20	Hastelloy B-3
Inboard Faces	Silicon Carbide/Silicon Carbide	Silicon Carbide/Silicon Carbide
Outboard Faces	N/A	Silicon Carbide/Carbon
Elastomer	Viton®	Viton®
Gasket	GFT	GFT
System		API Plan 53, SSE10™ P2 or W2

K. Sulphation and Sulphonation of Organic Chemicals

Animal and vegetable oils, fatty acids, fatty alcohols, aromatics and other organic chemicals are treated with Sulphuric Acid (or Oleum) to make them more reactive or to provide greater solubility. These processes are used in the production of detergents, wetting agents and other surfactants. In turn these are used in paints, dyes, paper coating and many other industries.

The Sulphuric Acid pumped into the reactors is usually cold and of high concentration (90% or above).

Sulphation/Sulphonation Cold Sulphuric Acid Pumps		
Option	Minimum Required	Best Available Option
Seal Type	External Single Seal	Cartridge Double Seal
Design	CS™ + Stationary	BI-Metal CDSA™
Metal Parts		Alloy 276 or Alloy 20
Inboard Faces	GFT/Alumina Ceramic	Silicon Carbide/Silicon Carbide
Outboard Faces	N/A	Silicon Carbide/Carbon
Elastomer	Viton®	Viton®
Gasket	GFT	GFT

The selection of seals for the reactors is somewhat more complicated, due to the range of ingredients, processes and equipment encountered. At lower temperatures Alloy 20 or Alloy 276 will be suitable, but some processes use temperatures as high as 175°C (350°F), where local cooling and/or non-metallic seals must be used. Kalrez® elastomers are needed for some organic chemicals. Please consult AESSEAL® Technical Department with specific application details, on the numbers shown on the back page.

L. Petroleum Refining

In a process known as Sulphuric Acid Alkylation, hydrocarbons are emulsified in 98% Sulphuric Acid at temperatures from –1°C to 10°C (30°F to 50°F). During the process, the acid concentration reduces to around 88%.
Lubricating oils and other distillates are acid treated with 83% Sulphuric Acid at 65°C to 100°C (150°F to 212°F). Water is then added to dilute the acid, to simplify centrifugal separation of oil from the sludge which arises from the treatment. Since the oil and acid remain mixed, corrosion is not usually a problem even after the acid has been diluted.
The acid will normally be cold when pumped into the reaction vessel.

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SULPHURIC ACID INDUSTRY

Alkylation - Cold Sulphuric Acid Pumps		
Option	Minimum Required	Best Available Option
Seal Type	External Single Seal	Cartridge Double Seal
Design	CS™ + Stationary	BI-Metal CDSA™
Metal Parts		Alloy 276 or Alloy 20
Inboard Faces	GFT/Alumina Ceramic	Silicon Carbide/Silicon Carbide
Outboard Faces	N/A	Silicon Carbide/Carbon
Elastomer	Viton®	Viton®
Gasket	GFT	GFT

M. Hydrometallurgy

Copper, Zinc, Nickel, Cobalt and Uranium are extracted from their ores by extractive hydrometallurgy, otherwise known as leaching. Sulphuric Acid solutions are used to dissolve the ores. Refined metal is then recovered by precipitation or electrode deposition. The acid solutions used tend to be of 3% to 30% concentration, and at temperatures from ambient to around 65°C (150°F). The presence of sulphates, oxides and other oxidising agents tends to reduce the corrosivity of the acid, though this can vary between locations. The presence of Chlorides may lead to crevice corrosion problems. Equipment is often made from Alloys 304 or 316, but the design may include a substantial corrosion allowance. Unless the plant has excellent experience of 316L, then Alloy 20 should be chosen for mechanical seal construction.

Pumps for 3% to 30% Sulphuric Acid, up to 60°C (140°F)		
Option	Minimum Required	Best Available Option
Seal Type	External Single Seal	Cartridge Single Seal
Design	CS™ + Stationary	BI-Metal CURC™
Metal Parts		Alloy 20
Inboard Faces	GFT/Alumina Ceramic	Carbon/Silicon Carbide
Elastomer	Viton®	Viton®
Gasket	GFT	GFT

Acid Slurry Pumps		
Option	Minimum Required	Best Available Option
Seal Type	Cartridge Single Seal	Cartridge Double Seal
Design	CURC™	DMSF™
Metal Parts		Alloy 20
Inboard Faces	Silicon Carbide/Silicon Carbide	Silicon Carbide/Silicon Carbide
Outboard Faces	N/A	Silicon Carbide/Carbon
Elastomer	Viton®	Viton®
Gasket	GFT	GFT
System	API Plan 32 strongly recommended	API Plan 53, SSE10™ P2 or W2

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Commercially Available Strengths of Sulphuric Acid & Oleum

	Sulphuric Acid %	Seal Selection (see below)	Specific Gravity	Boiling Point (Approx)		Freezing Point (Approx)	
				°C	°F	°C	°F
Battery Acid	33.33	1	1.25	110	230	-50	-58
Chamber Acid	62.18	1	1.53	143	289	-32	-26
Tower Acid	77.67	2,3	1.71	160	320	-10	+14
Oil of Vitriol	93.20	2,3	1.84	290	554	-34	-29
	98.0	2,3	1.84	325	617	+3	37
	100.0	2,3	1.84	280	536	+10	+20
20% Oleum	104.5	4	1.915	141	286	0	+32
40% Oleum	109.0	4	1.983	101	214	+32	+90
66% Oleum	114.6	4	1.992	58	136	-4	+25

Alternative measures are occasionally used to measure the strength of solutions:

Degrees Twaddell (UK)
°Tw = 200 (Specific Gravity – 1.0)

Degrees Baumé (US)

$$°Bé = 145 - \left(\frac{145}{\text{Specific Gravity}}\right)$$

Seal Selections

1. 0% to 65% Sulphuric Acid, up to 60°C (140°F)		
Option	Minimum Required	Best Available Option
Seal Type	External Single Seal	Cartridge Single Seal
Design	CS™ + Stationary	SEH1, SEA2, BI-Metal CURC™
Metal Parts		Alloy 276 or Alloy 20
Inboard Faces	Car/Alumina Ceramic	Carbon/Silicon Carbide
Elastomer	Viton®	Viton®
Gasket	GFT	GFT

2. 65% to 100% Sulphuric Acid, up to 60°C (140°F)		
Option	Minimum Required	Best Available Option
Seal Type	External Single Seal	Cartridge Double Seal
Design	CS™ + Stationary	BI-Metal CDSA™
Metal Parts		Alloy 276 or Alloy 20
		(do not use Alloy 20 between 65% & 80%)
Inboard Faces	GFT/Alumina Ceramic	Silicon Carbide/Silicon Carbide
Outboard Faces	N/A	Silicon Carbide/Carbon
Elastomer	Viton®	Viton®
Gasket	GFT	GFT
System		API Plan 53, SSE10™ P2

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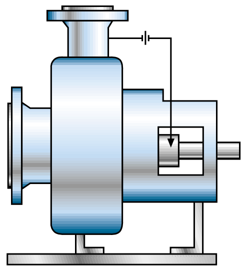
3. 70% to 100% Sulphuric Acid, 60°C to 100°C (140°F to 212°F)		
Option	Minimum Required	Best Available Option
Seal Type	Cartridge Single Seal	Cartridge Double Seal
Design	SEH1, BI-Metal CURC™	DMSF™
Metal Parts	Hastelloy B-3	Hastelloy B-3
Inboard Faces	Silicon Carbide/Silicon Carbide	Silicon Carbide/Silicon Carbide
Outboard Faces	N/A	Silicon Carbide/Carbon
Elastomer	Viton®	Viton®
Gasket	GFT	GFT
System		API Plan 53, SSE10™ P2

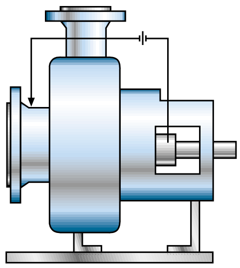
4. Oleum (Fuming Sulphuric Acid) up to 60°C (140°F)		
Option	Minimum Required	Best Available Option
Seal Type	Cartridge Single Seal	Cartridge Double Seal
Design	SEH2, BI-Metal CURC™	DMSF™
Metal Parts	Alloy 276	Alloy 276
Inboard Faces	Silicon Carbide/Silicon Carbide	Silicon Carbide/Silicon Carbide
Outboard Faces	N/A	Silicon Carbide/Carbon
Elastomer	Viton®	Viton®
Gasket	GFT	GFT
System		API Plan 53, SSE10™ P2

API PLAN SCHEMATIC DETAILS

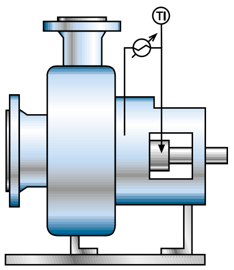
Throughout seal selection, system plan numbers are referred to. These plan numbers and their meaning have been summarized below:-



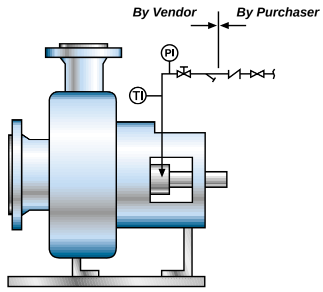
API PLAN NO.11
Product Recirculation from Pump Discharge to Seal through a Flow Control Orifice.



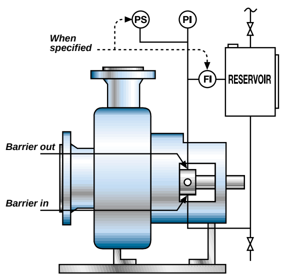
API PLAN NO.13
Product Recirculation from Seal Chamber to Pump Suction via a Flow Control Orifice.



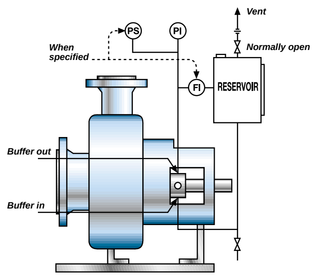
API PLAN NO.23
Product Recirculation from Seal Cavity through Heat Exchanger and back to the Seal Chamber. Normally includes some form of Pumping Ring.



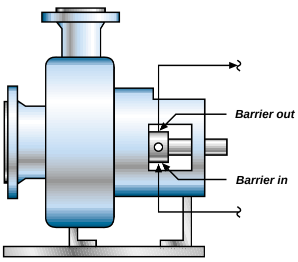
API PLAN NO.32
Flush injected from an External Source.



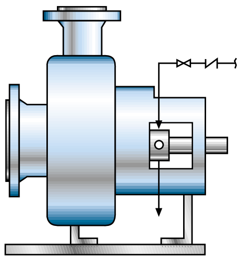
API PLAN NO.53
Pressurized Barrier Fluid Reservoir. Barrier pressure is greater than Product pressure. Circulation is maintained by a Pumping Ring.



API PLAN NO.52
Unpressurized Buffer Reservoir, Circulation normally maintained by Pumping Ring. Also system normally continuously vented.



API PLAN NO.54
Pressurized External Barrier Fluid, Normally from a separate Pumped system (e.g. PUMPPAC™).



API PLAN NO.62
External Quench straight through to drain.

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