MECHANICAL SEAL

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Mechanical seal

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THE BASIC FUNDAMENTALS

Mechanical seals have the purpose of inhibiting leakage/Seepage of a fluid (liquid or gaseous) through the clearance between a shaft and the liquid container. (Fig.1)

The central components of a mechanical seal are the seal rings on which a mechanical pressure is acting, produced by springs or bellows, and a hydraulic force, produced by the process fluid pressure.

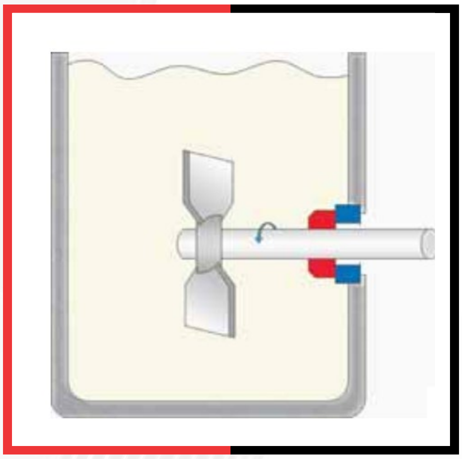

Fig.1

The seal ring which revolves with the shaft is called the "rotary ring"; the seal ring fixed on the casing of the machines is called the stationary ring. Secondary seals are necessary to perform static sealing between rotary rings and shafts and also between stationary rings and the casing of the machines. Elastomeric O-Rings are generally used as secondary seals but alternate systems can be used, as described in the subsequent sections. (Fig.2)

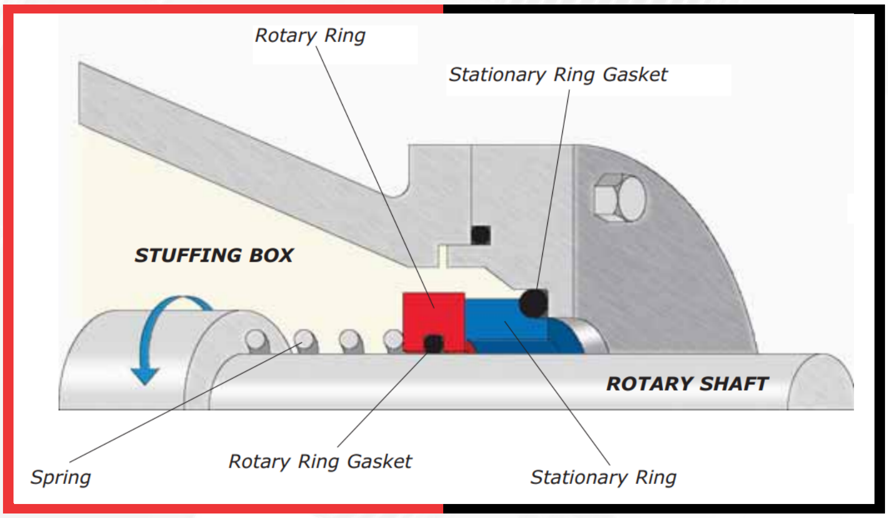

Fig. 2

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Typically, mechanical seals are mounted on pumps and mixers. (Fig.3 &a 4)

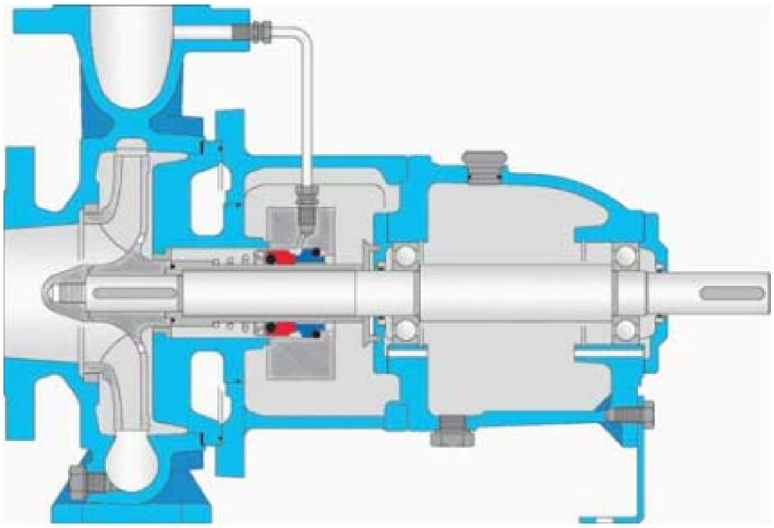


Fig. 3

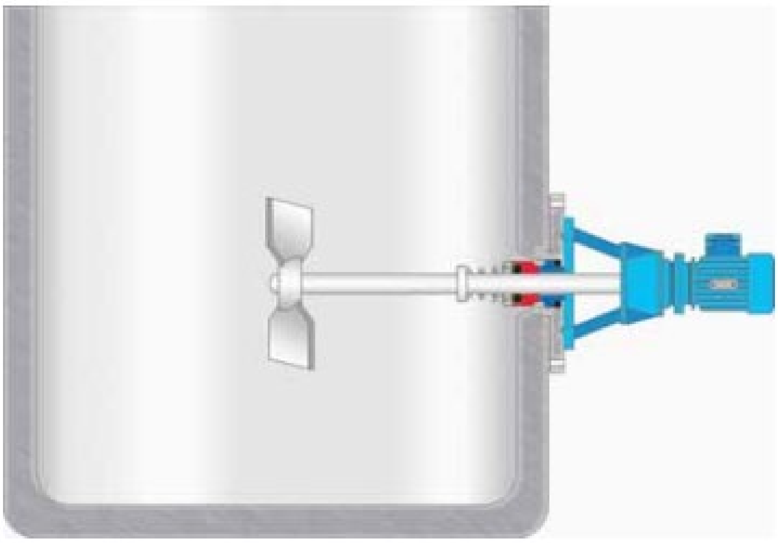


Fig. 4

On both of the above arrangements, the installation of a proper device is essential to seal the fluid contained in the casing.

The Liquid Film

In order to diminish the sum of friction between the seal rings a resourceful lubrication is essential.

Seal faces can be lubricated by the process fluid or, with double mechanical seals, by an appropriate auxiliary fluid (see chapter relevant to configurations).

A stable and comprehensive layer of lubrication significantly affects the performance and the life of a mechanical seal. (Fig.5)

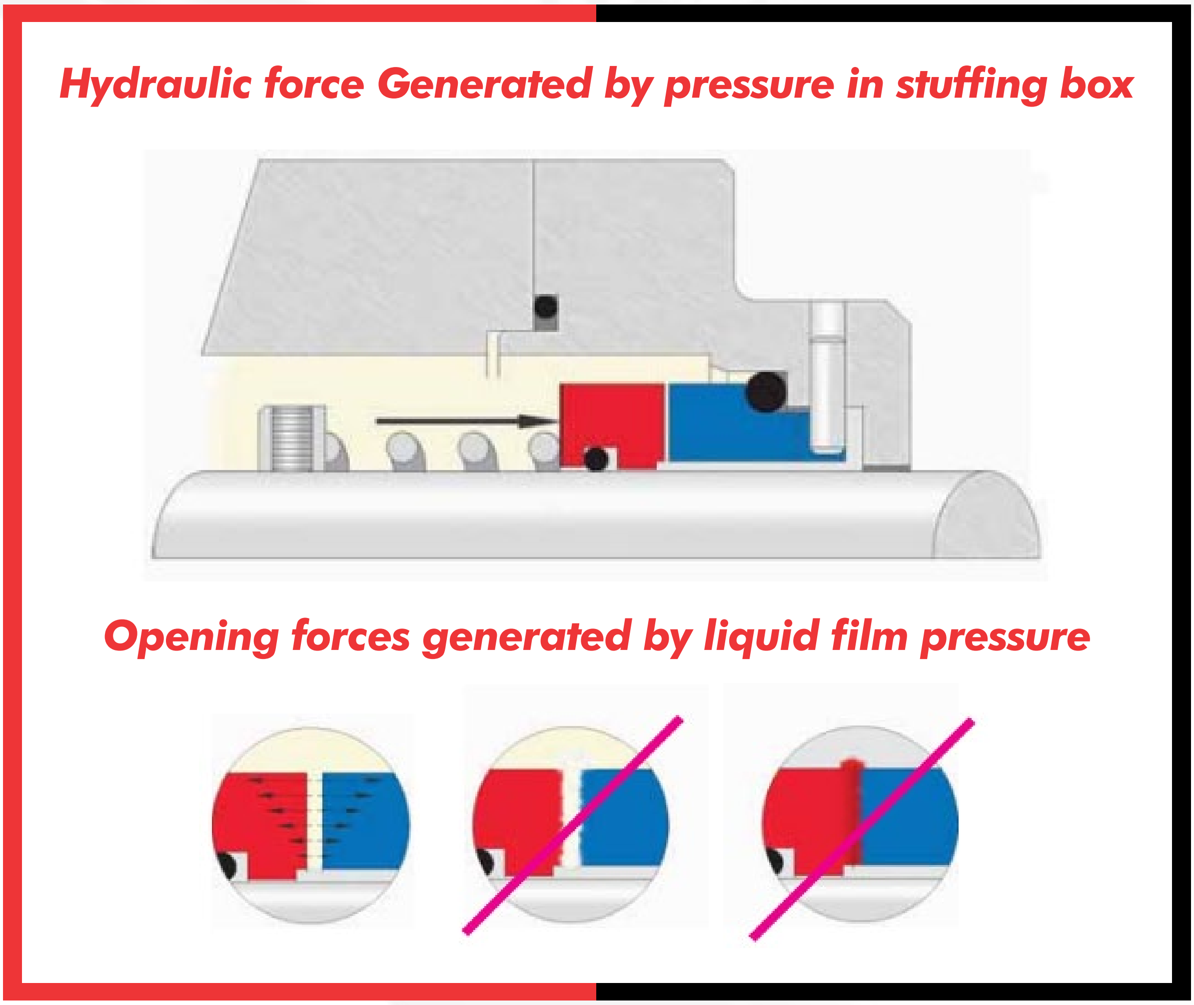


Fig. 5

In order to indemnify good lubrication and adequate cooling of the seal rings, the precise selection of a mechanical seal shall take into consideration the following factors:

- Process fluid temperature.
- Evaporation pressure at operating temperature.
- Process fluid features Shaft speed.

(see also chapter relevant to selection)

Theories and principles above discussed are valid for all mechanical seals working with a liquid fluid. Dry-running seals and gas-seals function on different principles and shall be considered further on.

Leakage

All mechanical seals generate leakage.

The cause lies in the formerly discussed theory of lubrication; it is recognizable that a constant lubrication layer means a certain quantity of leakage.

Leakage/Seepage can be calculated and depends on numerous factors as rotational speed, fluid pressure and features, and balancing ratio. But the apparatus on which the mechanical seal is installed can have some effect on it too. Often leakage is so decreased that it cannot be detected (vaporization).

Degree of Freedom

The elastic mechanisms of a mechanical seal (spring or bellow, gaskets) are of dominant importance for good performance.

The gasket mounted on the seal ring pressed by the spring or bellow (usually the rotary ring) has to follow the movement of the ring induced by inevitable phenomena like vibrations, misalignment and shaft run-out and for this reason it's called "dynamic" (Fig.6)

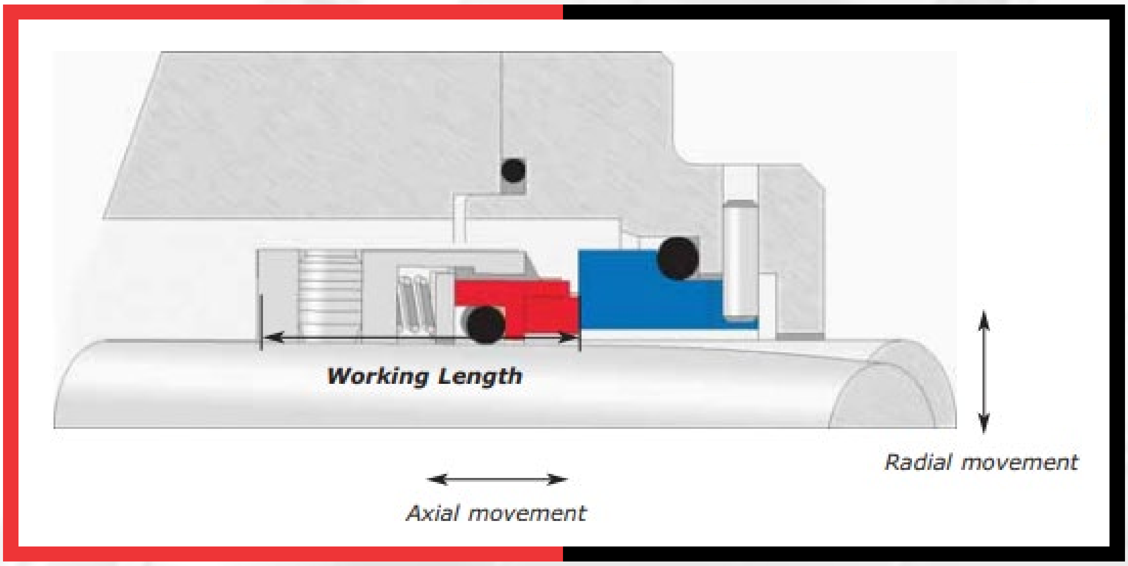


Fig. 6

It follows that such factors as working length, gasket compatibility with the process fluid, dimension and finishing of the shaft have to be wisely considered for good application of a mechanical seal.

Balancing Ratio

If we consider a piston on which a continuous pressure is applied, we know that the force created shall be proportional to the area of the piston itself.

In mechanical seals, in addition to the closing force produced by the springs or bellow, a hydrostatic force produced by the fluid pressure acts on the seal ring.

As earlier discussed the fluid pressure also penetrates between the seal faces, generating a lubrication film and producing an opening force.

The ratio between the forces which are closing the seal ring and the ones which are opening the seal ring is called the “balancing ratio”.

When the balancing ratio is greater than one, we have an unbalanced seal. In the other situations we have a balanced seal.

The dimensions necessary for a balanced seal are attainable thanks to a small notch placed on the sleeve or on the body of the seal itself.

Unbalanced Seals

In general, unbalanced seals have good enactment when subjected to vibrations, misalignments or cavitation; they are inexpensive and their application does not need shaft or sleeve notching.

The main drawback in the application of unbalanced mechanical seals is the working pressure. High pressures produce an extreme closing force which affects the stability of the liquid film between the seal faces, inducing high temperature and premature wearing. (Fig.7)

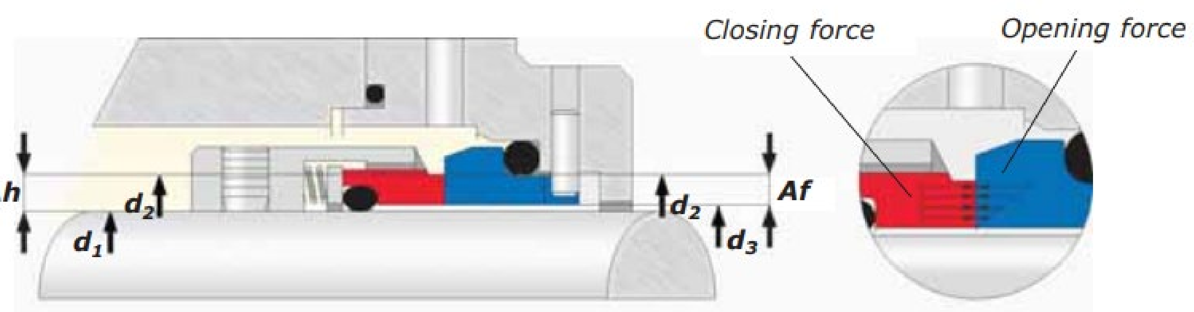


Fig. 7

K= Ah/Af   Ah>Af   K>1

Ah=(d 2-d 2)-□/4 Af=(d 2-d 2)- □ /4

Ah= Angular area on which the pressure is acting Af= Sliding faces area

Balanced Seals

High pressure and high speed apparently generate correspondingly high values of friction heating.

Balanced seals address this problem with a reduced closing force, as earlier discussed.

Also in cases where a high rate of vapour pressure has to be considered, a balanced mechanical seal is the correct choice.

API standard describes as “flashing” all hydrocarbons that have a vapour pressure higher than 1 barg and for these liquids a double or tandem balanced seal has to be provided. (Fig.7a)

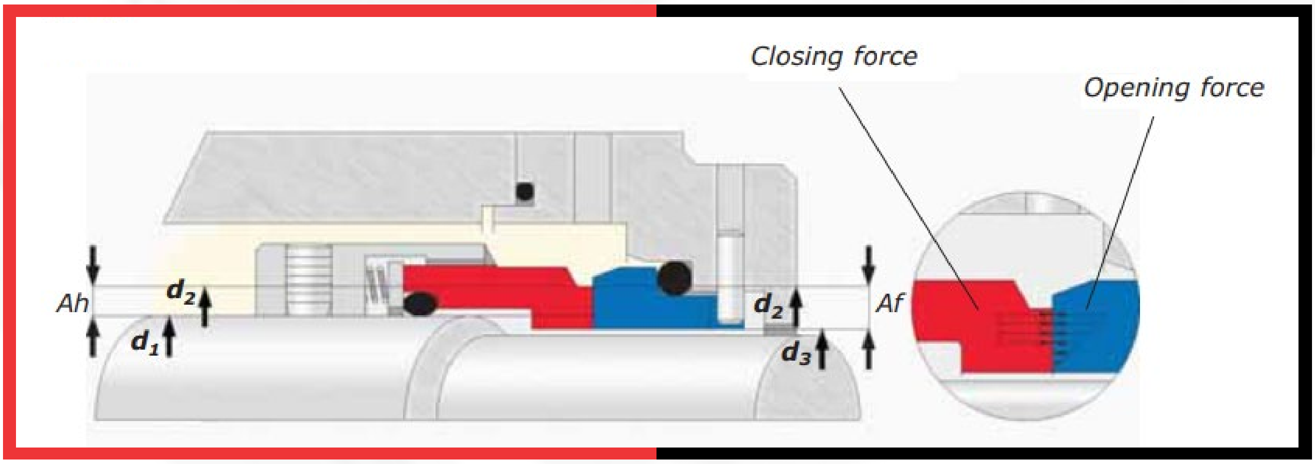


Fig. 7a

K= Ah/Af   Ah<Af   K<1

Ah=(d22-d 2)-□/4 Af=(d 2-d 2)- □ /4

Ah= Angular area on which the pressure is acting Af= Sliding faces area

THE CONFIGURATIONS

Single Internal Seal

This is the most prevalent and proficient configuration for the most applications. It is called internal because of its being entirely submerged in the product. The balancing ratio is intended for pressure acting outside the seal, therefore generally, if installed as an external seal, the liquid pressure will cause translation of the stationary ring and extreme separation of the seal faces. (Fig.8)

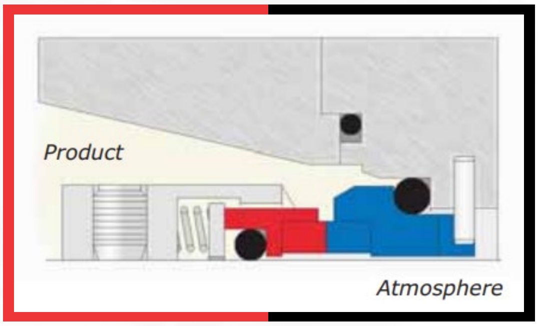


Fig.8

Single external seal

In this implementation the sealed product is inside the seal and the exterior part of the rotary ring is exposed to the atmosphere. (Fig.9)

It is engaged with aggressive fluids which can chemically attack materials generally used for internal seals or when the use of distinctive materials is considered too costly.

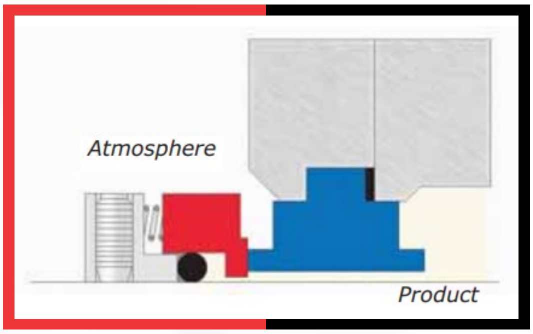


Fig.9

In this kind of seal often there are no metal parts in contact with the product or, if there are any, distinct materials such as Hastelloy or Titanium are used.

The rotary ring and the stationary ring (in interaction with process fluid) can be made of graphite, ceramic or silicon carbide.

Gaskets can be in perfluoroelastomer, PTFE or fluoroelastomer.

The application of external seals is frequently employed in top entry mixers because of an easy installation and the probability to carry out an effective cooling of the stationary ring, necessary for dry running applications.

Back-to-back Double Seal

This configuration is suggested with critical products (i.e. abrasive, gaseous, toxic or lethal) and usually when no emissions in the atmosphere are allowed.

The back-to-back lay-out, so called because the two seals are placed accurately back to back, gives the probability to form a barrier made of a pressurised auxiliary liquid not dangerous to the atmosphere.

The lubrication of the seal faces is carried out by the auxiliary liquid which should be compatible with the process fluid. (Fig.10).

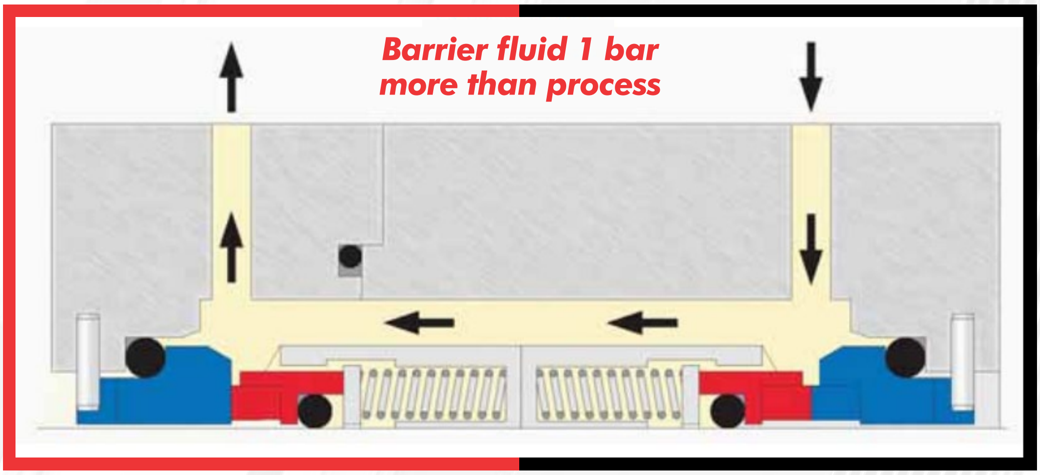


Fig.10

In a back-to-back arrangement an internal pressurisation having a significance greater than the process fluid (at least 1 bar or 10% more) is essential in order to avoid opening of the seal (as explained in chapter relevant to internal single seals) and to offer a competent barrier against leakage of process fluid into the environment.

Tandem Double Seal

In this configuration the two seals are assembled with the same alignment.

The auxiliary fluid generally is at a lower pressure than the process fluid but also pressurised systems can be employed with appropriate seal rings (see dual seals). (Fig.11)

Buffer fluid at atmospheric pressure

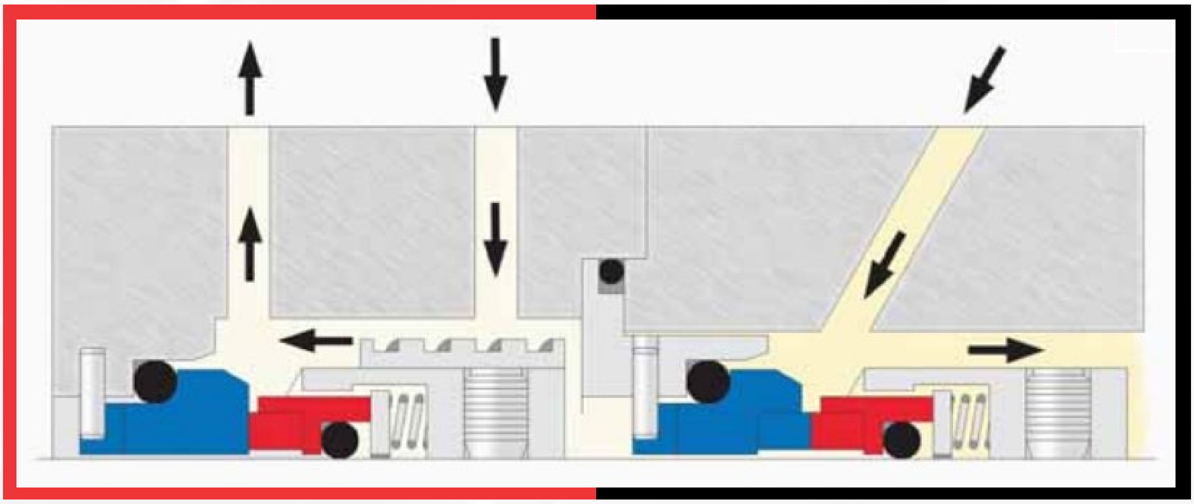


Fig. 11

IIn an unpressurised configuration there is the benefit of evading relatively expensive pressurisation systems gaining a performance corresponding to the one of the back-to-back lay-out, which comprises of:

- No leakage of the process fluid into the environment.
- Good lubrication and cooling of the seal rings.

This configuration however is not appropriate with toxic, abrasive or extremely viscous process fluids, liable to to create sticking of seal rings; in these situations, the back-to back configuration should be used.

Tandem double seals are generally employed in petrochemical and refinery plants, where service with high vapour pressure and low precise weight on centrifugal pumps is essential.

Dual Seal

This is a new arrangement anticipated by API 682 standard (American Petroleum Institute), where the two seals are assembled in a tandem lay-out.

A distinct design of the seal rings gives the probability to function both in an unpressurised system and in a pressurised system (as with the back-to-back configuration), gaining the benefits of the two previous configurations.

Only a cartridge assembly is allowable by API 682 in this configuration.(Fig.12)

Buffer fluid at atmospheric pressure or Barrier fluid 1 bar more than process

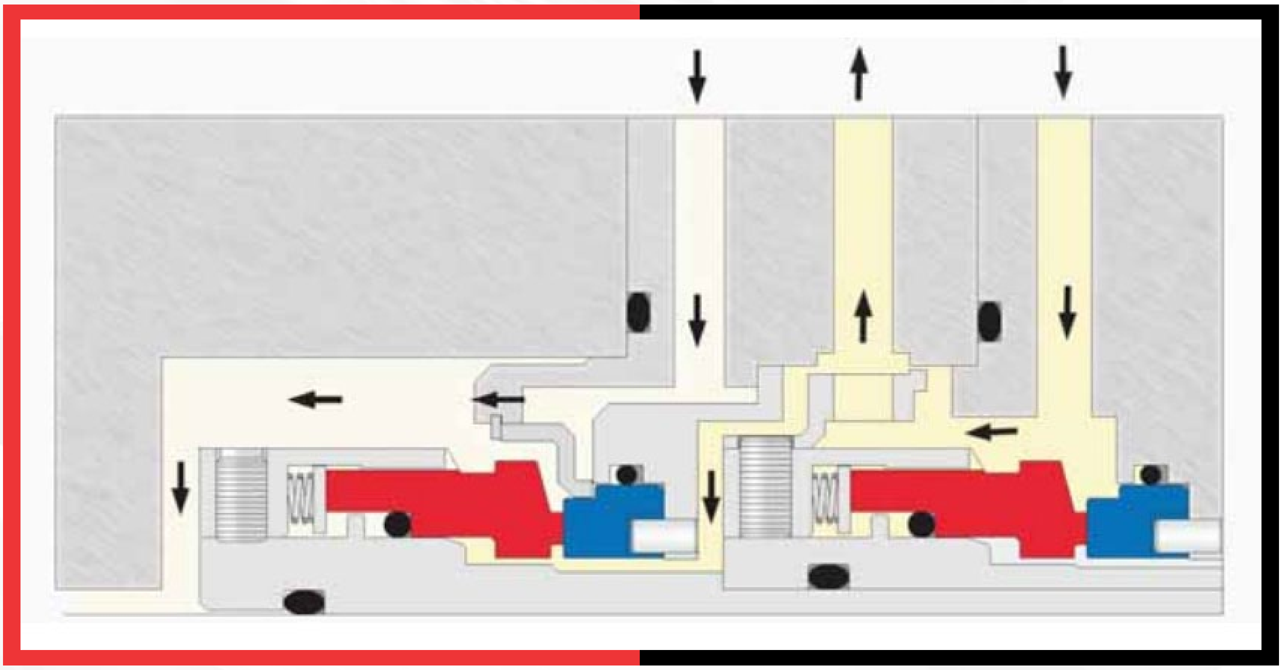


Fig. 12

Face-to-face Seal

This last double seal configuration is collected by a distinctive central stationary ring and two opposite rotary rings.

It can work in the similar way as a dual seal (pressurised and unpressurised system).

Less used than some of the earlier configurations, it has some remarkable features like:

- Reduced total length.
- Spring not in contact with the process fluid (Fig.13).

Buffer fluid at atmospheric pressure or Barrier fluid 1 bar more than process

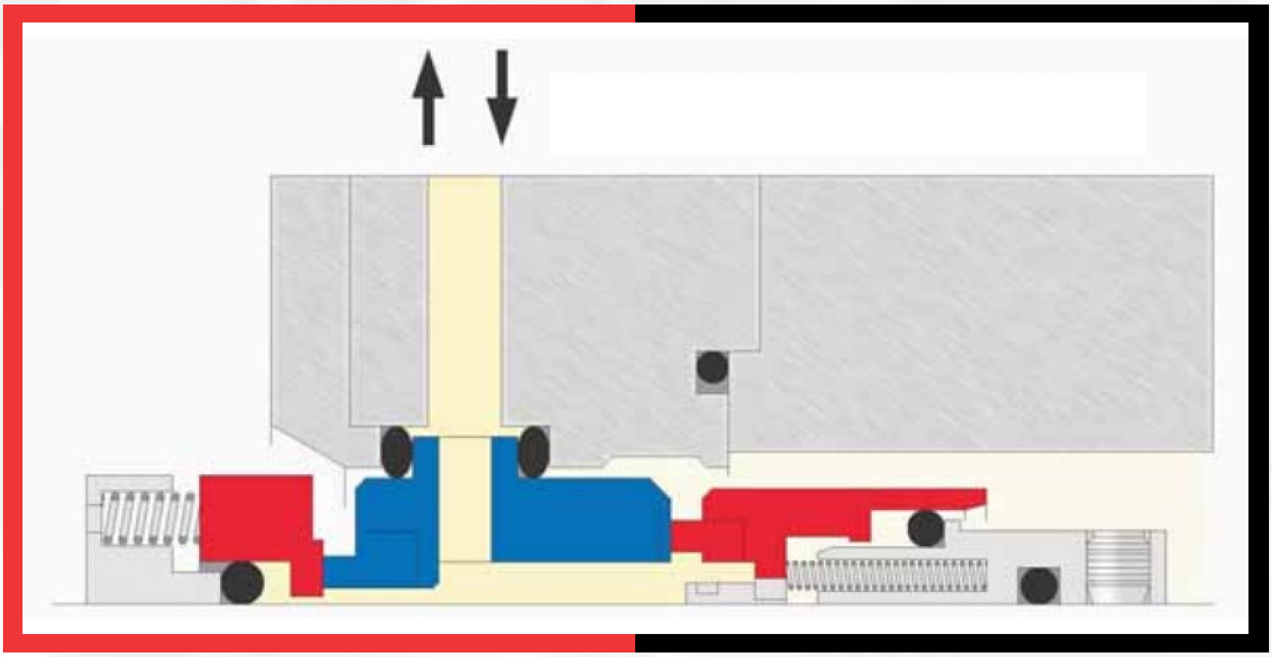


Fig. 13

THE SELECTION

Cooling System and API Planes

The great significance of efficient lubrication of the seal rings for good importance has been earlier underlined. It follows that an appropriate cooling system should be employed to limit the operating temperature of the seal.

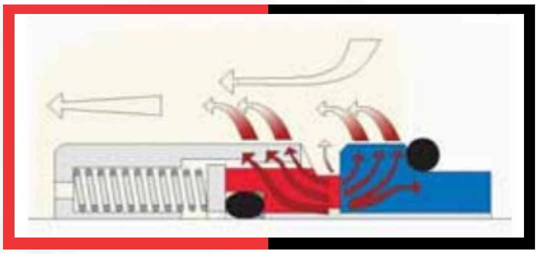


Fig.14

Many different lay-outs can be used, depending on the configuration and the necessary service. (Fig.14)

A good seal range must include standards for a safe and durable installation. API standard has supplied a comprehensive collection of flushing and pressurisation lay-outs, each anticipated for a particular service. The various connection lay-outs are recognized by a particular number which gives the probability to simply define all possible configurations (See API plans at pag.20)

Selection of Mechanical Seals

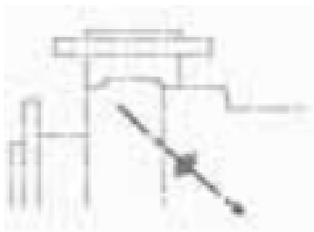
The API 682 standard is an influential tool to carry out mechanical seal selection for intended use in refinery plants.

In chemical plants the wide range of applications and process fluids makes the selection of the seal a challenging work.

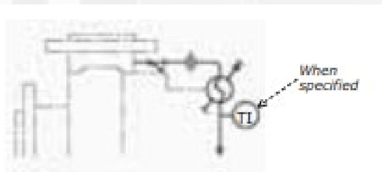
Many factors should be measured as characteristics of the fluids, configuration of the machines on which the seal has to be installed, particular requirements in terms of compatibility with some restricting standards (i.e. FDA rules for the food industry).

In the next segments the most diffuse products and significant recommended configurations are gathered into families and defined with the intent of enlightening the logic of the API plans.

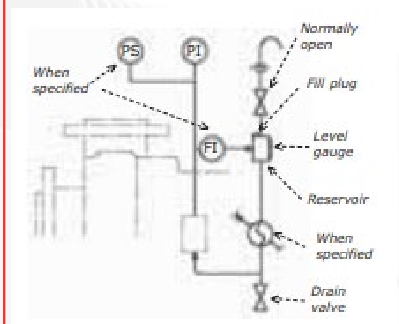
More details about particular products can be found in our catalogue, in the selection section.



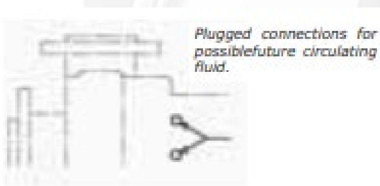
Plan 01
Internal recirculation from pump discharge to seal.



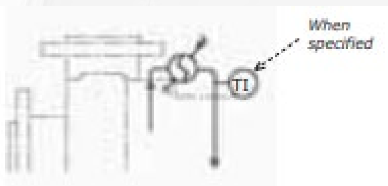
Plan 22
IRecirculation from pump case through orifice, strainer and heat exchanger to seal.



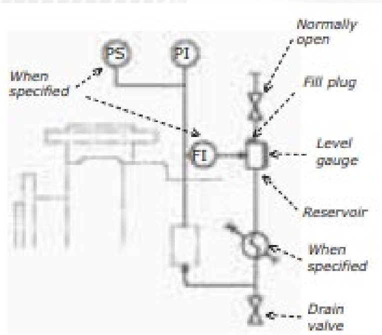
Plan 52
Non pressurized exterior fluid reservoir (see note 3) with forced circulation; normally used with tandem seal arrangement.



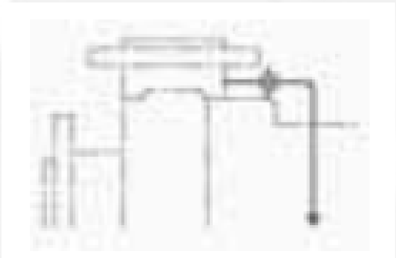
Plan 02
Dead-ended seal compartment with no circulation of flushed fluid; water-cooled stuffing box jacket and throat bushing necessary when specified.



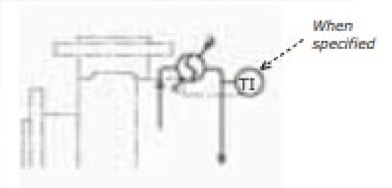
Plan 23
Recirculation from seal with pumping ring through heat exchanger and back to seal.



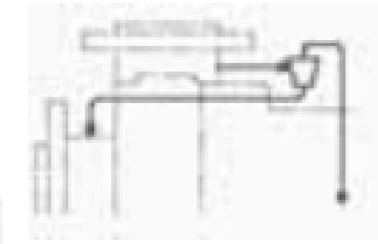
Plan 53
Pressurized external fluid reservoir (see note 3) with forced circulation; usually used with double seal arrangement.



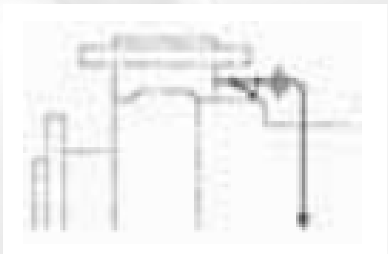
Plan 11
IRecirculation from pump case through orifice to seal.



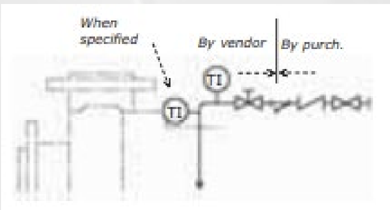
Plan 23
Recirculation from seal with pumping ring through heat exchanger and back to seal.



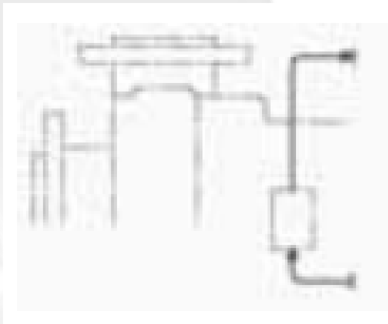
Plan 31
Recirculation from pump case through cyclone separator providing clean fluid to seal and fluid with solids back to pump suction.



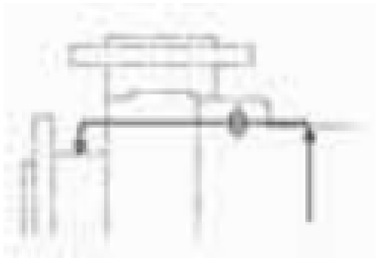
Plan 12
Recirculation from pump case through strainer and orifice to seal.



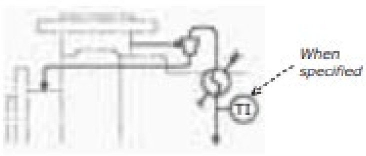
Plan 32
Injection to seal from an external source of clean fluid.



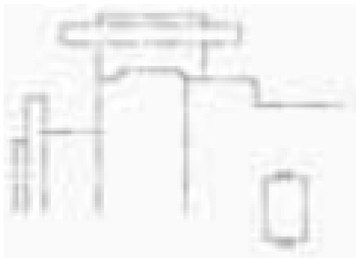
Plan 54
Circulation of clean fluid from external systems (see note 3); usually used with double seal arrangement.



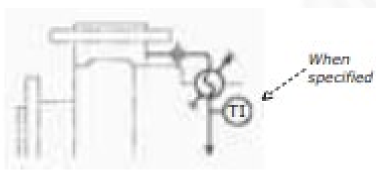
Plan 13
Recirculation from seal chamber through orifice and back to pump suction.



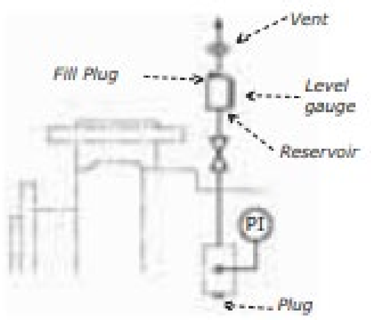
Plan 41
Recirculation from pump case through cyclone separator providing clean fluid through heat exchanger to seal and fluid with solids back to pump suction.



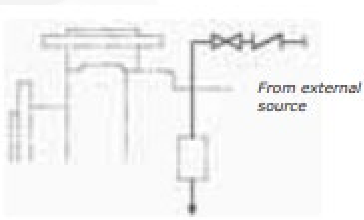
Plan 61
Tapped connections for buyer's use. Note 3 applies when the buyer is to supply fluid (steam, gas, water, etc.) to an auxiliary sealing device (single or double arrangement).



Plan 21
Recirculation from pump case through orifice and heat exchanger to seal.



Plan 51
Dead-ended blanket (usually methanol - see note 3); usually used with auxiliary sealing device (single or double seal arrangement).



Plan 62
External fluid quench (steam, gas, water, etc. see note 3); usually used with throttle bushing or auxiliary sealing device (single or double arrangement).

Note:

1) These plans signify frequently used systems. Other variations and systems are offered and should be specified in detail by the purchaser and mutually agreed upon by the buyer and the vendor.

2) When supplemental seal fluid is provided, the buyer will specify the fluid characteristics. The vendor shall specify the pressure, volume, and temperature required, where these are factors.

Legenda Simboli:

Heat exchanger

Pressure gauge

Temperature gauge

Pressure switch

Cyclone separator

Flow indicator

Filtro a Y

Flow regulating valve

Block valve

Check valve

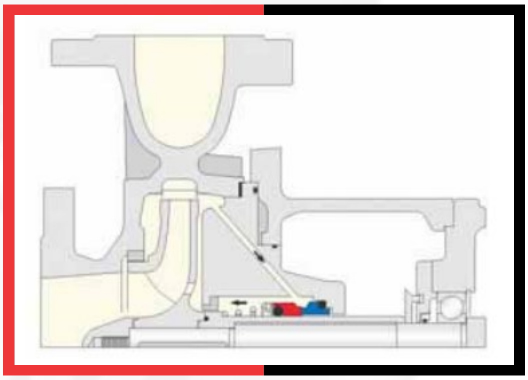
Orifice

Clean, Not Dangerous, Neutral, Not Flammable Products

Example: Vegetal oil, Water, Glycol

API Plan 11 or 01 is the suggested lay-out, in order to disintegrate the heating produced by the seal rings and to carry out a suitable venting of the stuffing box.

In the case of a conical stuffing box also **API Plan 02** can be used.

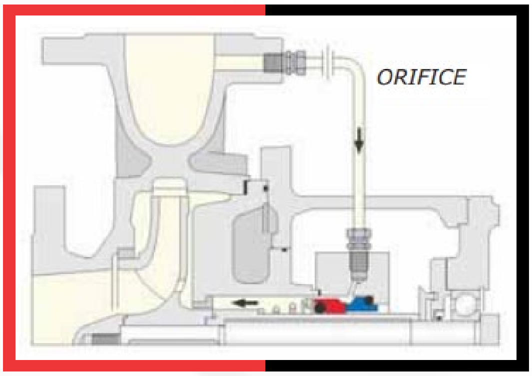


API Plan 01

Fluids Crystallizing When In Interaction With Atmosphere

Example: Phosphates, sulphates, saline solutions, alkaline solutions.

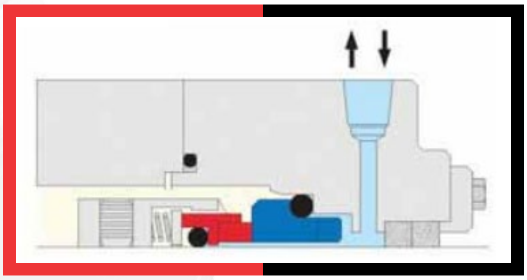
A single configuration is suggested, combined with **API Plan 11 or 01** in order to disintegrate the heating produced by the seal rings and to carry out a suitable venting of the stuffing box.



API Plan 11

Employing a surplus API Plan 62 with water or steam at low pressure (max 0.3 barg), an effective removal of crystallization deposits can be assured, preventing locking of the rotary ring (see also degree of freedom at pag.4).

PLAN 62:
It consists in washing the seal on the atmospheric side with a suitable fluid, an auxiliary seal (packing, lip seal, floating bush) to avoid the leakage in the atmosphere.



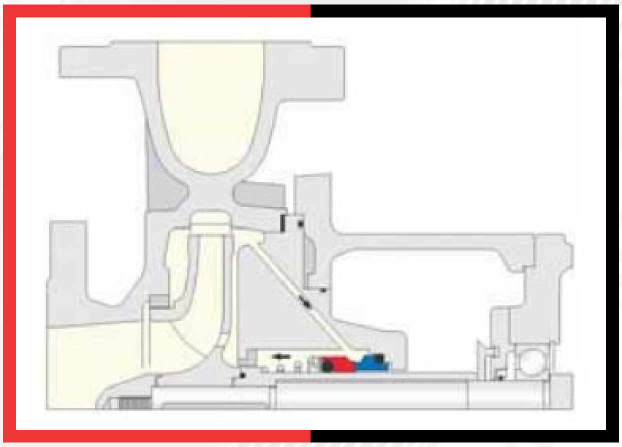
API Plan 62

PLAN 61:
The same assembly for plan 62 is closed and offered for the end-user.

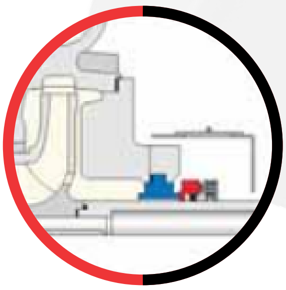
Acid products

A single internal seal is suggested, **API Plan 11/61** or **01/61** is in theory the suitable connection.

In case of conical stuffing boxes use **API Plan 02/61.**

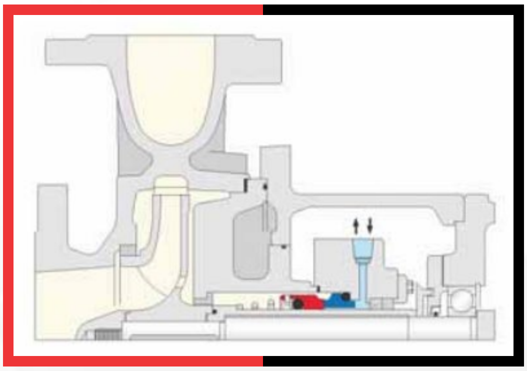


API Plan 02



With these products an external seal is appropriate too; in this case protection should be provided to avoid possible spraying of product.

Hot Liquids


API Plan 02/62

Example: Heavy hydrocarbons, diathermic oils Temperatures over 200°C up to 400°C are distinctive applications in refinery plants or pumps for diathermic oil.

It is significant to assess the efficient operating temperature in the stuffing box
.
Many pumps come with a cooling system which decreases the temperature in the stuffing box, in order to evade very costly configurations of the mechanical seals.

The range of the materials and the configuration will primarily depend on the operating temperature.

The suggested configuration is a single internal seal, with **API Plan 02**.

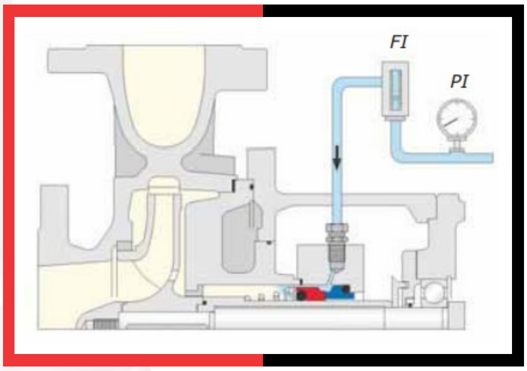
A comprehensive venting of the stuffing box is necessary and then the installation of a suitable system has to be verified.

Employing an additional **API Plan 62** with water or steam at low pressure (max 0.3 barg), an effective removal of crystallization deposits can be assured, preventing locking of the rotary ring (see also degree of freedom at pag.4).

For a more precise analysis, make reference to API 682 specifications.

Aqueous Solutions Prone to Solidify or Produce Sediments

Example: paper, pulp, lime, slurry



API Plan 32

A single internal seal suggested, installed with the **API Plan 32** flushing system in order to supply a hygienic fluid, compatible with the process fluid for a good lubrication and cooling of the seal faces (auxiliary fluid should have a pressure higher than the process fluid).

A throat bushing, correctly dimensioned, offers a barrier flushing equivalent to a pressurised system.

A valid alternative, if solid particles are in low percentage, is an **API Plan 02/62** in a conical stuffing box.

A quench with water delivers an efficient washing of the seal rings and cools them as well.

Toxic, Poisonous or Highly Viscous Fluids

AExample: Solvent based resins, inks, creams, glues, lattice

The back-to-back configuration is suggested with a pressurised **API Plan 53.**

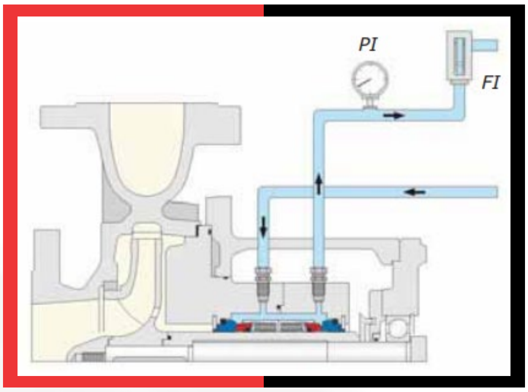
The lubrication of the seal faces is provided by the auxiliary fluid. Appropriate instruments (i.e. level switch) installed on the pressurisation system can identify an eventual leakage.

Abrasive Fluids

Example: slurries, Water mixed with sand.

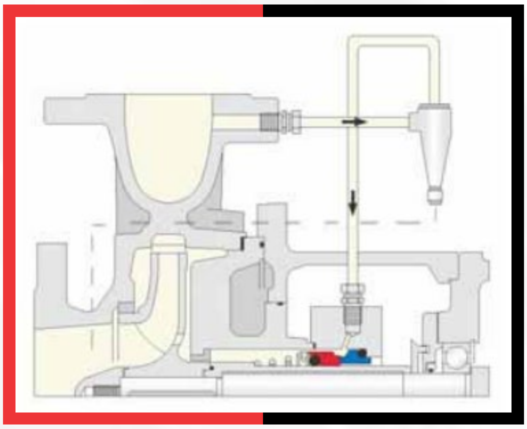
A dual configuration is suggested with a pressurised **API Plan 54.**

The finest lay-out is a stationary seal with the product outside the seal rings.



API Plan 54

Less used but occasionally suitable is a single inner seal with **API Plan 31**, where the pumped liquid is passed through a cyclone separator and then injected into the stuffing box.



API Plan 31

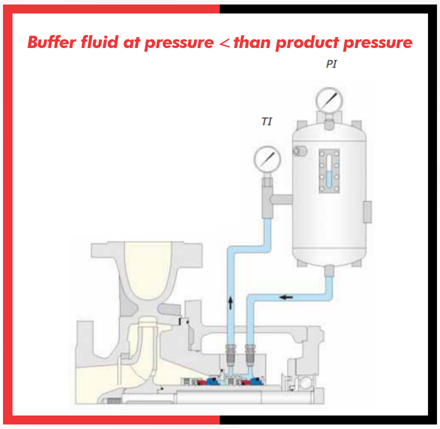
Flammable Fluids

Example: Hydrocarbons, solvents

A tandem configuration is suggested with an unpressurised **API Plan 52.**

An auxiliary tank, comprehensive with level and / or pressure switch can offer an efficient flushing of the seal and avoid emissions into the atmosphere.

For a more precise analysis make reference to API 682 specifications.



API Plan 52

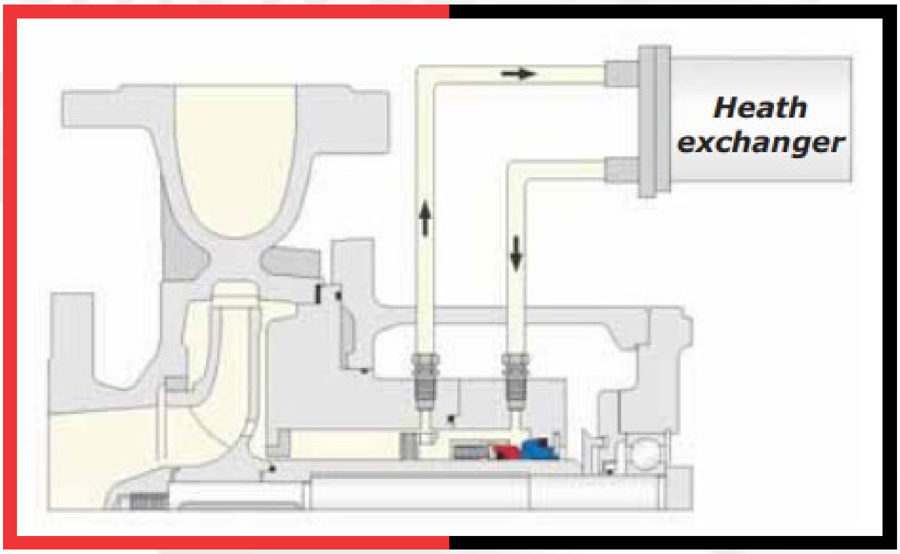
Hot Water

Example: boiled feed water, condensate recovery

These types of applications are more problematic than expected at a primary evaluation. Viscosity of water constantly decreases at high temperatures, supplying a poor lubrication of seal faces.

At temperatures over 90°C the constancy of the lubrication film is so reduced that a progressive and fast wearing of seal faces can be anticipated.

The suggested choice is a single internal seal with **API plan 23.**



API Plan 23

The hot water is cooled while it follows the pathway of a closed loop around a heat exchanger, all with the help of an appropriate pumping device, usually a pumping ring. With proper dimensioning of the flushing system, operating temperatures lower than 90°C can be obtained, assuring good performance of the mechanical seal.

A specific datasheet is available to specify all parameters required for proper selection.

THE TYPES

Agitator Mechanical Seals

Agitator Mechanical Seals are designed for handling extreme hard conditions like products producing contaminated vapours during the reaction procedure. In Agitator Mechanical Seals, the bearing is installed precisely close to the seal. This type of assembly efficiently halts the shaft whip for smooth operation, allowing greater seal life. The cooling jacket, also a standard feature, helps to maintain a cool environment around the seal. Large clearance between the rotating shaft/sleeve and mating ring enables greater deflection of the shaft, invariably related to top-entry agitators.

Main advantages: Agitator Mechanical Seals facilitates independent rotation in all directions

Cartridge Mechanical Seals

Cartridge Mechanical Seal is a self-sufficient unit comprising mechanical seals in a seal chamber in any combination which can be used as a pressure barrier fluid or a non-pressurised buffer liquid. Cartridge Mechanical Seals arrangements are an excellent upgrade to single cartridge seals when it is vital the media does not leak into the atmosphere.

Main advantages: low cost, robust construction suitable to withstand sticking of seal faces,

Metal Bellow Mechanical Seals

Metal Bellow Mechanical Seals are generally used in the high temperature and extremely corrosive media and appropriate for high start-up torque since the bellow unit is independent of torque transmission. The unique feature of welded metal bellow mechanical seals is that there are no dynamic "0" rings and therefore it will never hang-up or damage the mechanical sleeve seals and shaft.

Main advantages: suitability of operation with extremely viscid fluids or with liquids containing solid particles.

Reactor Mechanical Seals

Reactor Mechanical Seals comprises a reactor that works to seal a moving or reciprocating part. It contains stationary and rotating seal faces that are made from one hard and one softer material. The Reactor Mechanical Seals act as a stopper from process to atmosphere and seal leaks on parts of Reactors, mixers, and vessels.

Main advantages: designed to prevent leakage. This is critical for reactor applications where the materials being processed can be dangerous, toxic or flammable.

Rubber Bellow Mechanical Seals

Rubber Bellow Mechanical Seals contain an open-coil helical spring that generally works towards offering resistance to a compressive force, which is applied axially. The Helical Coil Spring can be coiled as conical, concave, convex, or even in different combinations, but these springs are usually coiled at a constant diameter. The compression helical coil springs are mainly used to resist the force and even store the energy, depending upon the application.

Main advantages: easy to install - there are seldom any measurements to make or set screws to tighten to the shaft.

Spring Mechanical Seals

Spring Mechanical Seals are rugged in design and find their wide application for different purposes. It is used to handle corrosive chemicals, chemical process pumps, water, sewage & submersible pumps as well as light and general chemicals.

Main advantages: Spring mechanical seals are designed to minimize leakage, which is critical in applications where the sealed medium must be contained within the equipment.

Teflon Bellow Mechanical Seals

Teflon Bellow Mechanical Seal is a simple kind of seal that works in a technique of containing fluid present in a vessel, which can be typically a pump or a mixer. The Teflon Bellow Mechanical Seal is designed for handling extremely corrosive chemicals including caustic, concentrated acids, strong oxidizing, and reducing agents making the vessel leak-free. The PTFE bellow seal or Teflon bellow seal are simple to install and remove. The Teflon Bellow Mechanical Seals are mounted outside with a simple connection procedure and used in different applications especially for corrosive media sealing.

Main advantages: good tightness, stable performance, less leakage, low friction power consumption, long service cycle

Bi-directional seals

By all means the most popular type of seal.

A suitable seal body, carrying springs, secondary seal and rotary ring can be installed on the shaft and locked by means of set screws.

Main advantages: low cost, robust construction suitable to withstand sticking of seal faces, cavitation and misalignments.

Engineered Balanced Seal

Engineered Balanced Seal is a compact designed product used in all kinds of centrifugal pumps. Due to the multi spring construction, the number of springs in its border, the seal is named so. Because of uneven spread of spring compression on the mechanical seal's face, the load acts throughout the seal's dimensions and leads to very less wear and helps for higher life. Engineered Balanced Seal is used at places where high pressure sealing is required.

Main advantages: reduces the seal ring area (Ah) on which the hydraulic pressure of the liquid in the pump (Pp) acts.

Reverse Balanced Mechanical Seal

Reverse Balanced Mechanical Seal is designed to handle abrasive or corrosive media. Reverse Balanced Mechanical Seal is compact in design and neither axial or radial extra space is important for its installation and is used to handle corrosive chemicals, hydrocarbons, and general & light chemicals.

Main advantages: eliminate movement of elastomer hence reduce fretting effect on shaft greatly.

Single Acting Balanced Seal

Single Acting Balanced Seal has standard design independent of the rotation's direction, presence of single seal, has no shaft fretting and springs are placed outside the media. The unbalanced and balanced version of single acting seals are achieved by altering the carbon face that is assembled via circlip provided on it. Single Acting Balanced Seal can be used to handle different media and is suitable for crystallizing solutions, slurries, and sludge.

Main advantages: extremely effective in restricting the flow through the gap, which remains undetected when it comes to liquid or gas.

THE MATERIALS

Seal Face Materials

A decent sealing function needs perfect planarity of the seal faces, even under reliable gradients of temperature.

Moreover, the high relative speed and pressure at which seal faces have to function need an optimised lubrication and cooling.

The arrangement of the above parameters brings to the selection of suitable materials suitably designed and machined **(lapping).**

The selection of a proper seal face material is the first and most significant step for long wear and favourable results.

The most trustworthy combination of materials is that of one seal face in graphite and the counter face in silicon carbide, tungsten carbide or ceramic.

The main benefit of a graphite seal ring is its capability to effortlessly complement the counter face after a short time of operation.

When the liquid to be sealed is abrasive it is suggested to install two hard faces such as silicon carbide or tungsten carbide.

In this latter case specific care should be taken to avoid the possibility of transitory dry running which can lead to permanent damage of the seal.

Graphite

The self-lubricating properties of this material make it the primary choice as a seal face. Many ranges are available on the market, all of them produced by means of the sintering of carbon and graphite powder, bonded with suitable resins or metals

.

Bonding is necessary to seal the micro porosity produced by the high temperature (over 1000°C) which is necessary for the sintering procedure.

The more common types of graphite are:
Resin saturated graphite, with high chemical resistance and then appropriate for most chemicalapplications.

Metal saturated graphite (typically antimony or bronze), appropriate for higher operating temperatures and pressures.

Electro graphite, sintered at a very high temperature (2500°C). Appropriate for high temperatures and very aggressive fluids.

Main advantages of graphite:
capability to wear off minor initial defects of planarity in a short time. Good self-lubricating properties which permit transitory dry running.

PTFE

This material has properties similar to graphite, except for the mechanical strength which is comparatively low. Numerous bonding materials are used to increase the wearing resistance; glass is the most frequently used.

PTFE is in practice entirely inert and then appropriate for any kind of aggressive fluid when mating a silicon carbide or ceramic counter face. Not appropriate for mating with Chromium steel and Stellite.

Stellite

This alloy is composed of Tungsten, Cobalt and Chromium which give high superficial hardness.

Usually employed as coating on stainless steel rings to deliver a hard sliding surface. Poor capability to take thermal dilatation.

Chromium Steel

It is a stainless steel with a great percentage of Chromium, which gives an outstanding combination of rigidity and resistance to corrosion. Seal rings made of this material do not have the drawbacks of Stellite in respect to thermal dilatation. Chromium steel is commonly combined with graphite counter faces.

Ceramic

This substance is an Aluminium Oxide (Al_2O_3) and it is produced by sinterization of powders and machined by grounding.

Different categories are available on the market, recognized by the level of purity of the material.

Ashish Seals is using 99.7% pure Al_2O_3, with high chemical and wearing resistance. Ceramic has great rigidity, so appropriate for abrasive products. Main drawback is a poor resistance to thermal shocks.

Generally it is mated with counter faces in resin saturated graphite or reinforced PTFE.

Tungsten Carbide

This material has great mechanical resistance, so it is appropriate to function with abrasive fluids and has a limited but extremely useful capability to endure short transitory conditions of poor lubrication. The alloy can be made of Tungsten bonded with Cobalt or Nickel. The bonding materials give diverse properties.

Cobalt offers high mechanical strength and it is generally used for machining tools. Nickel gives a slightly lower mechanical resistance but it increases the chemical resistance and it is preferred for the production of seal faces.

The fabrication is obtained by sinterization in vacuum atmosphere, then machining by grounding. A very small level of porosity makes it a perfect material for seal faces. The typical mating material is resin or antimony saturated graphite but, when operating with extremely abrasive products, it is common practice to install a counter face in Tungsten Carbide or Silicon Carbide, taking care to always deliver efficient lubrication.

Silicon Carbide

This material is manufactured by the sinterization of powders of silicon carbide, and, in some situations, with the addition of pure Silicon.

Depending on the process of production two different types of Silicon carbide are available on the market.

Sintered alpha (Sic)
It does not comprehend free Silicon and it shows a great chemical resistance, even against caustic solutions and oxidation acids.

Reaction bonded (SiSiC)
It comprehends free Silicon.

The mechanical properties are better than the ones of Sic but the chemical resistance is lower. Friction coefficient is the finest among hard materials. Not suggested for alkaline solutions where Sic is the major selection and Tungsten Carbide the alternative material. Silicon carbide generally mates resin saturated with graphite or antimony (at high temperature). The comparatively low friction coefficient makes it appropriate for mating with parent material.

TAB. 1

Materials	Constructive Shape	Ashish Seals Code
Metals		
AISI 316 + stellite	Massive	S
Cast chrome - molybdenum steel	Massive	Y1
Carbides		
Silicon carbide infiltrated	Massive	U41
Silicon carbide infiltrated	Incert	U42
Silicon carbide sinterizzed	Massive	U31
Silicon carbide sinterizzed	Incert	U32
Tungsten carbide - nickel binder	Massive	K21
Tungsten carbide - nickel binder	Incert	K22
Metallic Oxides		
Ceramic	Massive	C
Graphites		
Graphite antimony impregnated	Massive	Z11
Graphite antimony impregnated	Incert	Z12
Graphite resins impregnated	Massive	Z31
Graphite resins impregnated	Incert	Z32
Graphite resins impregnated - dry-running	Massive	ZD71
Graphite resins impregnated - dry-running	Incert	ZD72
Graphite resins impregnated - dry-running - F.D.A. Approved	Massive	ZD51
Graphite - food Industrie - F.D.A. approved	Massive	Z51
Graphite - food Industrie - F.D.A. approved	Incert	Z52
Non Metals		
PTFE + glass	Massive	T1
PTFE + glass	Massive	T11
PTFE + glass	Incert	T12

TAB. 2

Material	Graphite	PTFE	Stellite	Ceramic	Tungsten Carbide	Silicon Carbide SIC	Silicon Carbide SI-SIC	Note
Lubricating Properties	Good	Good	Poor	Poor	-	-	-	
Chemical Resistence	Good (1)	Very Good	Sufficient	Very Good (2)	Limited	Very Good	Good (2)	1) Some oxydating products can generate unpredictable chemical reactions 2) Unsuitable for basic environments (caustic)
Resistence to high temperature	Good (1)	Poor (2)	Good	Good if Constant (3)	Good	Very Good	Very Good	1) Up to 180* C Resin impregnated. Up to 350* C Metal impregnated. Up to 450* C Electrographite. 2) Upto 250* C in static applications. Up to 80* C when used as seal face 3) Fragile with thermal shock.
Wear resistence (suitable to operate with abrasive or crystallizing products)	Poor	Poor	Limited	Good	Very Good	Very Good	Very Good	
Deformation at high pressure	Yes	Yes	No	No	No	No	No	At high pressure monolithic seal rings are recommended
suitable for food & pharma ceutical applications	No (1)	SI Se FDA approved		Yes		Yes	Yes	1) In some cases there is not an actual problem of contamination but release of graphite powder can change the colour of the product
Thermal conductivity	Poor	Very Poor	Poor	Poor	High	High	High	

TAB. 3

MATERIAL	RESIN IMPREGNATE D GRAPHITE	ANTIMONY IMPREGNATE D GRAPHITE	PTFE 25% GLASS REINFORCED	STELLITE (GRADE 1)	CERAMIC A12 O2 99.5%	TUNG, CARB COBALT BINDER	TUNG, CARB COBALT BINDER	SILICON CARBIDE "REACTION BONDED" SISIC	SILICON CARBIDE "SINTERED ALPHA" SIC
Specfic Weight (Kg/m3)	1800	2500	2250	8690	3870	14700	14700	3100	3100
Bending Strength (N/mm3)	65	90	-	-	320	1750	1700	500	450
Tensile strength (N/mm3)	41	48	12-20	618 (UTS)	-	-	-	-	-
Thermal Condictivity (w/mk)	9	20	0.4	15	30	80	70	120	70
Hardness	90-100 SHORE A	85-95 SHORE A	70-75 SHORE D	600 HV	1800 HV	155-1600 HV	1300-1500 HV	1200-2700 HV	2400 HV
Thermal expansion coefficient (x 10x /*K)	3.0	3.5	44-92	11.3	6.9	5.1	4.8	3.4	4.0

Secondary Seal Materials

Selection of secondary seals depends on process fluid and operational temperature. Chemical incompatibility can lead to swelling of the gaskets and consequent failure of the mechanical seal.

Elastomers

Elastomers take their denomination from the tremendous elastic memory they have. This is the reason why elastomers are the main choice as secondary seals.

Their properties:

- Capacity to function in an acceptable way even when the mating surface is not precisely finished.
- Capacity to endure small misalignments between the shaft and the rotary ring.
- Capacity to engross shaft vibrations.
- Easy installation in any type of seat or shaft, even with key or sharp corners.
- The cost is mostly low, with the exception of perfluoroelastomer (Kalrez or equivalent).

Main composites are:

Nitrilic rubber

Composed of acrylonitrile polymer and butadiene
Temperature range: -40 a 100°C (120° max for a short time).
Availability: easy in all sizes
Chemical compatibility: extremely good with mineral oils. Good with greases, water and aliphatic
hydrocarbons.
Poor with aromatic hydrocarbons, concentrated acids, and ketones.

Fluoroelastomer

Composed by copolymer of hexafluoropropylene (HFP) and vinylidene fluoride (VDF or VF2).
Temperature range: - 20 a 200°C

Availability: easy in all sizes
Chemical compatibility: extremely good with mineral oils and hydrocarbons
Good with most acids
Poor with hot water and steam.
Very poor with concentrated alkaline solutions and ketones.

Ethylene Propylene

Composed of Copolymer of ethylene e propylene
Temperature range: -55 to 150°C
Availability: easy in all sizes
Chemical compatibility: extremely good with hot water, steam, acids, alkaline solutions, ketones, hydraulic fluids.
Very poor with petroleum based fluids which cause consistent swelling

Perfluoroelastomer

Temperature range: -12 to 260°C
Availability: not easy, depends on size.
Chemical compatibility: extremely good with most aggressive fluids.
Excellent resistance to high temperature.

Silicone

Temperature range: -115 to 232°C
Chemical compatibility: medium

Neoprene

Temperature range: -20° to 90°C
Chemical compatibility: Very good with Freon

Aflas

Temperature range: -10° to 200°C
Chemical compatibility: extremely good with hot water and steam.
Good with acids

Non Elastomeric Materials

For the most challenging applications elastomeric materials cannot give a suitable answer. Extremely high or very low temperatures, below 100°C and over 300°C, cannot be tolerated by any kind of elastomer. PTFE for chemical compatibility and Graf oil for high and low temperature are the standard selection in severe applications.

It is worth underlining that these materials need a more accurate and specific design.

Mating surfaces must be finished within Ra 0.4 - 0.2. No misalignments are allowable.

Graf oil can work only as a static seal.

PTFE (Polytetrafluoroethylene)

Temperature range: -180° to 250°C
Availability: easy in all sizes and shapes
Chemical compatibility: Outstanding with any kind of product. The only drawback of PTFE is a non- elastomeric behaviour which makes it inappropriate for dynamic applications. To overcome this great restriction, Ashish Seals has developed a special gasket, Fluigam, which can be employed in dynamic applications. The working principle of Fluigam is simple; since PTFE does not have good elastic properties, a spring-shaped stainless steel core is built in, lending the necessary elasticity to the gasket. Fluigam is commonly used as a dynamic gasket for a rotary ring. Another way to enhance the elasticity of PTFE is to insert an elastomeric gasket inside a PTFE gasket that is, in a more accurate way, to coat an elastomeric gasket, generally of Viton or Silicone with a PTFE layer.

FEP (Fluoruro of ethylene e propylene)

Actually, a particular material called FEP (having characteristics similar to PTFE), is used for the coating. FEP is marginally porous and this has to be deliberated during selection. Extremely aggressive products can infiltrate the coating and attack the elastomeric gasket inside. Availability of FEP coated gasket is restricted.

Graf Oil And Asbestos Free

Graf oil is commonly used for temperatures over 300°C and up to 500°C.

Since graphite has no elasticity, any dynamic application is nearly impossible.

In the past, when the choice between gasket materials was restricted, graphite wedges were used with good results but currently such an application does not make any sense.
Asbestos free gaskets are usually suitable for all static applications.

TAB. 4

Materials	Codice Ashish Seals
Elastomeri	
Etilene propilene	D
Gomma al silicone	O
Gomma al silicone rivestito FEP	O2
Gomma Nitrile	G
Neoprene N	N
Perfiuoroelastomero	G711
Perfiuoroelastomero	G741
Perfiuoroelastomero	G771
Tetrafiuoroetilene e propilene - Aflas	G4
Viton	V
Viton rivestito FEP	V2
Non Elastomeri	
ASBESTOS FREE universale	A
Grafoil	G5
PTFE	T
PTFE + molla in AISI 316	T3

Metallic Parts

Ancillary parts of a mechanical seal such as springs, body, sleeves, and flanges are, as a standard option, made of AISI 316.

For aggressive products there are valid substitutes such as Hastelloy, Titanium or Monel.

Many other less diffuse materials are offered on the market for specific applications.

TAB. 5

Materials	Ashish Seals Code
AISI 301	J
AISI 304	Q
AISI 316	E
AISI 904L	E1
Duplex (SAF 2205)	E3
Duplex (SAF 2507)	E9
Hastelloy B2	H
Hastelloy B3	H3
Hastelloy C22	I2
Hastelloy C276	I
Inconel 718	I3
Monel 400	M
PVDF	T5
Titanium	L
Hast. C (Bellow) + Carpenter 20	xE
AM350 (Bellow) + AISI 316	xG
Hast. C (Bellow) + Hast. C	xH
Hast. C (Bellow) + AISI 316	xI
AM350 (Bellow) + AISI 316 + Carpenter 42	xK
Inconel 718 HT (Bellow) + Carpenter 42 + AISI 316	xL
Carpenter 20 (Bellow) + Carpenter 20	xZ

ASHISH - SEALS INDIA™

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AN ISO 9001-2015 CERTIFIED COMPANY

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