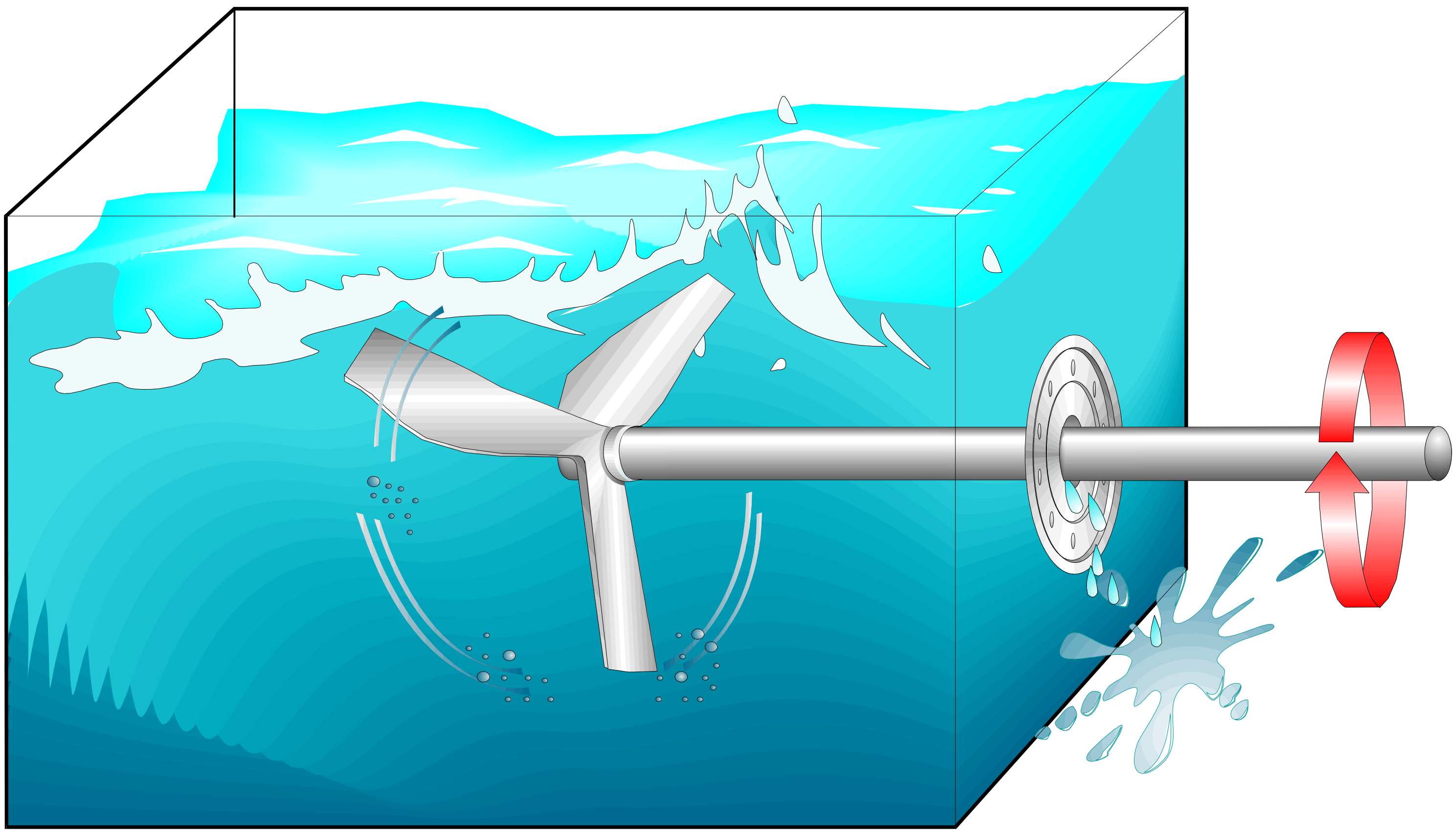
Mechanical seal for PDH Project

Seal Operation and Support system

Overview

Understanding of Mechanical Seal

Engineered Sealing

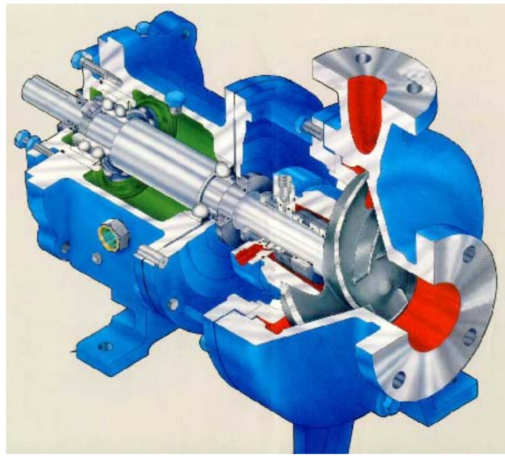


Where Mechanical Seal Use?

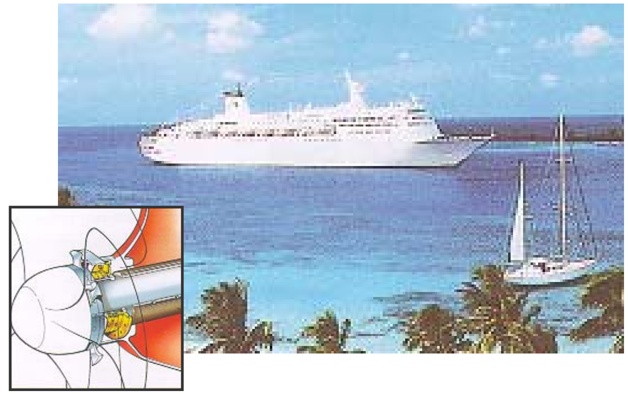
Any Rotating Equipment handling liquid or gas such as :

Mixers

Pumps

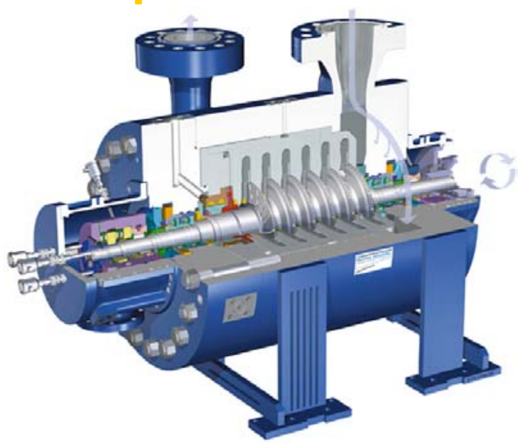


Propeller shafts



Steam turbines

Compressors



Gas turbines

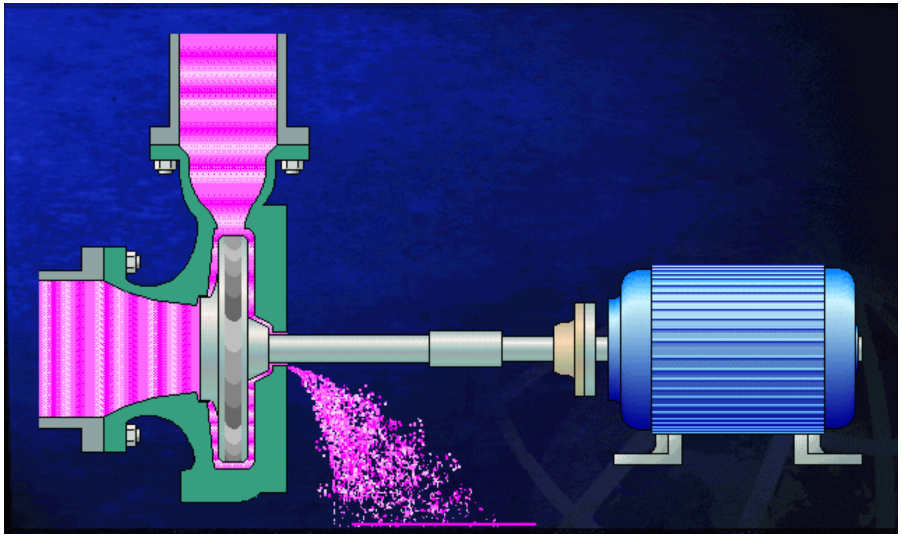
Gearbox

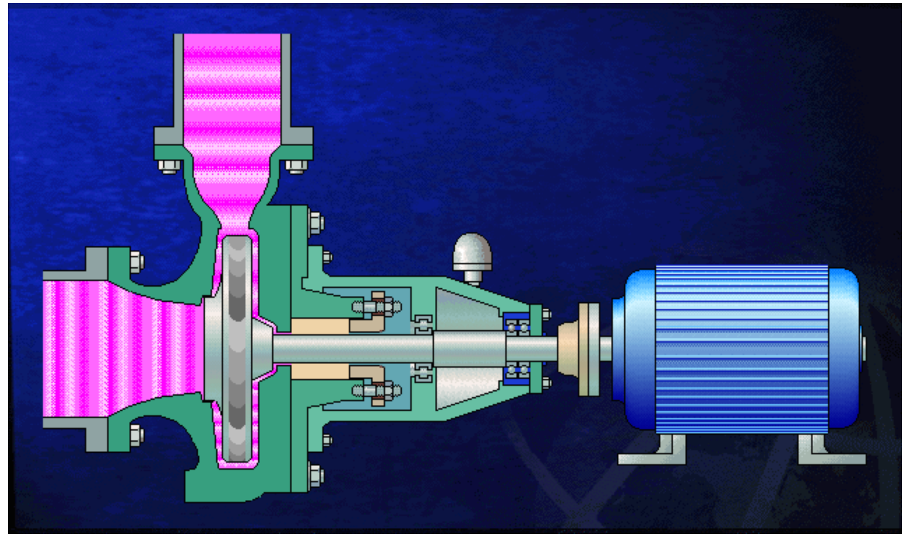
Centrifuges

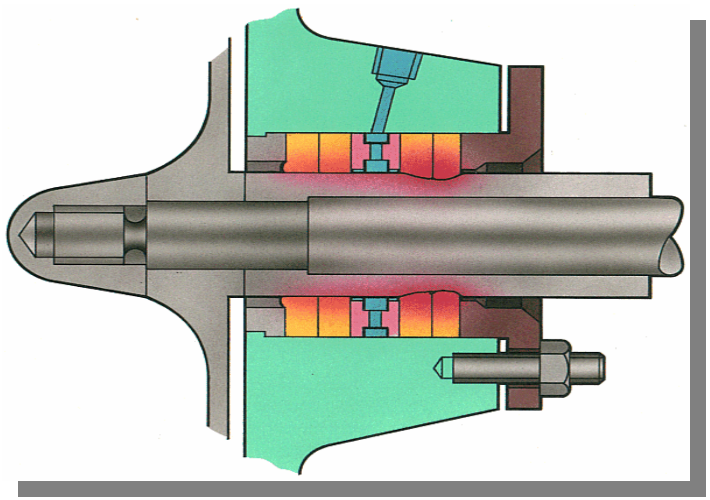
Key Equipment

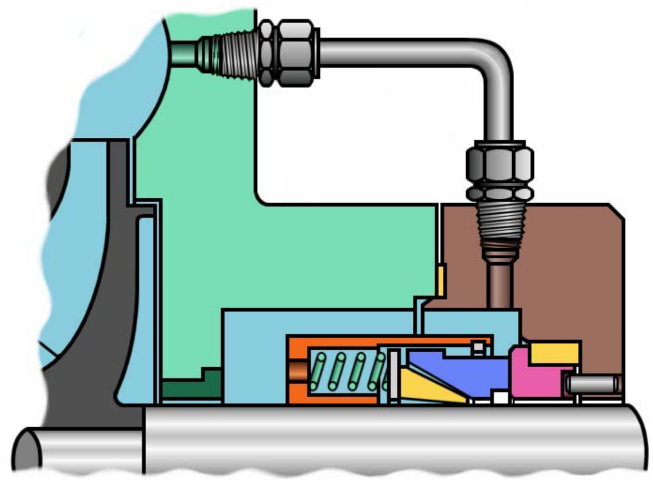
- Other equipment includes
  - air and gas compressors
  - refrigeration compressors
  - turbines (steam and water)
  - dryers
  - conveyors
  - anywhere a rotating shaft passes through a stationary housing where product has to be contained
  - agitators / mixers / reactors

How Mechanical Seal Work







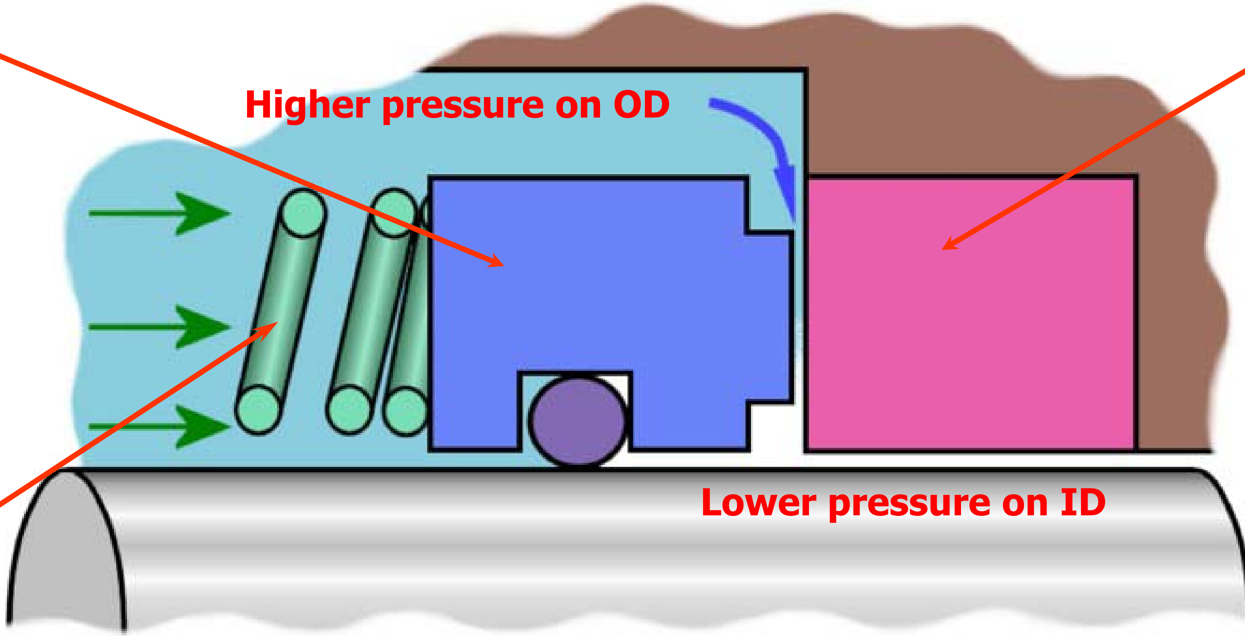


How Mechanical Seal Work

Primary Ring

Mating Ring

Springs



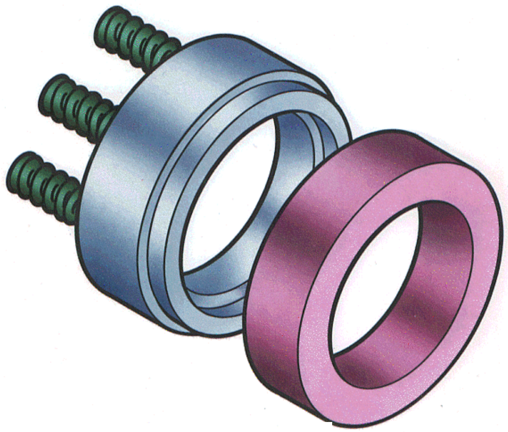
Higher pressure on outside diameter

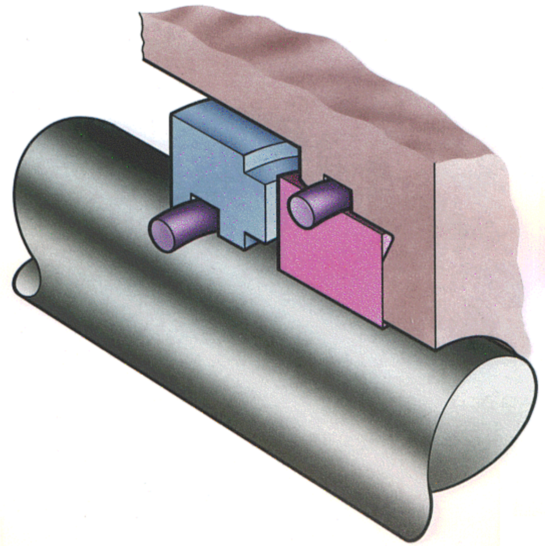
Higher pressure holds faces closed

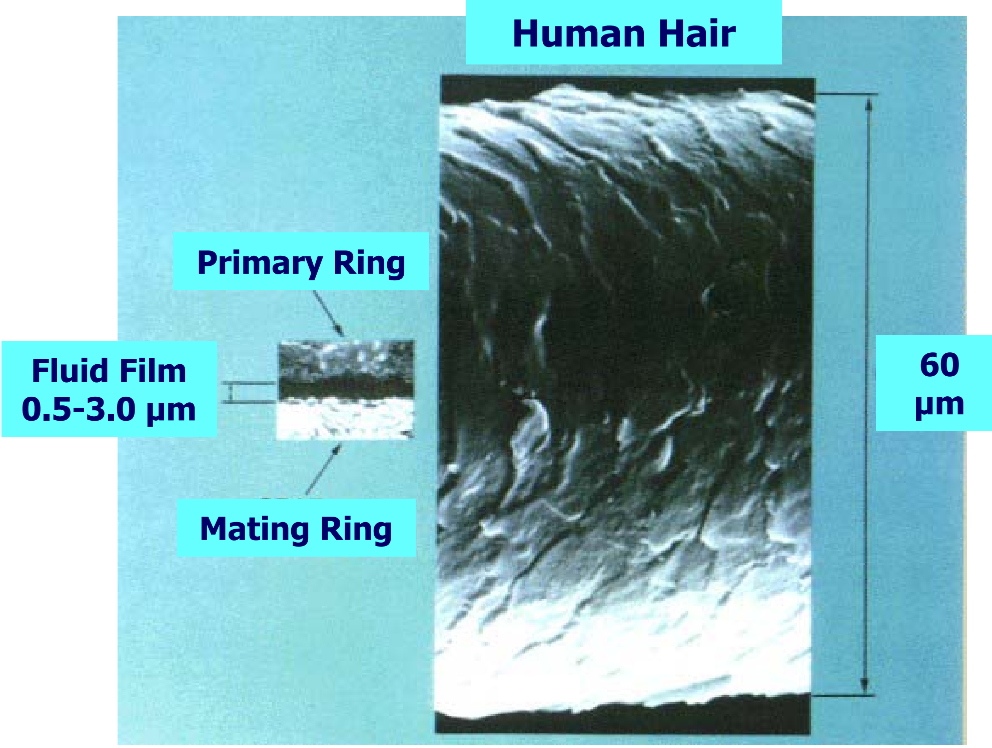
Fluid is forced between faces to lubricate

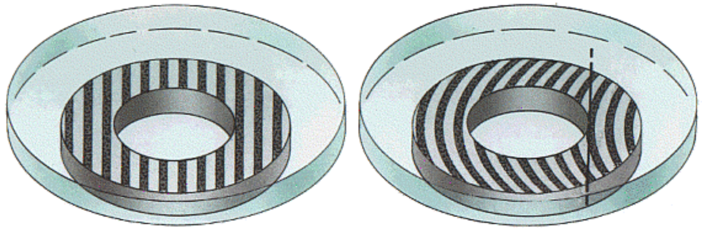
Springs keep faces closed when no pressure

How Mechanical Seal Work



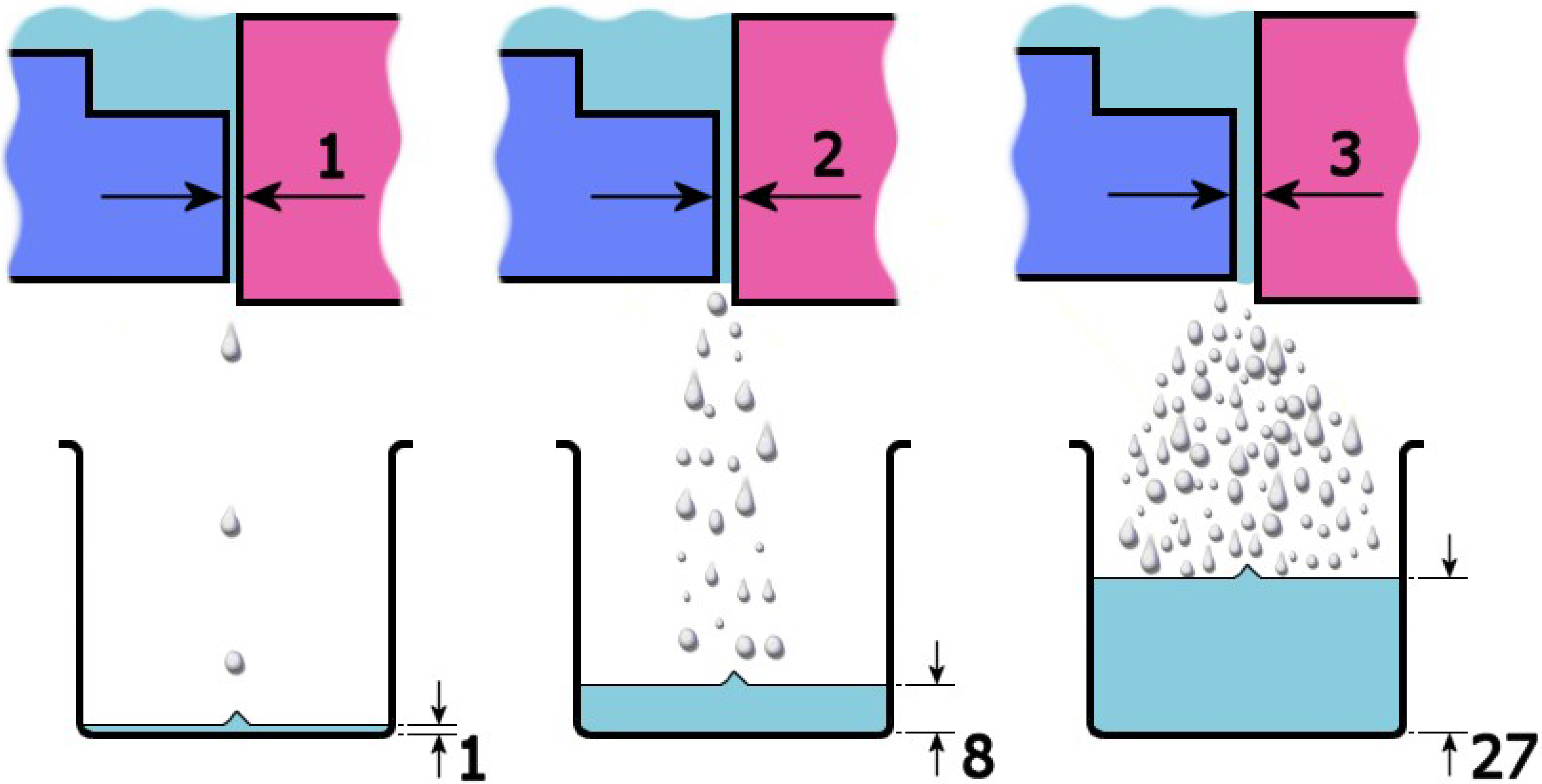




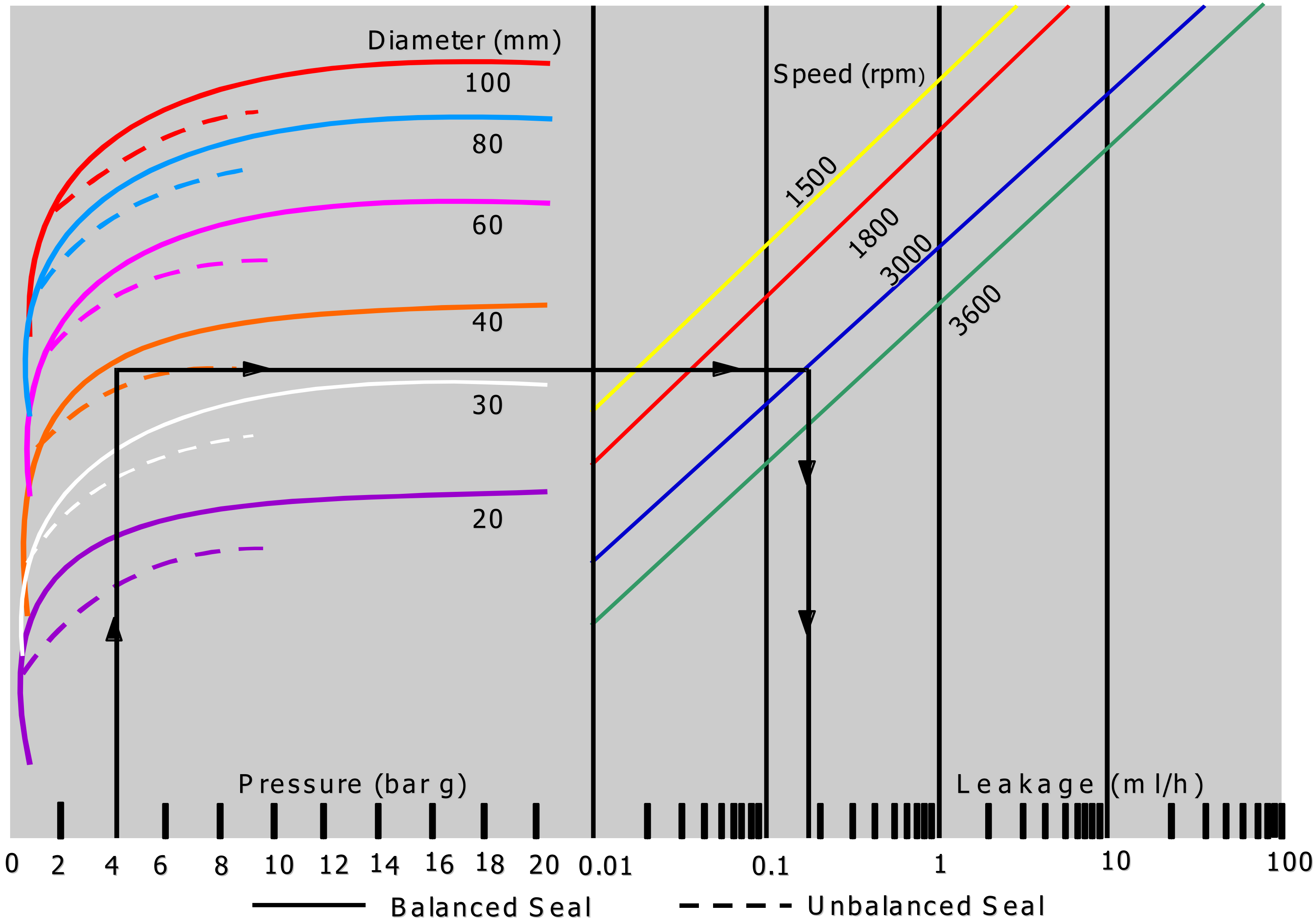


Faces lapped flat to within 1 - 3 light bands

Film thickness = leakage



Leakage - Newtonian Fluids



Summary

- **Fluid film thickness is very important**
  - too thin - wear, causing early seal failure
  - too thick - visible leakage
- **Must be:**
  - present - beware dry running
  - stable
  - clean - beware abrasive wear symptoms
  - reasonable viscosity
  - temperature controlled
  - acceptable pressure

Overview

Seal piping plan in PDH Project

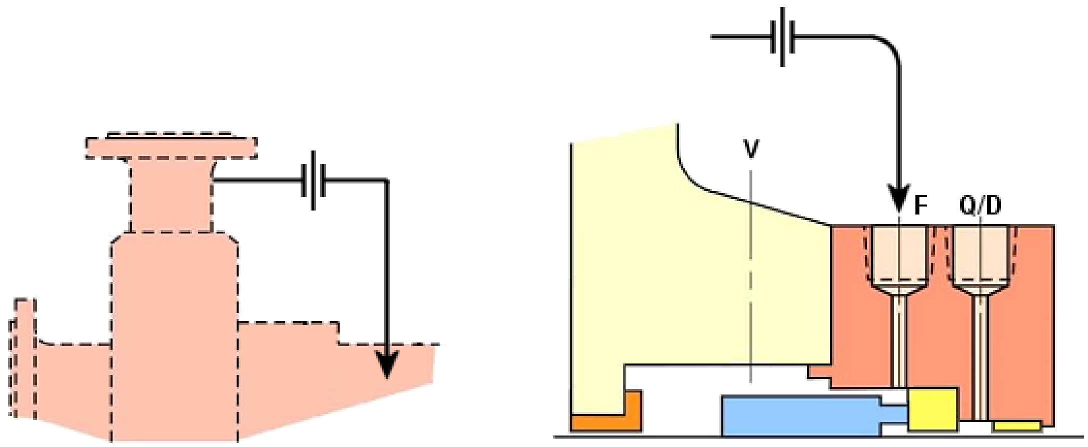
Grouped by a variety of categories

API Plan	ANSI/ASME Plan	Description
01, 02	7301, 7302	Internal systems
11, 13, 14	7311, 7313	Simple recirculation systems
12, 21, 22, 23, 31, 41	7312, 7321, 7322 7323, 7331, 7341	Recirculation systems with ancillary equipment designed to modify the product pumped
32, 62	7332, 7362	External system used to modify the sealing environment
52, 53, 54, 74	7352, 7353, 7354	External systems for dual seals
72, 75, 76	No corresponding plan	External control for containment seals used on dual seals

API Plan 11 (ANSI 7311)

API Plan 11 flushing is a recirculation of the process fluid from the equipment discharge back to the seal chamber:

Plan 11



Recirculation from pump discharge through a flow control orifice to the seal.

API Plan 11 (ANSI 7311)

Points to note:

Advantages

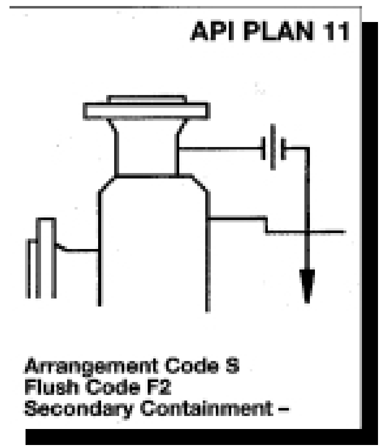
- no process contamination - the flush source is from the main process stream, and returns to the main process stream
- simplified piping - consists of only pipe or tubing (and sometimes an orifice)

Limitations

- not suitable if the process fluid is not a good face lubricant or is dirty, since the seal can become damaged or clogged

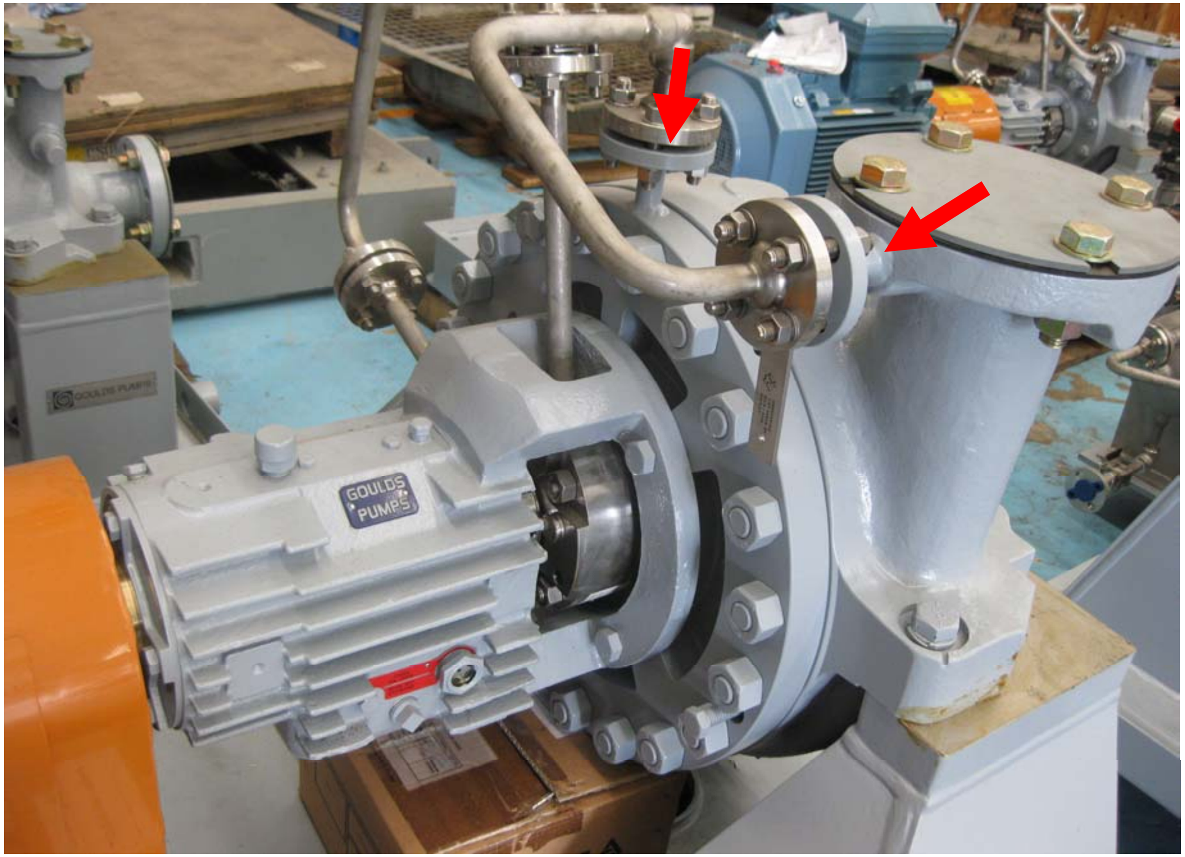
Note

API Plan 11 flushing is the most common flush plan in use today. This piping plan simply takes an appropriate amount of fluid from the discharge of the equipment (or the discharge of one of the intermediate stages if applicable), and returns it into the seal chamber to provide cooling and lubrication to the seal faces.



API Plan 11 (ANSI 7311)

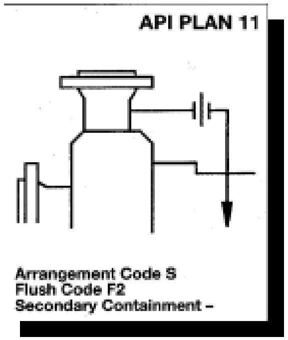
On simple single-stage (overhung) pump

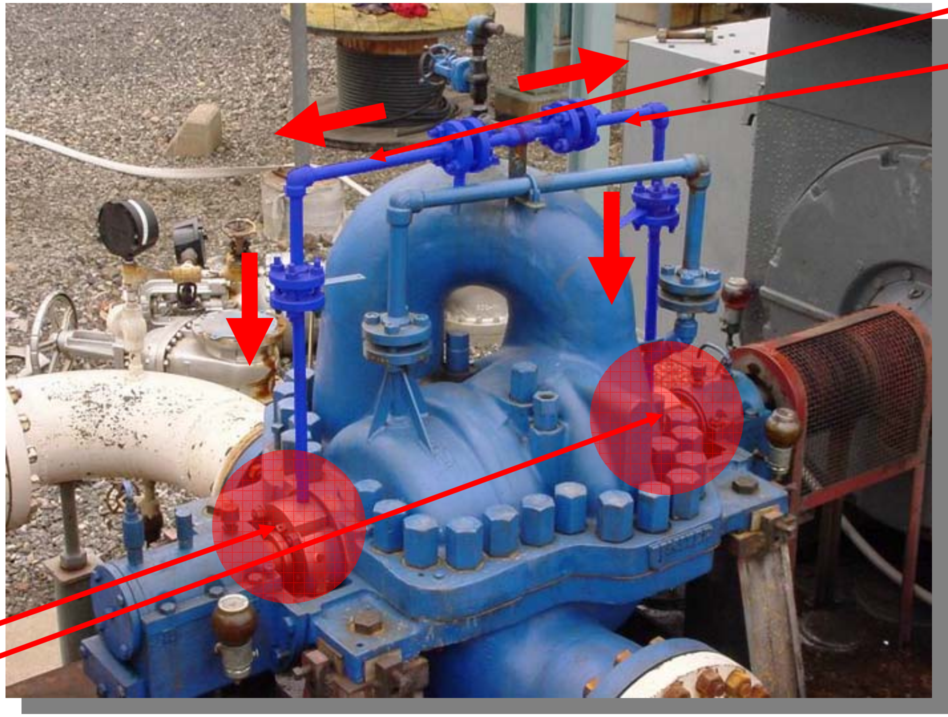


API Plan 11 recirculation line from pump discharge to the mechanical seal

API Plan 11 (ANSI 7311)

On 'between bearings' pump





API Plan 11 recirculation line to drive end and non-drive end

mechanical seals

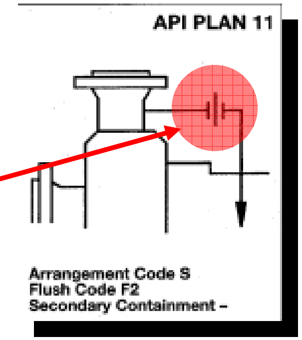
API Plan 11 (ANSI 7311)

Flush Flow Rate:

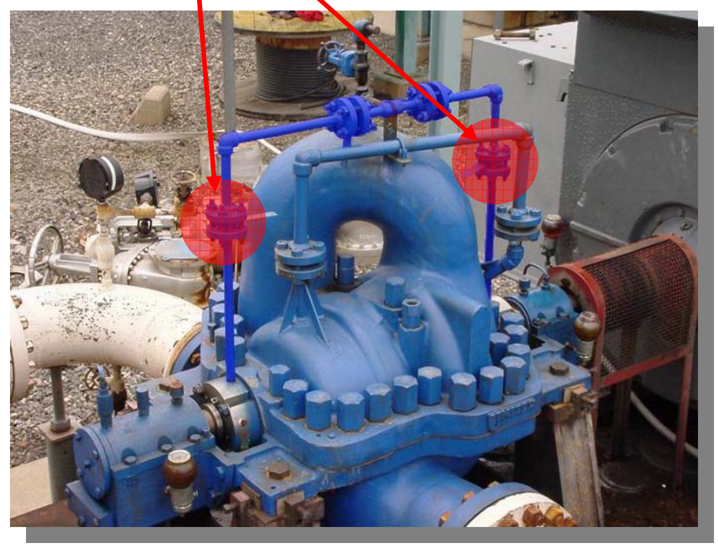
The necessary flush flow rate to the mechanical seal will be calculated based on service conditions, pump speed and seal size. The flow rate must be sufficient to maintain a thermal balance between the heat generated and the heat dissipated.

For API Plan 11 (and other external recirculation plans) the flush flow rate is usually controlled by an **orifice plate** in the flush line, simply a plate with a specified size of hole in the middle. Orifices should not be less than 1/8” (3mm) in diameter, unless the process fluid is very clean and customer approval is obtained.

Many small or low speed pumps have a low differential pressure between the discharge and the seal chamber, and in such cases no orifice is required in the piping.



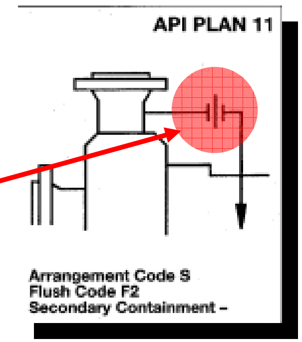
orifice plates



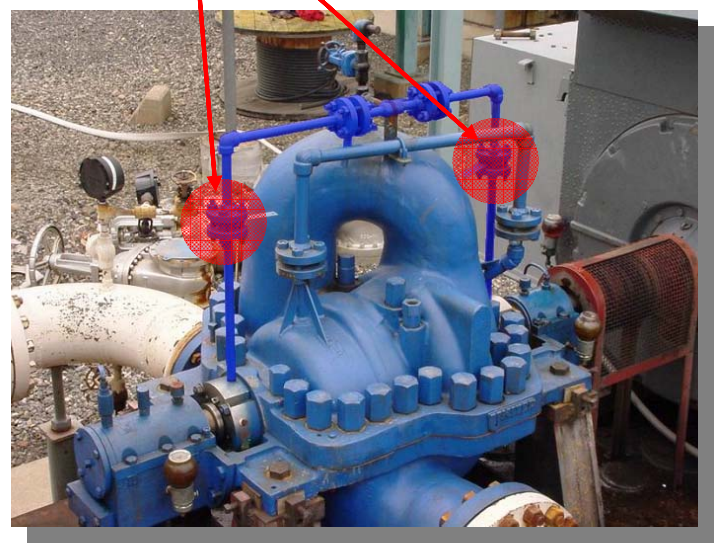
API Plan 11 (ANSI 7311)

Preventative Maintenance

- Use an orifice with a minimum 0.125” (3 mm) diameter.
- Calculate flow rates to size orifice for adequate seal chamber flow.
- Increase boiling point margin with proper orifice and throat bushing sizing.
- Flush should be directed over seal faces with piping at 12 O’clock position.
- Typical failure mode is a clogged orifice – check temperatures at pipe ends.



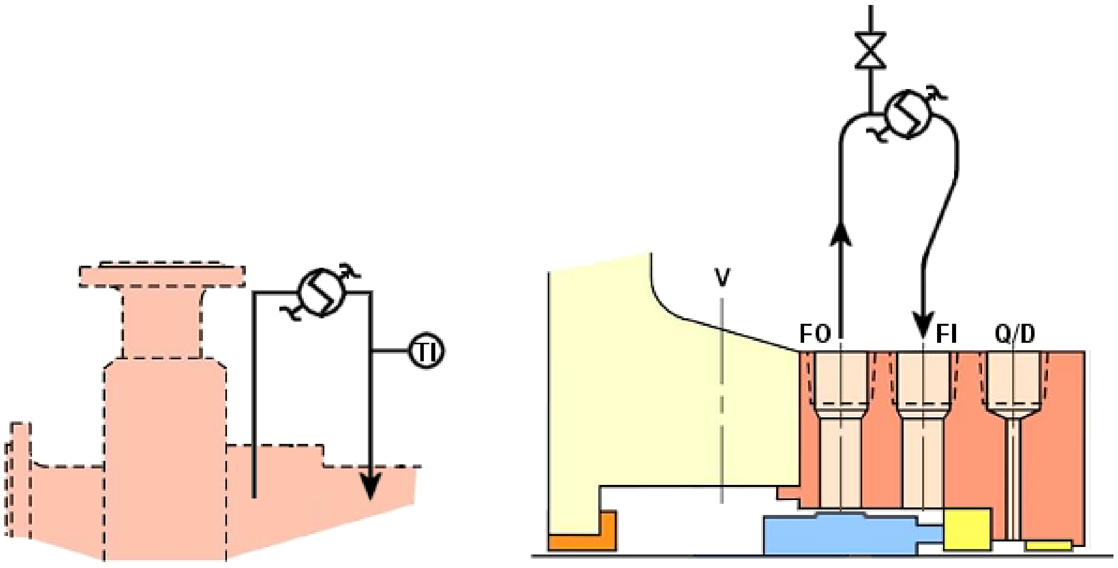
orifice plates



API Plan 23 (ANSI 7323)

API Plan 23 flushing is a recirculation from the seal chamber through a **heat exchanger** and back to the seal chamber (i.e. **closed-loop** cooling):

Plan 23



Recirculation from a pumping device in the seal chamber through a cooler and back into the seal chamber. Can be used on hot applications to minimise the heat load on the cooler by cooling only the small amount of liquid that is recirculated. The plan of choice for all hot water services.

API Plan 23 (ANSI 7323)

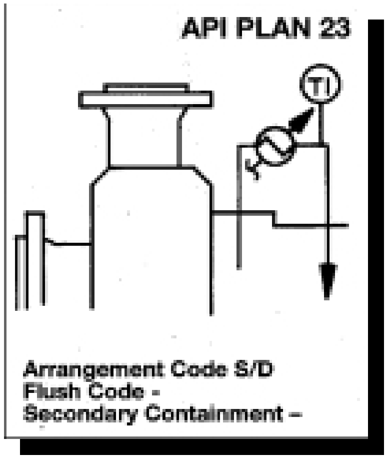
Points to note:

Advantages

- the process fluid is used to cool and lubricate the seal, and there is no dilution of the process stream
- as closed-loop cooling API Plan 23 is very efficient
- API Plan 23 can provide a cooled seal chamber through effective thermosyphon even when the pump is idle

Limitations

- the initial cost is more than API Plan 21, because API Plan 23 includes a pumping ring, throat bushing and additional piping
- API Plan 23 is not used for fluids with high freezing points, or for viscous fluids, because in such cases the pumping ring may not be able to force a circulation
- venting is essential for API Plan 23, to prevent vapour locking
- selection, design and location of the pumping ring along with the inlet and outlet ports are all crucial to the successful functioning of API Plan 23



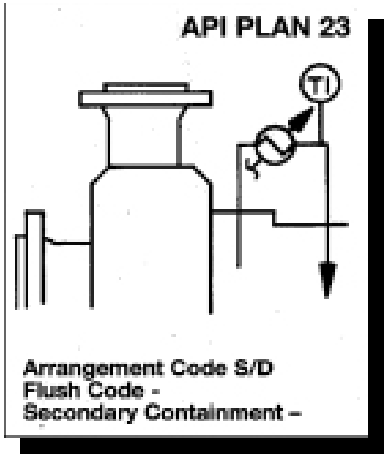
API Plan 23 (ANSI 7323)

Points to note:

API Plan 23 is a thermosyphon design - for best circulation the heat exchanger is normally located 30 to 60cm (12 to 24”) above the centre line of the rotating equipment.

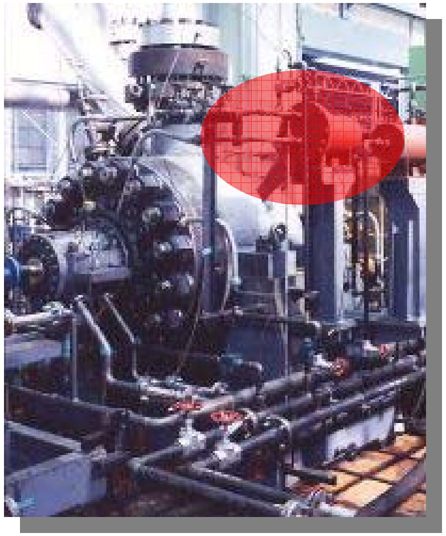
A typical application is for high temperature boiler feed pumps. Other applications include high temperature liquids close to their boiling point.

A close-fitting neck bushing is normally installed at the bottom of seal chamber, to isolate the closed-loop cooling from the main process fluid.

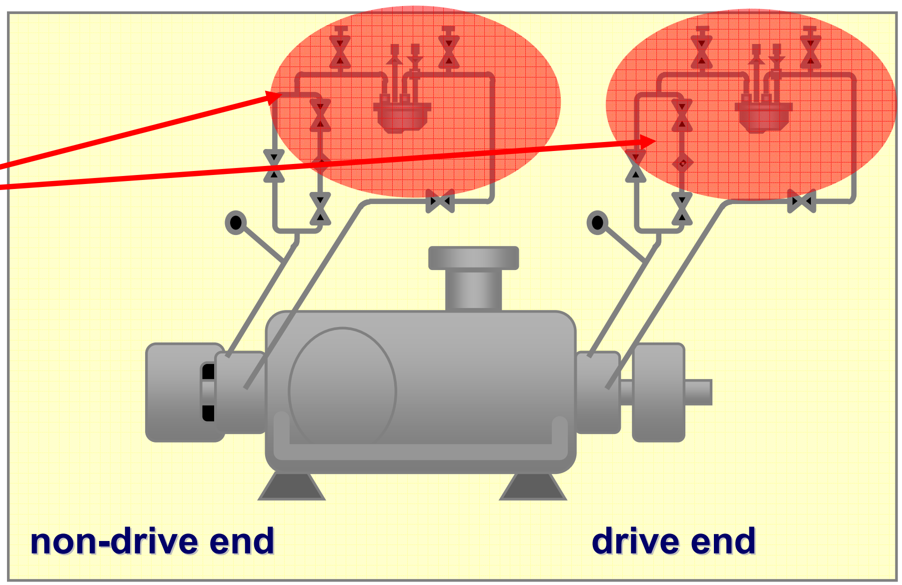


API Plan 23 (ANSI 7323)

In a power station the main boiler feed pumps are generally large multistage pumps, pumping boiler feed water at high pressures and at temperatures >200°C.
API Plan 23 is used to provide effective closed-loop cooling to the seals at both ends of the between bearings pump:



API Plan 23 closed-loop cooling circuits (from seal / through heat exchanger / back to seal)



API Plan 23 (ANSI 7323)

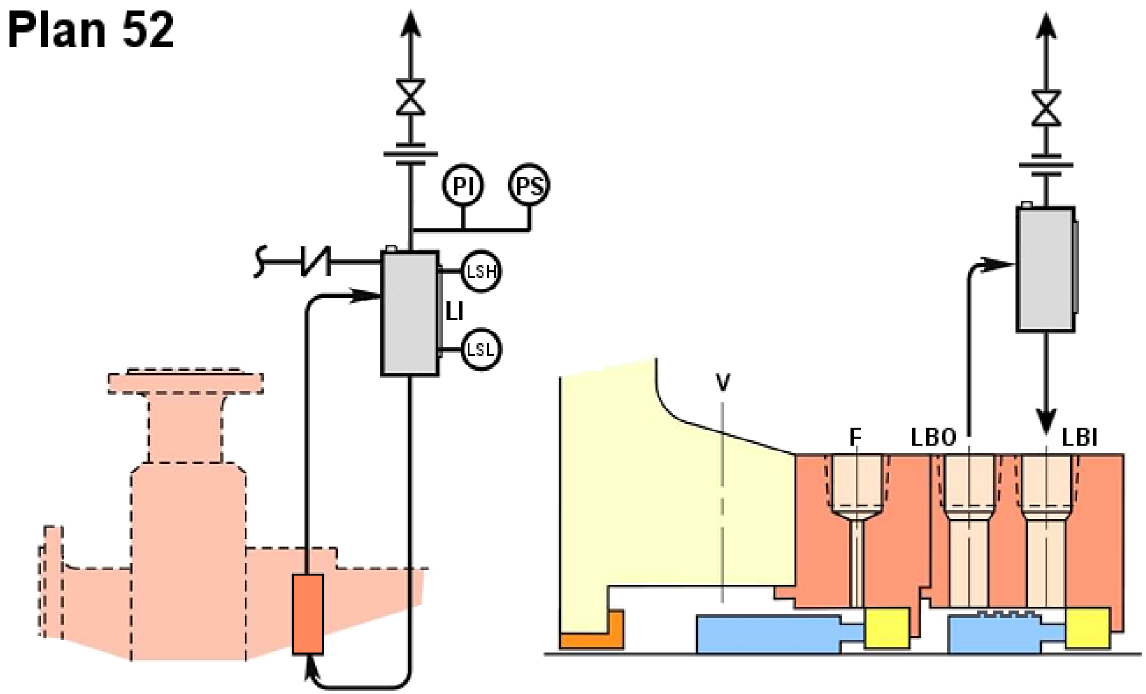
Preventative Maintenance

- Seal cooler piping must have air vents at highest elevation – vent before starting.
- Seal chamber requires close clearance throat bushing to isolate process fluid.

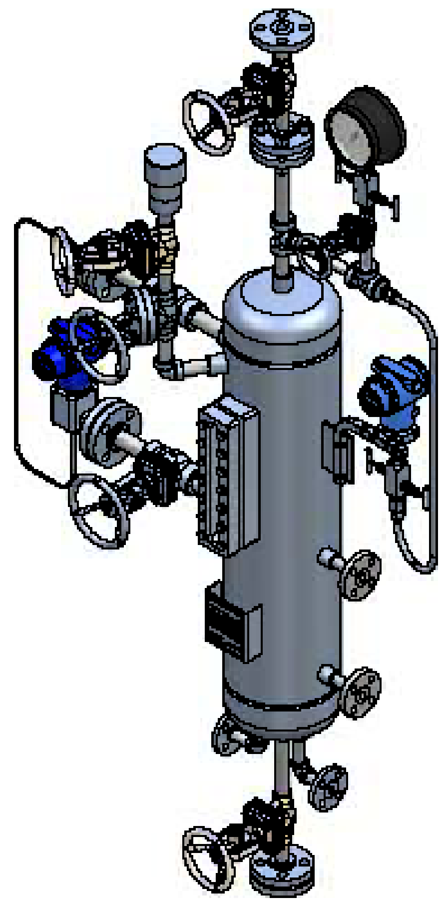
- Regularly monitor cooler inlet and outlet temperatures for signs of plugging or fouling.

API Plan 52

API Plan 52 is the circulation of an unpressurised buffer fluid from an external reservoir supply:



External reservoir providing buffer fluid between unpressurised dual seals. Circulation is maintained by an internal pumping ring. The reservoir is usually continuously vented to a safe area/system and maintained at a pressure less than that in the seal chamber.



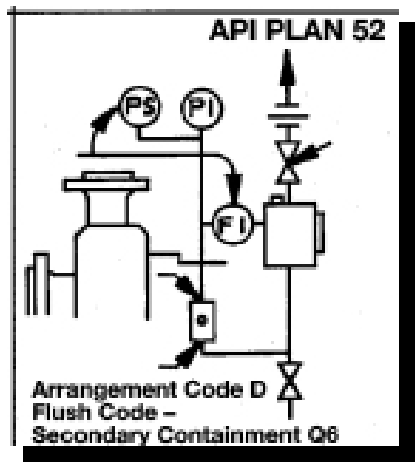
API Plan 52

Points to note:

API Plan 52 is used for dual unpressurised seals with a liquid buffer fluid.

Advantages

- in comparison to single seals, the dual unpressurised seal can reduce net leakage rates, as well as provide back-up in the event of inboard seal failure
- the buffer fluid should be unable to enter the process stream and contaminate the process fluid, because the buffer fluid system is unpressurised
- the buffer fluid can serve as a contained quench for the inboard seal

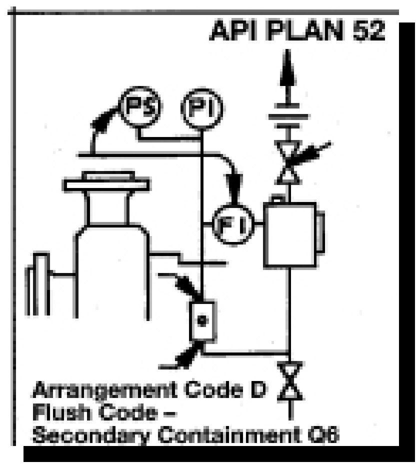


API Plan 52

Points to note:

<u>Limitations</u>

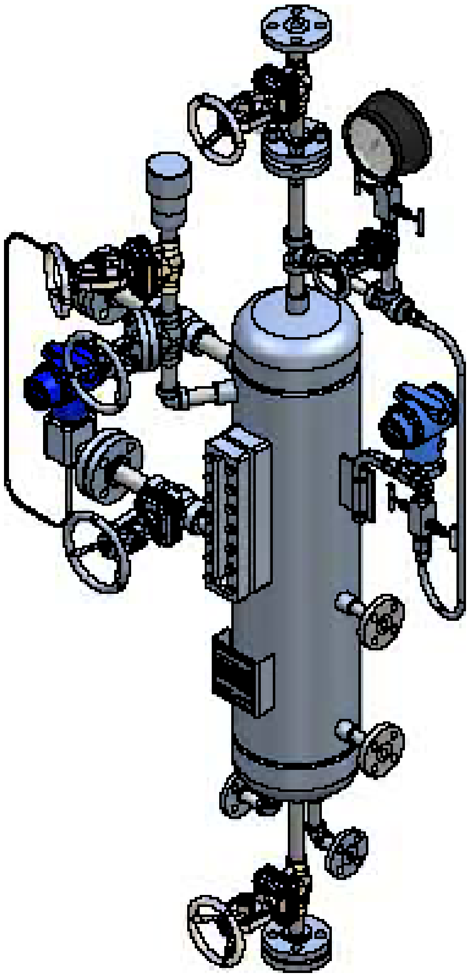
- as with any multiple seal system, Plan 52 is more complex and more expensive than a single seal and piping system
- there will always be at least minor leakage from the process seal into the buffer system, so the buffer system gradually becomes contaminated by the process fluid
- selection of a compatible buffer fluid with suitable properties is vital to the successful operation of the system
- proper venting is essential for Plan 52, to avoid vapour locking if gases collect near the pumping ring
- selection, design and location of the pumping ring along with inlet and outlet ports is crucial to the operation of the Plan 52
- the pumping ring requires energy, and so may have a small effect on total pump efficiency



API Plan 52

Preventative Maintenance

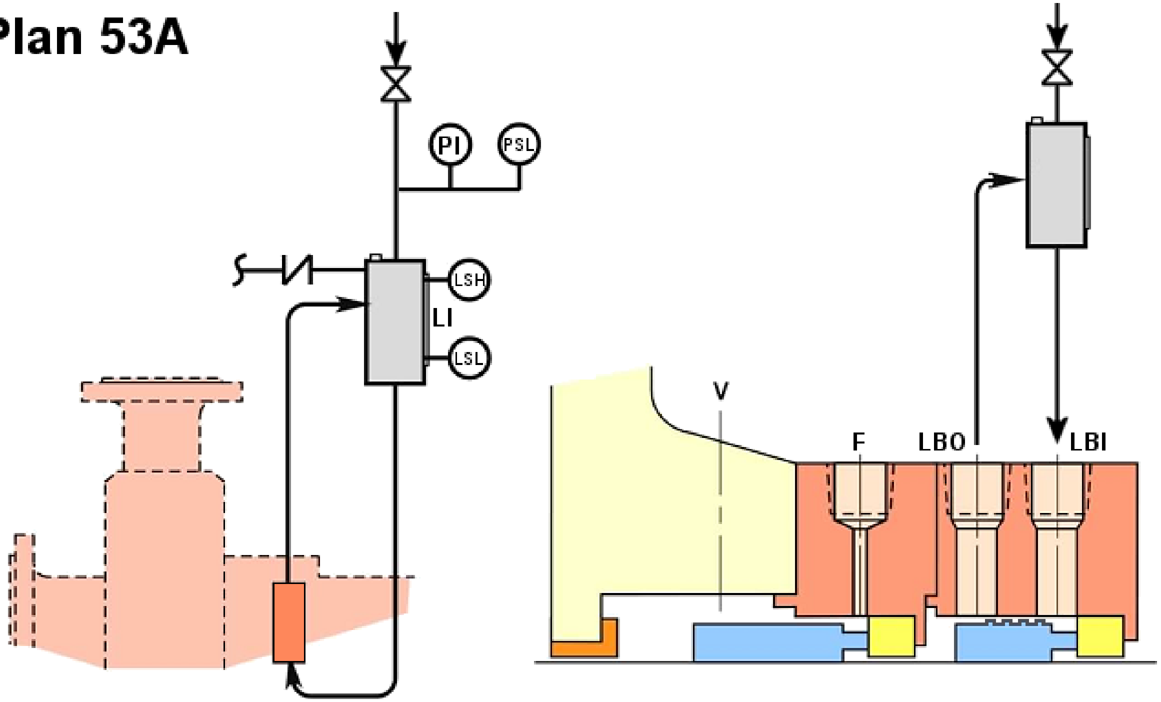
- Piping loop must self-vent to vapor recovery/flare system near atmospheric pressure.
- Process vapor pressure is generally greater than reservoir pressure.
- Buffer fluid must be compatible with process leakage.
- Primary seal leakage is indicated by increased vent pressure.
- Reservoir level gage indicates outboard seal leakage.



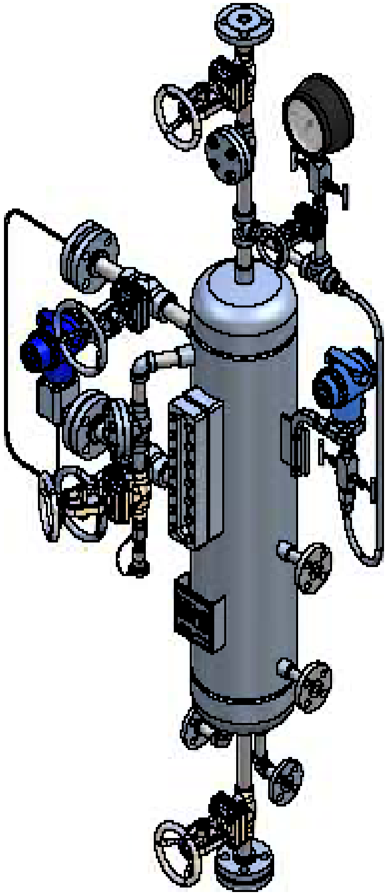
API Plan 53A

API Plan 53A is the circulation of a pressurised barrier fluid from an external reservoir supply:

Plan 53A



Pressurised external barrier fluid reservoir supplying clean fluid between dual seals. Circulation is maintained by an internal pumping ring. Reservoir pressure is greater than the process pressure being sealed.

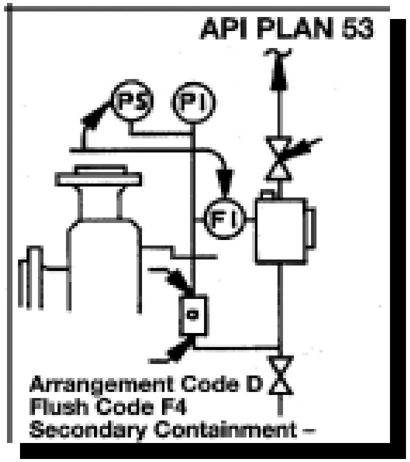


API Plan 53A

Points to note:

Advantages (compared to other API Plan 53 arrangements)

- least expensive of the various API Plan 53 systems
- should the system become contaminated for any reason, the contamination is isolated to a single installation only
- any wear particles that are heavier than the barrier fluid will settle to the bottom of the reservoir (the outlet to the seal should be located at least 2" from the bottom of the reservoir)
- the volume of buffer fluid is dependent upon the size of the reservoir - larger flow rates can use larger reservoir sizes, so that retention / cooling time in the reservoir is maximised

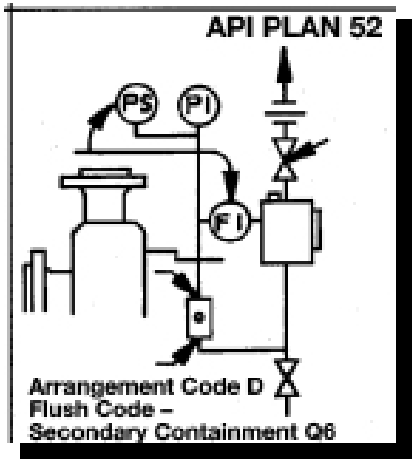


API Plan 53A

Points to note:

<u>Limitations</u> (compared to other API Plan 53 arrangements)

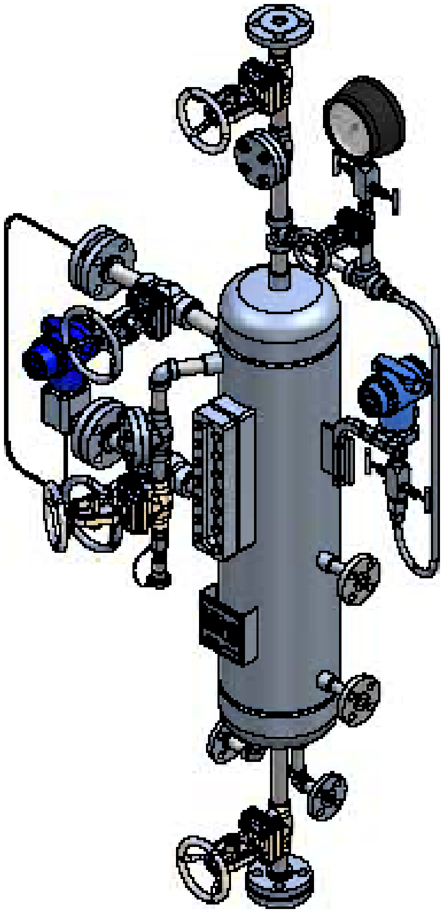
- the API Plan 53A barrier fluid is subject to possible gas absorption at higher pressures, due to direct exposure to the pressurising gas
- heat dissipation capacity is limited to the reservoir's cooling coils, unlike API Plan 53B and 53C which have separate cooling and potentially larger capacity
- API Plan 53A is limited to supplying only a single seal installation; for a large number of rotating equipments, multiple API Plan 53A installations can become more expensive than a single API Plan 53B or 53C system serving several pieces of rotating equipment



API Plan 53A

Preventative Maintenance

- Piping loop must self-vent to reservoir located at highest elevation.
- Pressurize reservoir at all times,
- Barrier fluid must be compatible with process.
- Reservoir level gage indicates both IB and OB seal leakage.

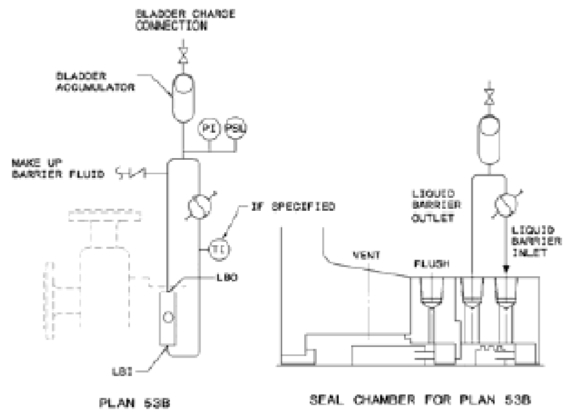


API Plan 53B

Plan 53b is also a pressurized dual seal and differs from Plan 53a in that pressure is maintained in the seal circuit through the use of a bladder type accumulator.

In the traditional Plan 53A, nitrogen gas is used to pressurize the barrier fluid in the reservoir. As the pressure of the nitrogen gas is increased, the gas will begin to dissolve into the barrier fluid. The barrier fluid in the reservoir is cooler, and the barrier fluid can thus dissolve more gas. As the barrier fluid reaches the seal chamber, it is heated and the solubility of the nitrogen decreases and the gas is released. The out gassing can accelerate face wear since portions of the seal interface will be running dry. The barrier fluid can also start to foam, which can hinder circulation through the piping.

53B's should be employed at pressures above 400 psig or when a barrier fluid temperature change of 40°F is anticipated. Barrier pressure will be lost quickly if the accumulator volume is small.



API Plan 53B

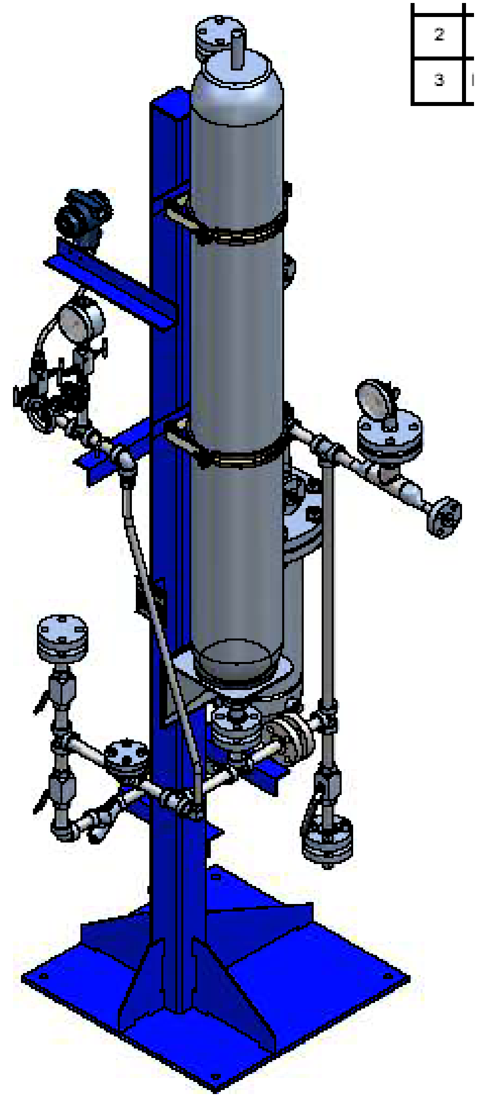
Points to note:

- Pressurized barrier fluid circulation with a bladder accumulator.
- Fluid is circulated by a pumping ring in the dual seal assembly
- Higher pressure than Plan 53A.
- Used with dual pressurized seals (“double”).
- High vapor pressure fluids, light hydrocarbons.
- Dirty, abrasive or polymerizing fluids.

API Plan 53B

Preventative Maintenance

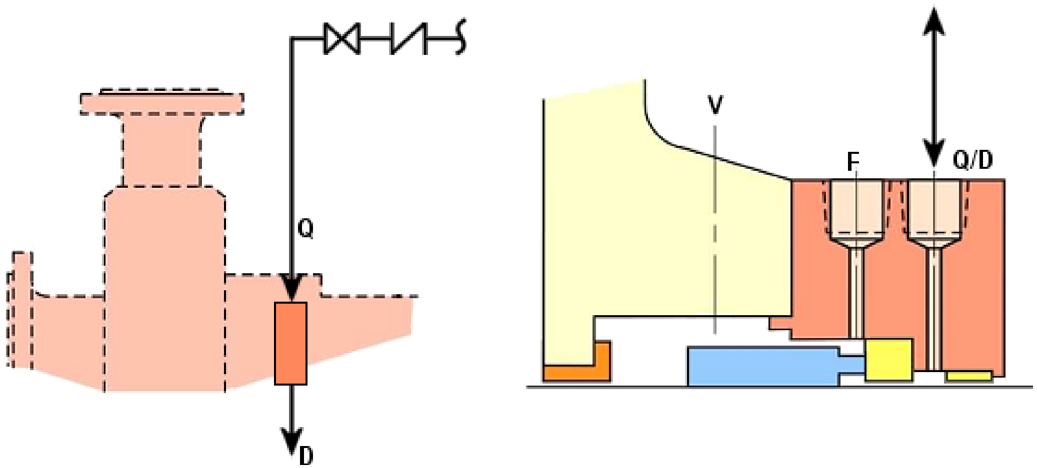
- Piping loop must be fully vented before starting.
- Accumulator must be pressurized at all times, usually by gas charge.
- Barrier fluid must be compatible with process.
- Regularly monitor barrier pressure – manually add barrier fluid when pressure decays.



API Plan 62

API Plan 62 is a clean external quench fluid, supplied to the atmospheric (outboard) side of the seal from an external source:

Plan 62



Exterior source providing a quench, such as low-pressure steam, gas or water.

API Plan 62

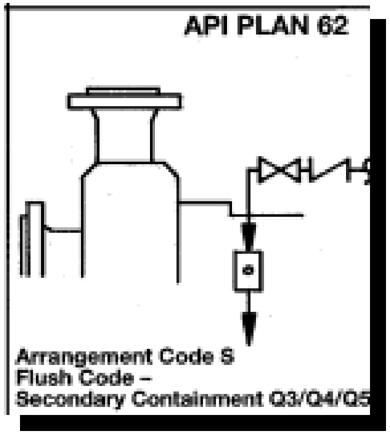
Points to note:

Advantages

- low cost alternative to tandem seals, to improve conditions at the outboard (atmospheric) side of the mechanical seal
- can be used to prevent conditions such as coking, polymerising etc. at the outboard side of the seal, where the process fluid meets atmospheric conditions

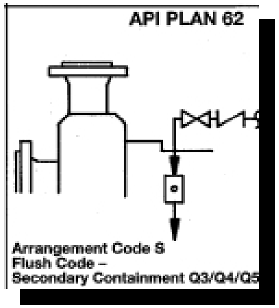
Limitations

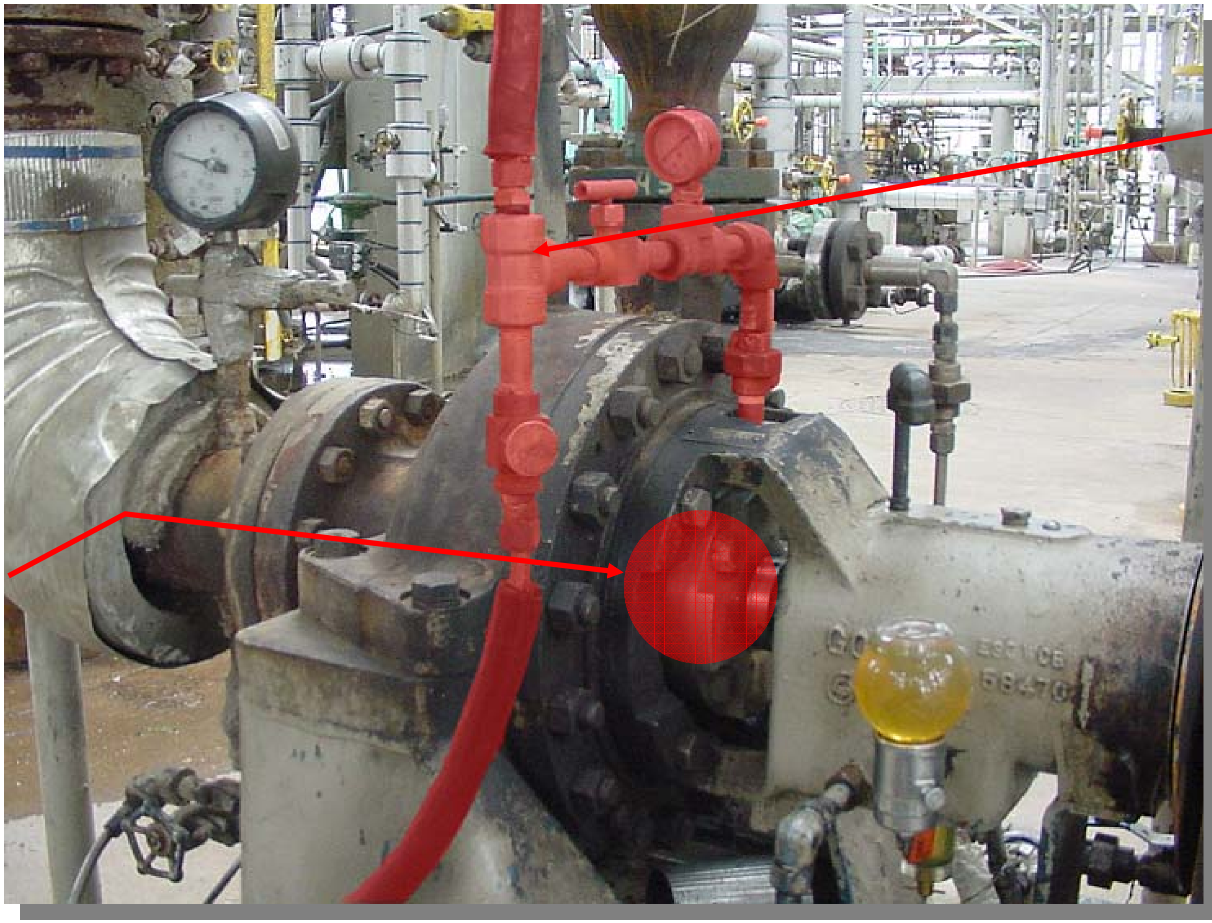
- leakage of process fluid past the primary seal is contained only with a secondary containment device such as a throttle bushing - process fluid leakage will either leak to atmosphere or go to a vent or drain
- must always be maintained at a low pressure (e.g. <0.5 BARG) - higher pressures would increase leakage of the quench fluid, and could cause a possible reverse pressure on the mechanical seal
- a continuous quench will over time use large volumes of fluid



API Plan 62

Installation of API Plan 62:





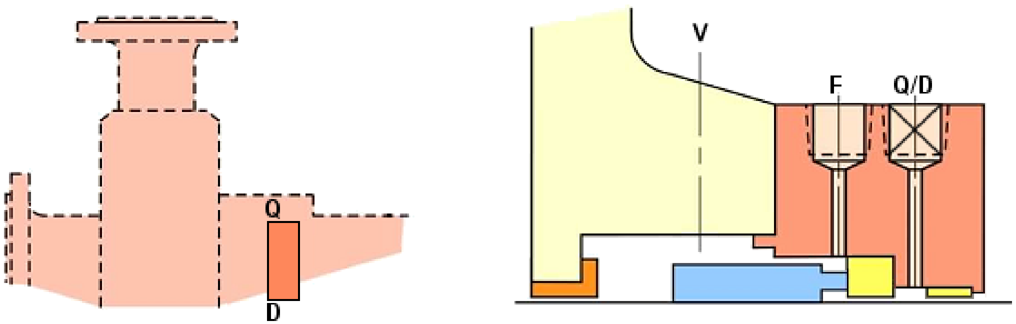
mechanical seal

API Plan 62 piping from external source of quench liquid

API Plan 61

API Plan 61 is a set of tapped connections provided at the atmospheric (outboard) side of the seal, for use by the end-user as required:

Plan 61



Tapped and plugged quench and drain connections for the purchaser's use. Typically, this plan is used when the purchaser is to provide a quenching medium to an external sealing device.

API Plan 61

Points to note:

API Plan 61 are tapped connections which the user of the seal may either choose to:

- connect to an external supply of some kind (e.g. API Plan 62 quench such as steam, gas or water)
- connect to vent and drain collection systems
- be left plugged

At the outboard side of the Plan 61 connections will be some form of **secondary containment device**, such as a bushing, lip seal or other simple sealing device.