MECHANICAL SEAL PIPING PLANS

Pocket Guide

flexaseal
ENGINEERED SEALS AND SYSTEMS, LLC

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Introduction

Piping Plan Diagrams & Notes

Symbols

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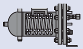
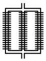
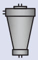
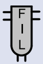
	Cooler, tube in shell		Pressure gauge
	Cooler, finned tubing		Pressure transmitter w/ local indicator
	Cyclone separator		Strainer
	Differential pressure transmitter w/ local indicator		Temperature indicator
	Filter		Valve, normally open
	Flow indicator		Valve, normally closed
	Flow orifice		Valve, check
	Flow transmitter w/ local indicator		Valve, needle
	Bladder accumulator		Valve, pressure control

Color Key

Cool/Clean Fluid Pump Medium	Hot, Contaminated Fluid
Leakage	Quench Fluid
Contaminated Fluid	Barrier/Buffer Fluid
Hot Fluid	Solids

Equipment Alignment

FIG. 1: Shaft Runout

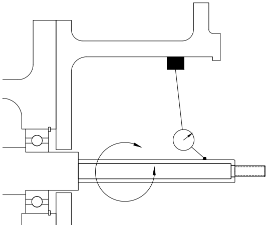


FIG. 2: Bearing Fit

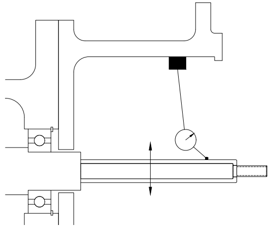


FIG. 3: Bearing Frame Perpendicularity

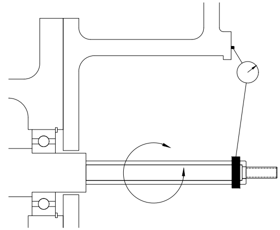


FIG. 4: Axial Shaft Movement

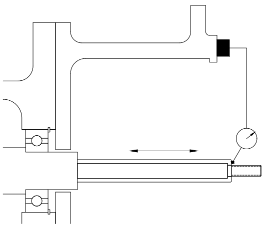


FIG. 5: Seal Chamber Bore Concentricity

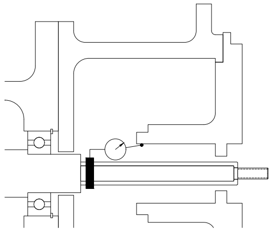
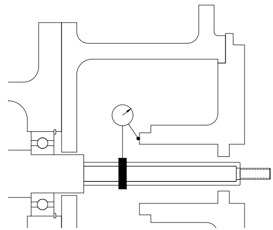


FIG. 6: Seal Chamber Face Squareness



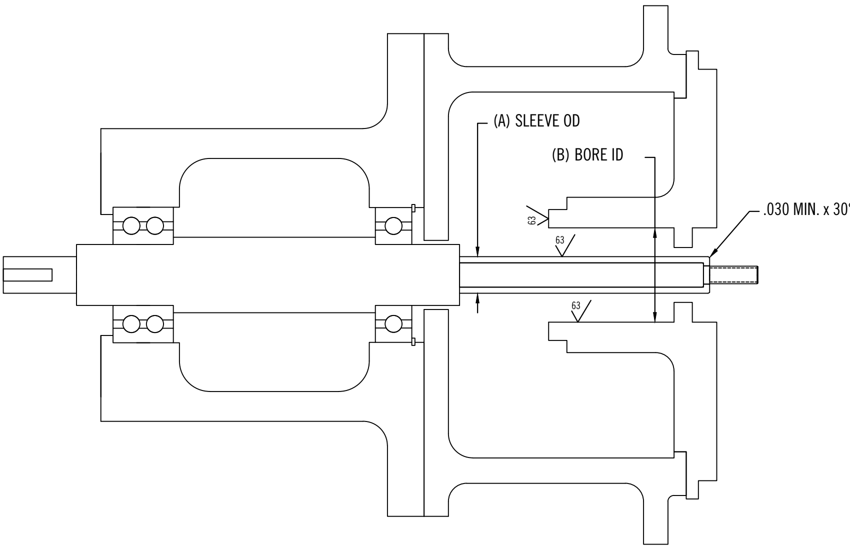
Maximum Alignment Variation (TIR)

FIG. 1	Radial shaft movement (shaft runout)	0.0015–0.003 in.
FIG. 2	Radial bearing fit	0.002–0.003 in.
FIG. 3	Bearing frame perpendicularity	0.0005 in./in.
FIG. 4	Axial shaft movement (end play)	0.002 in.
FIG. 5	Seal chamber bore concentricity	0.005 in.
FIG. 6	Seal chamber face squareness	0.0005 in./in.

For proper function and satisfactory operation of the seal it is imperative that connections, dimensions, finishes, and alignments are all acceptable based on the specified design. If measured values exceed the values given above, adjust the equipment to meet the specifications before installing the seal. These values are general guidelines and the pump OEM should be used to verify acceptable values whenever possible.

Seal Chamber Preparation

Sealing surfaces of the shaft, sleeve, bore, and seal chamber face must have a surface finish limit of 63 Ra-μin. For ease of installation, the leading edge of the shaft or sleeve should be chamfered as shown and all parts should be deburred.



Installation and Operation Best Practices and Notes

Tubing shall have a minimum diameter of 1/2 in. [13 mm] for shafts smaller than 2-1/2 in. [64mm]. Tubing shall have a minimum diameter of 3/4 in. [19 mm] for shafts 2-1/2 in. [64 mm] or larger.

To minimize friction losses:

- Use long, smooth radius bends
- Use larger tubing whenever possible
- Use rigid tubing whenever possible

Use thread sealant instead of thread tape; thread tape can break apart and damage the seal.

Minimize use of 90° elbows, 45° elbows are preferred.

Use continuously rising lines at a minimum slope of 0.5 in./ft. [42 mm/m]. There should be no relative high points that may result in trapped air in the tubing.

Insulate hot lines as necessary for safety of personnel.

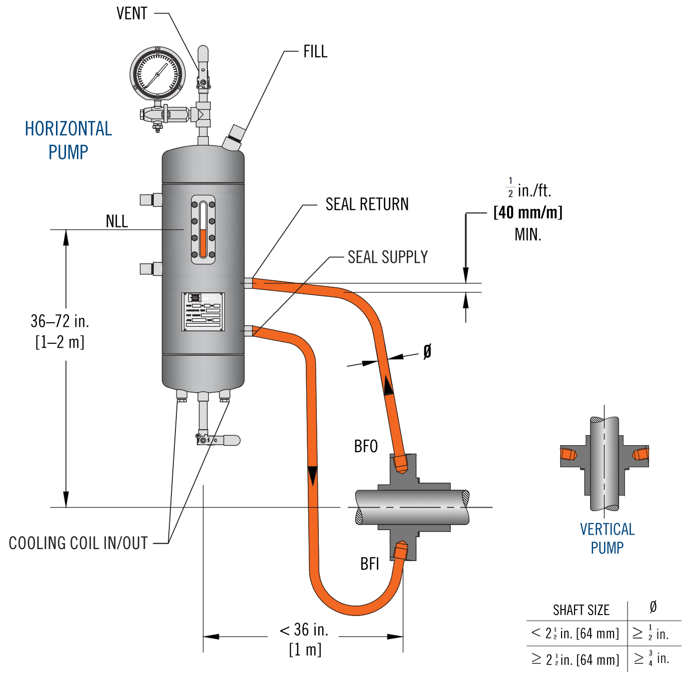
IMPORTANT PLAN NOTES:

All recirculation from discharge to lower pressure regions will result in some loss of pump efficiency.

For all single or dual unpressurized seals, the product in the pump must be a good face lubricant for successful seal performance.

Piping Practices for Seal Support Reservoir Systems

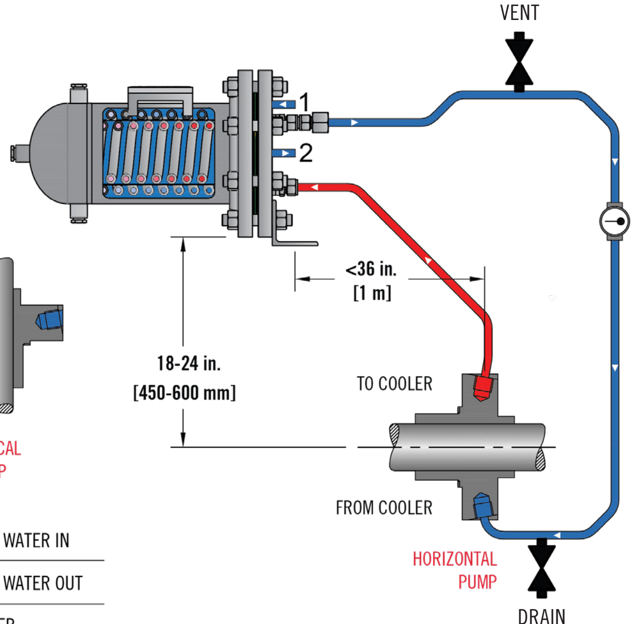
- Reservoir should have a minimum 3 gallon [11.4 L] volume for shafts less than 2-1/2 in. [64 mm]. Reservoir should have a minimum 5 gallon [18.9 L] volume for shafts 2-1/2 in. [64 mm] or larger.
- The reservoir normal liquid level (centerline of sight glass) should be 36 in. [1 m] above gland centerline.
- Reservoir should be located as close to the pump as possible (within 36 in. [1 m] radius) while still leaving room for operation and maintenance.
- Do not mount the reservoir directly above the pump.

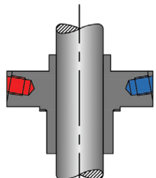


SHAFT SIZE	ø
< 2 1/2 in. [64 mm]	≥ 1/2 in.
≥ 2 1/2 in. [64 mm]	≥ 3/4 in.

Seal Cooler Layout and Best Practices

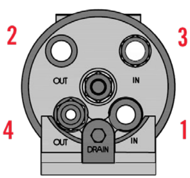
- The seal cooler should be mounted 18–24 in. [450–600 mm] above the gland centerline.
- Cooler should be located as close to the pump as possible (within 36 in. [1 m] radius) while still leaving room for operation and maintenance.
- Do not mount the cooler directly above the pump.





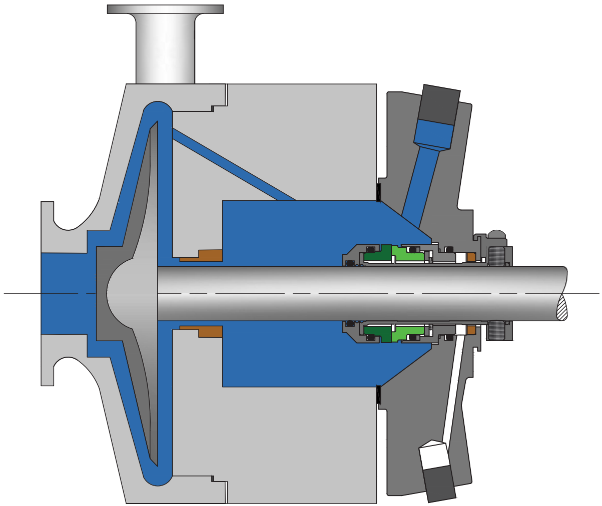
VERTICAL PUMP

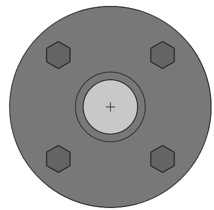
COOLER CONNECTIONS



1	COOLING WATER IN
2	COOLING WATER OUT
3	TO COOLER
4	FROM COOLER

Internal recirculation from pump discharge to the seal chamber.





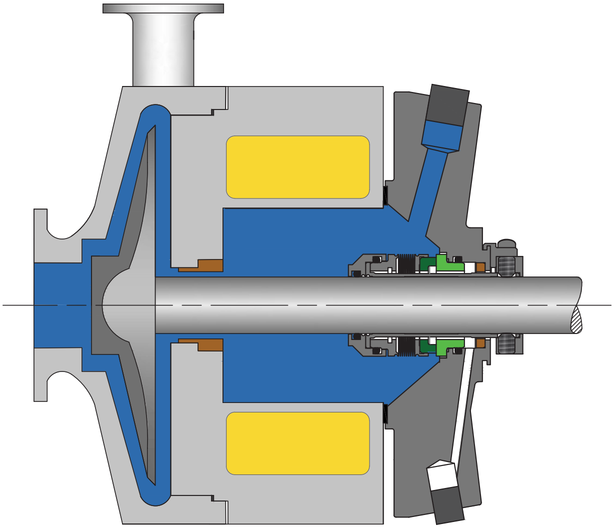
GLAND END
VIEW

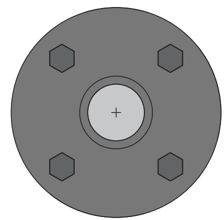
PLAN 01

Application Notes:

- Used with fluids which are at risk of freezing, thickening, or solidifying in external piping.
- Same concept as Plan 11, without the external piping.
- Raises the seal chamber pressure.
- Vents the seal chamber during flooding of horizontal pumps.
- The seal chamber is not self-venting in vertical applications.
- May only be used with clean fluids.
- The flush is not usually directed right at the faces but may come in over the seal head.

Dead-ended seal chamber with no recirculation of fluid and optional cooling/heating jacket.





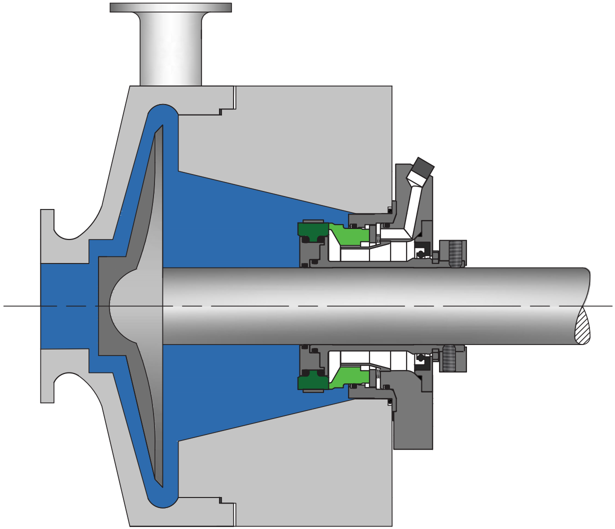
GLAND END VIEW

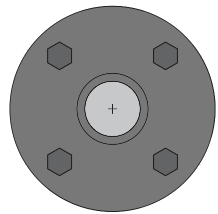
PLAN 02

Application Notes:

- Used in low speed applications with low seal chamber pressures where control of the seal chamber temperature is desired.
- Common in the chemical industry.
- Cooling or heating jacket may be used to control the seal chamber temperature. Cooling jacket is recommended for narrow seal chambers.
- Chamber must be fully vented prior to pump startup.
- Flush port is plugged.
- No external hardware or piping to the seal.
- Pump efficiency is unaffected.
- Solids are not reintroduced to the seal area.
- Cooling jackets are prone to fouling in high temperature applications.

Open-ended or tapered seal chamber.





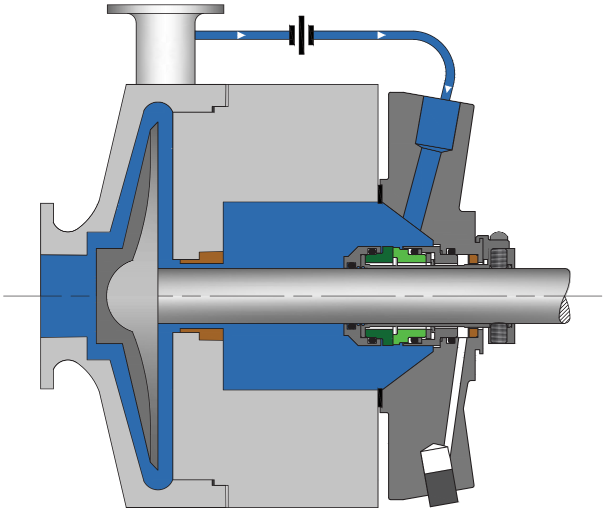
GLAND END
VIEW

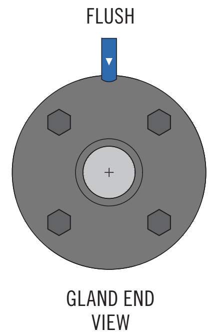
PLAN 03

Application Notes:

- Circulation between the pump and seal chamber is driven by the geometry or flow enhancement features in the seal chamber.
- Used in applications where solids would collect in a traditional cylindrical seal chamber.
- Flush port is plugged.
- Provides cooling for the seal without use of any external hardware or piping.
- Vents air or vapors from the seal chamber in horizontal pumps.
- No throat bushing.
- Control of the seal chamber environment is limited.
- The seal chamber is not self-venting in vertical applications.
- May not be recommended in applications with high seal chamber pressures and/or temperatures.

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



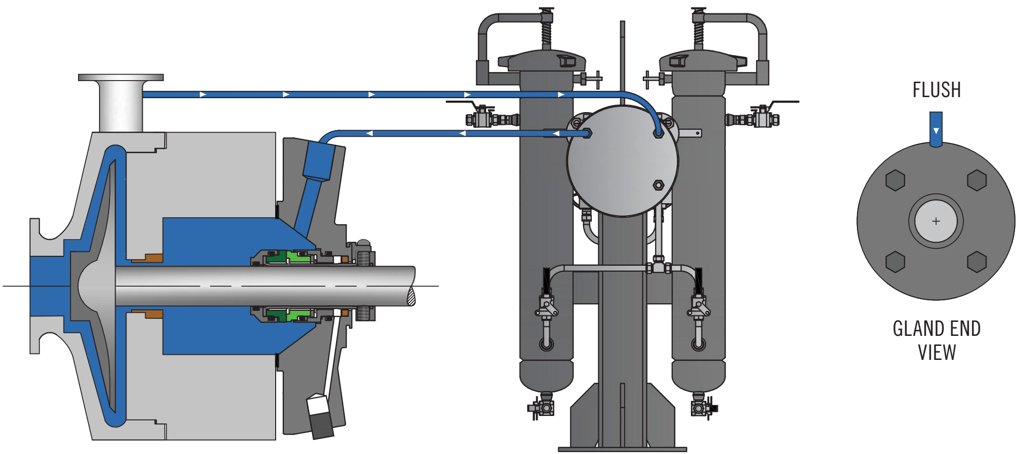


PLAN 11

Application Notes:

- Default seal flush plan for all Arrangement 1 and 2 seals.
- Fluid flows from the seal chamber back into the process stream.
- Important to determine the required flush flow rate (especially for high-head applications) and select proper orifice and throat bushing dimensions to assure adequate flow.
- Can be used without a flow control orifice for some low differential head or high viscosity applications.
- Provides cooling for the seal.
- Vents air or vapors from the seal chamber in horizontal pumps.
- Applicable for all general duties with sufficient pressure differential.
- Polymerizing fluids can cause clogging of the orifice and piping.
- Should not be used with fluids which are at risk of freezing, thickening, or solidifying in external piping.

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

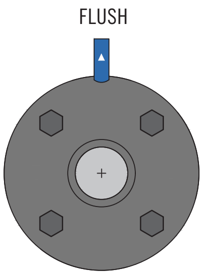


PLAN 12

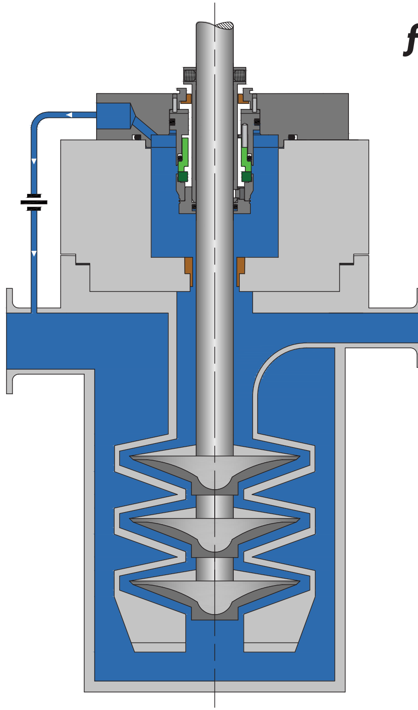
Application Notes:

- Fine and large solids are removed from the flush system, extending seal life.
- The system monitors the filter's differential pressure to alert the operator when a filter change is needed.
- Available in single or dual filter designs, as well as 3-micron and 10-micron filtration.
- Coalescing design available to remove water from flush stream in hydrocarbon applications.

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



GLAND END VIEW

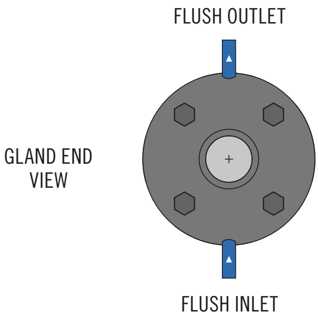


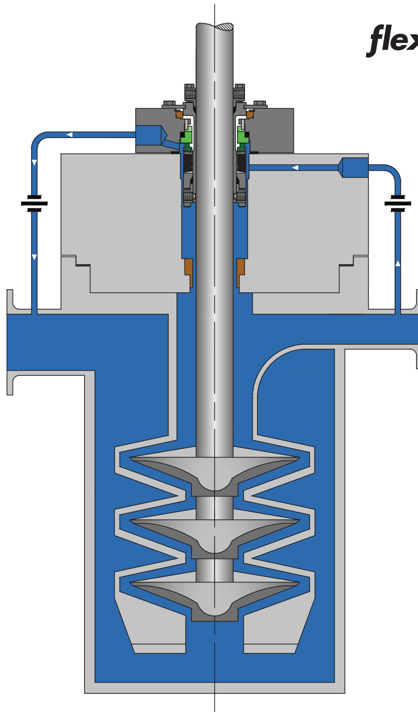
PLAN 13

Application Notes:

- Standard flush plan selection for most vertical turbine pumps.
- Flow control orifice can be omitted depending on the required flush flow rate.
- Helps to reduce the stuffing box or seal chamber pressure.
- Can also be used for high head horizontal pumps where Plan 11 cannot be used (i.e. low pressure differential between seal chamber and pump discharge).
- Vents air or vapors from the seal chamber in vertical pumps.
- Applicable for all general duties with sufficient pressure differential.
- Provides cooling for the seal.
- Polymerizing fluids can cause clogging of the orifice and piping.
- Should not be used with fluids which are at risk of freezing, thickening, or solidifying in external piping.

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



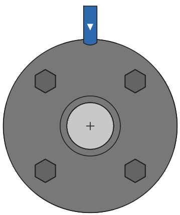


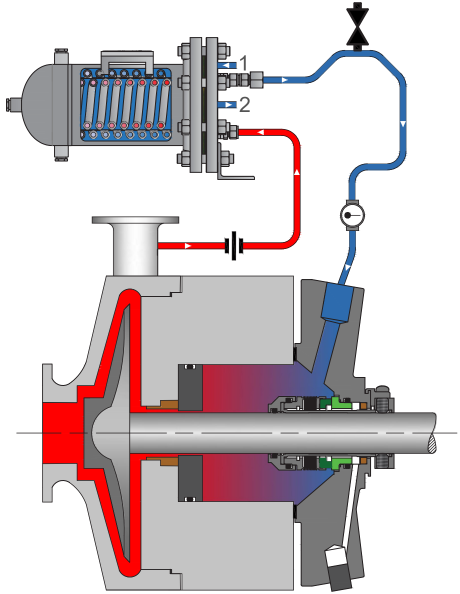
PLAN 14

Application Notes:

- Combination of Plan 11 and Plan 13.
- Most commonly used on vertical pumps.
- Acts to optimize cooling and continuous venting of the seal chamber. Vent must be at a high point.
- Flush is directed onto the seal faces.
- Can help to raise the pressure in the seal chamber.

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





PLAN 21

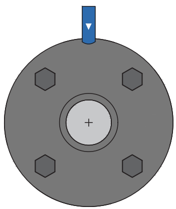
Application Notes:

- Plan 11 with cooler.
- Throat bushing is used to isolate product in the seal chamber from product in the pump volute.
- Provides a cool flush to the seal to improve lubricity, reduce coking, and/or avoid fluid flashing to vapor.
- If the cooler duty is high, fouling and clogging on the water side can occur over time.
- Potential clogging on the process side if the fluid becomes too viscous at reduced temperature.
- Requires more energy usage than Plan 23 since the fluid must be continuously pumped back to discharge.

Recirculation from pump discharge through a strainer, flow control orifice, and cooler to the seal chamber.

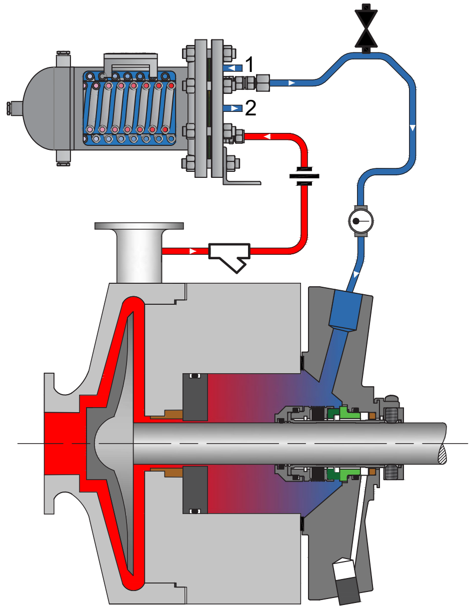
1	COOLING WATER IN
2	COOLING WATER OUT

FLUSH



GLAND END VIEW

VENT

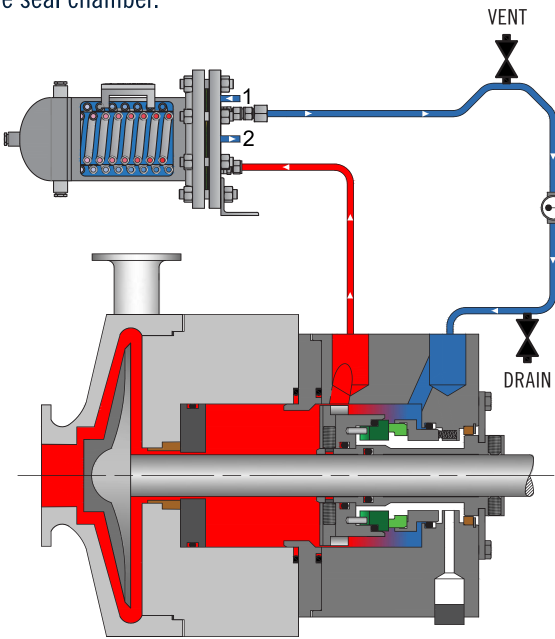


PLAN 22

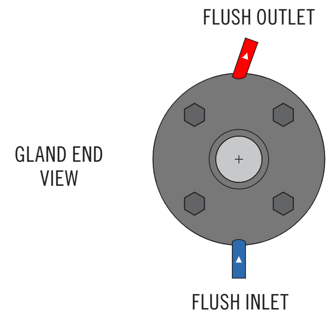
Application Notes:

- Plan 21 with strainer. Strainer must be located before the orifice.
- The orifice size should be at least 1/8 in. [3 mm].
- A flow indicator, differential pressure indicator, or alarm is recommended to indicate strainer malfunction.
- Solids are removed from the flush stream, thus keeping the seal clean.

Forced circulation from the seal chamber through a cooler and back to the seal chamber.



1	COOLING WATER IN
2	COOLING WATER OUT

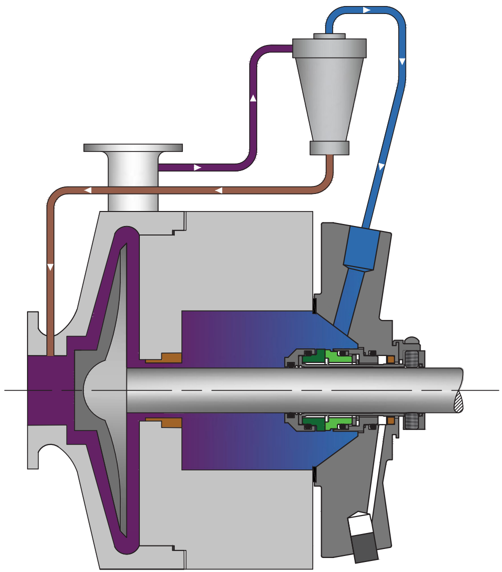


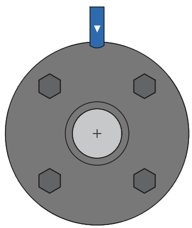
PLAN 23

Application Notes:

- Seal has an internal circulating device (pumping ring) that circulates seal chamber fluid through a cooler and back to the seal chamber.
- Provides a cool flush to the seal to improve lubricity, reduce coking, and/or avoid fluid flashing to vapor.
- Commonly used for hot water services above 180°F [80°C] (e.g. boiler feed water) and hot hydrocarbon services.
- Throat bushing is used to isolate product in the seal chamber from product in the pump volute.
- More energy efficient than Plan 21 since only the fluid in the seal chamber is run through the cooler.
- If the cooler duty is high, fouling and clogging on the water side can occur over time.
- Potential for clogging on the process side if the fluid becomes too viscous at reduced temperature.
- Best piping practices must be followed to avoid vapor entrapment and stalled flow in the tubing.

Recirculation from pump discharge through a cyclone separator, delivering clean fluid to the seal chamber and solids to pump suction.



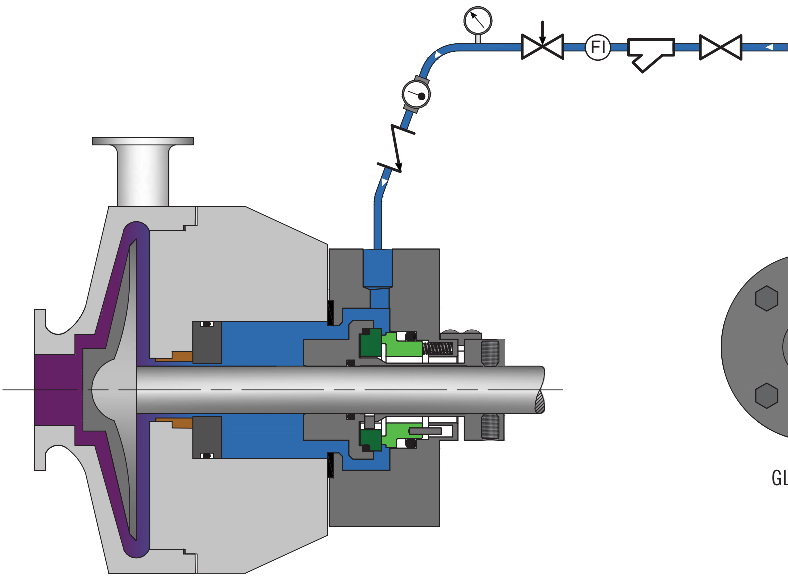


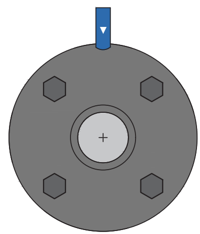
PLAN 31

Application Notes:

- Similar to Plan 11, with the addition of a cyclone separator.
- Cyclone separator needs at least a 25 psi [1.7 bar] differential between pump discharge and the seal chamber for optimum performance.
- For use with services containing solids with a specific gravity at least twice that of the process fluid.
- The difference in pressure between the two separator outlets should be as close to zero as possible.
- Maximum particle size in the process should be less than one quarter the size of the inlet orifice.
- If the process stream is very dirty or is a slurry, Plan 31 is not recommended.
- Solid particles are centrifuged from the stream and routed back to pump suction.
- Cyclone separator must be monitored for abrasive wear which reduces performance.

Clean fluid is injected into the seal chamber from an external source.



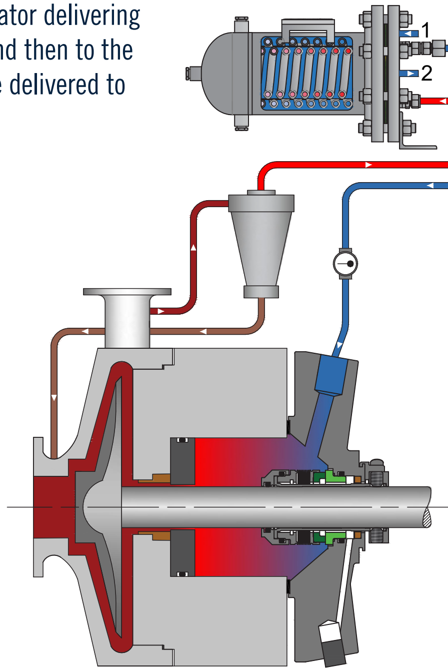


PLAN 32

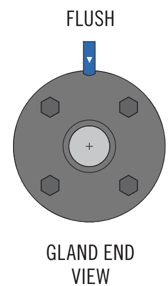
Application Notes:

- For use in services containing solids or contaminants, in which a cleaner and cooler external flush will improve the seal environment.
- External flush source must be continuous and reliable.
- Pressure of the external flush should always be at least 25 psi [1.7 bar] above the seal chamber pressure.
- Throat bushing is required to maintain an elevated pressure in the seal chamber, isolate it from the pumped media, and reduce flush fluid consumption.
- Provides the seal with a cool, clean lubricating fluid when the product cannot be conditioned into a quality seal flush through the use of other piping plans.
- Flush fluid must be compatible with the product because product dilution will occur.

Recirculation from pump discharge through a cyclone separator delivering clean fluid to a cooler and then to the seal chamber. Solids are delivered to pump suction.



1	COOLING WATER IN
2	COOLING WATER OUT



PLAN 41

Application Notes:

- Combination of Plan 21 (cooler only) and Plan 31 (cyclone separator only).
- Same application notes as Plan 21 and Plan 31.

External buffer liquid reservoir supplying clean fluid to the outboard seal faces.

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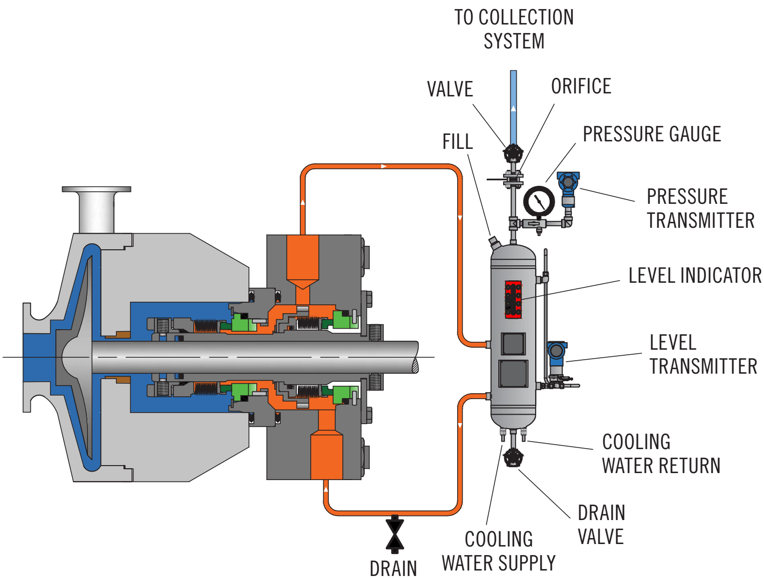
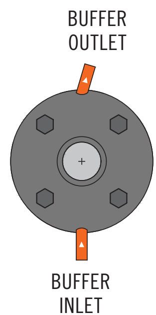




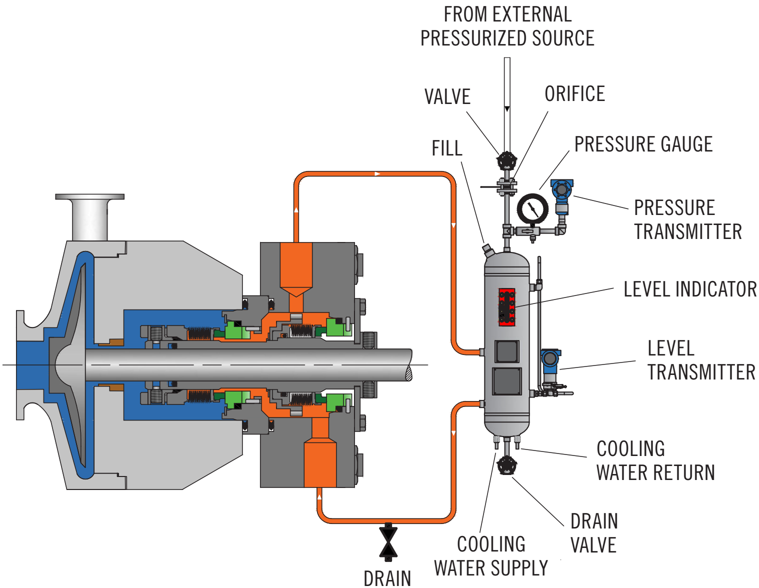
GLAND END VIEW

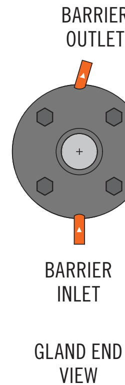
PLAN 52

Application Notes:

- Used with Arrangement 2 seals.
- Buffer system pressure is typically maintained close to atmospheric pressure.
- Used in applications where product contamination from a barrier fluid is unacceptable.
- Circulation of buffer liquid to and from the reservoir is dependent on thermal siphoning and/or an internal circulating device (pumping ring) inside the seal.
- Used with clean, non-polymerizing, pure products that have a vapor pressure higher than the buffer system pressure.
- Provides redundancy in the event of a seal failure.
- Leakage of higher vapor pressure liquids into the buffer system will flash in the seal reservoir and the vapor can escape into the collection system.
- Near zero process emissions.
- Cooling system is typically built into the reservoir.
- Buffer liquid must be compatible with the process liquid.
- Best piping practices must be followed to avoid vapor entrapment and stalled flow in the tubing.

Pressurized external barrier liquid reservoir supplying clean fluid to the inboard and outboard seal faces.



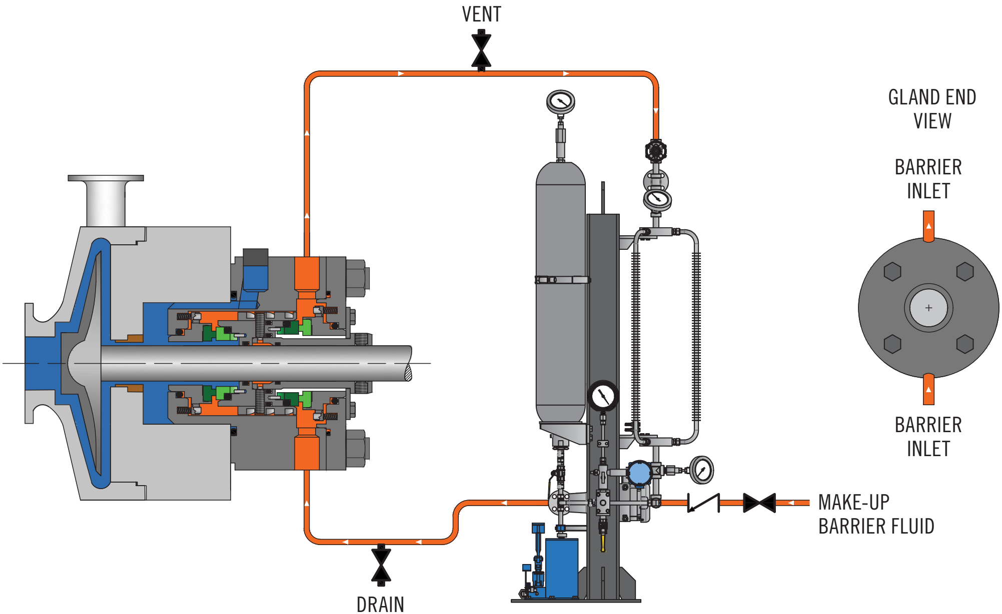


PLAN 53A

Application Notes:

- Used with Arrangement 3 seals.
- Typically chosen for dirty, abrasive, or polymerizing products not compatible with a Plan 32.
- Barrier liquid is maintained at a pressure greater than the seal chamber pressure. It is recommended that the barrier liquid pressure always exceeds the maximum seal chamber pressure by at least 20 psi [1.4 bar].
- Circulation of barrier liquid to and from the reservoir is dependent on thermal siphoning and/or an internal circulating device (pumping ring) inside the seal.
- Used when no process leakage to the atmosphere can be tolerated.
- Process fluid never leaks to the atmosphere unless reservoir pressure is lost.
- Cooling system is typically built into the reservoir.
- Barrier liquid must be compatible with the process liquid because it will leak into the product.
- Best piping practices must be followed to avoid vapor entrapment and stalled flow in the tubing.

External barrier liquid system pressurized by a bladder accumulator supplying clean fluid to the inboard and outboard seal faces.

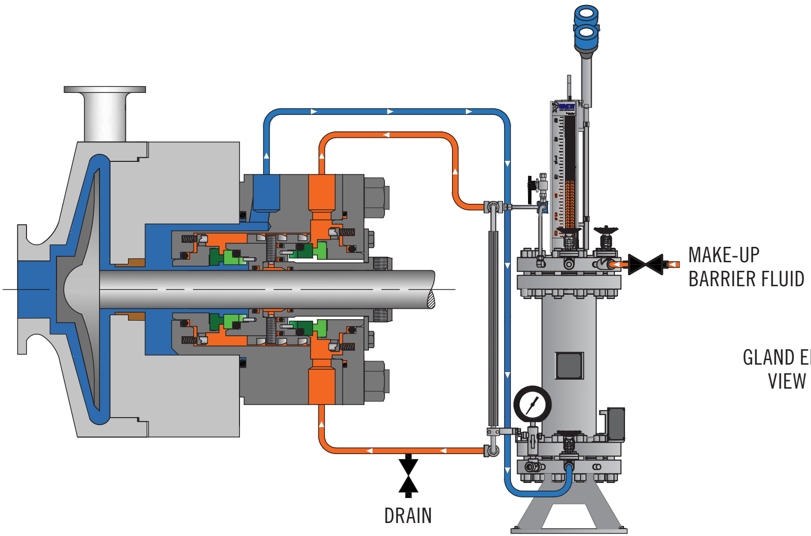


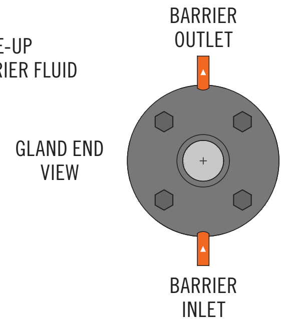
PLAN 53B

Application Notes:

- Used with Arrangement 3 seals.
- For use in applications where direct gas pressurization, such as in Plan 53A, would risk absorption of the gas into the barrier liquid.
- Accumulator and barrier liquid are maintained at a pressure greater than the seal chamber pressure. It is recommended that the barrier fluid pressure always exceeds the maximum seal chamber pressure by at least 20 psi [1.4 bar].
- Barrier liquid is circulated through the fluid circuit by means of an internal circulating device (pumping ring).
- Venting of the system during commissioning to eliminate all gas and air bubbles from the system is crucial to proper operation. Vent should be closed when pressurizing and during normal pump operation.
- The use of a bladder accumulator prevents contact between the pressurization gas and the barrier liquid. This prevents gas absorption into the barrier liquid and allows for high-pressure operation.
- Process fluid never leaks to the atmosphere unless system pressure is lost.
- Seal performance is monitored by pressure level. Changes in pressure indicate potential leaks at either the inboard or outboard seal faces.
- Heat is removed using a heat exchanger.
- Barrier liquid must be compatible with the process liquid because it will leak into the product.
- System is sensitive to environmental heat loads which may cause significant fluctuations of the system pressure.
- Best piping practices must be followed to avoid vapor entrapment and stalled flow in the tubing.

External barrier liquid system pressurized by a piston accumulator supplying clean fluid to the inboard and outboard seal faces.



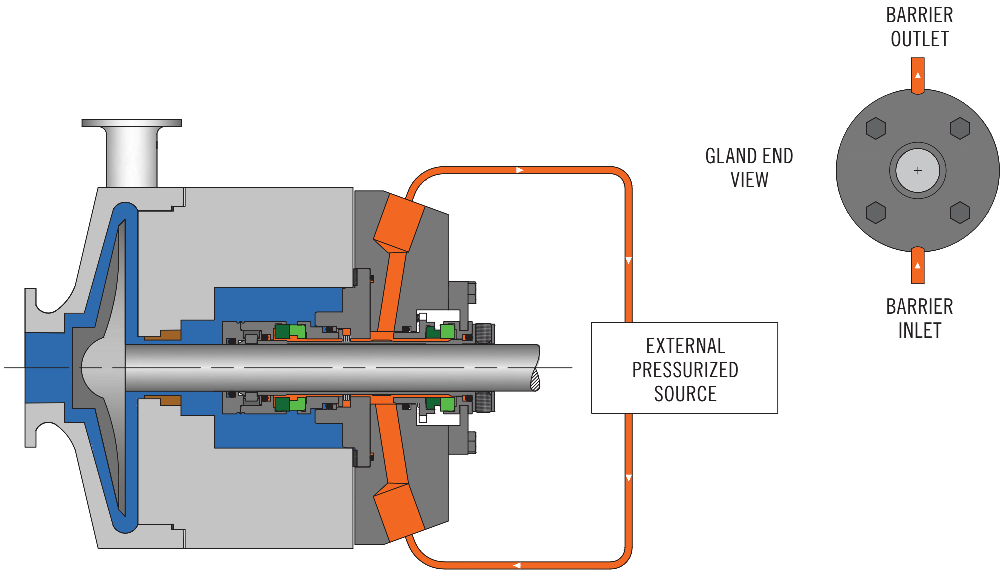


PLAN 53C

Application Notes:

- Used with Arrangement 3 seals.
- Piston accumulator senses pressure from a reference source (normally the seal chamber) and maintains a higher barrier system pressure through differential areas in the piston.
- Barrier liquid pressure should always exceed the maximum seal chamber pressure by at least 20 psi
[1.4 bar].
- Barrier liquid is circulated through the fluid circuit by means of an internal circulating device (pumping ring).
- Materials used in the piston accumulator must be compatible with the process fluid.
- Process fluid never leaks to the atmosphere unless system pressure is lost.
- Heat is removed using a heat exchanger.
- Barrier liquid must be compatible with the process liquid because it will leak into the product.

Pressurized external barrier liquid system supplying clean fluid to the inboard and outboard seal faces.

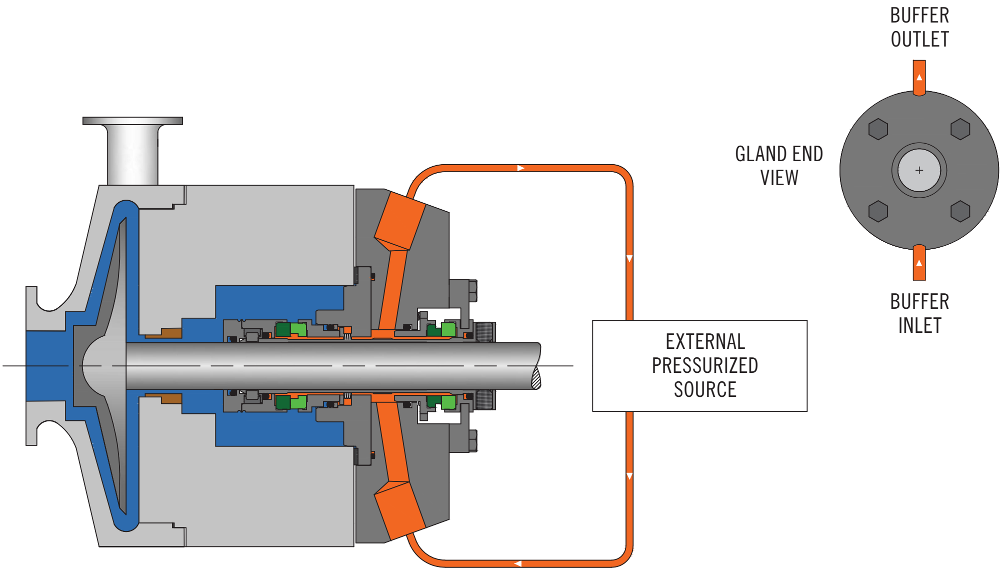


PLAN 54

Application Notes:

- Used with Arrangement 3 seals.
- Cool, clean product from an external source is supplied to the seal as a barrier liquid.
- Barrier liquid is maintained at a pressure greater than the seal chamber pressure.
- Barrier liquid pressure should always exceed the maximum seal chamber pressure by at least 20 psi [1.4 bar].
- Barrier liquid is circulated by an external pump.
- Process fluid never leaks to the atmosphere unless system pressure is lost.
- Superior management of seal generated heat due to higher flow rates than that of Plans 53A, 53B, and 53C.
- Provides barrier liquid cooling and circulation even if the process pump is not active.
- Sensors and flowmeters may be added within the external system to readily identify seal failure based on support system conditions.
- Barrier liquid must be compatible with the process liquid because it will leak into the product.
- If used on multiple seal installations, failure of one installation can affect all of the other installations unless proper precautions are taken to isolate the failed seal.

Unpressurized external buffer liquid system supplying clean fluid to the inboard and outboard seal faces.

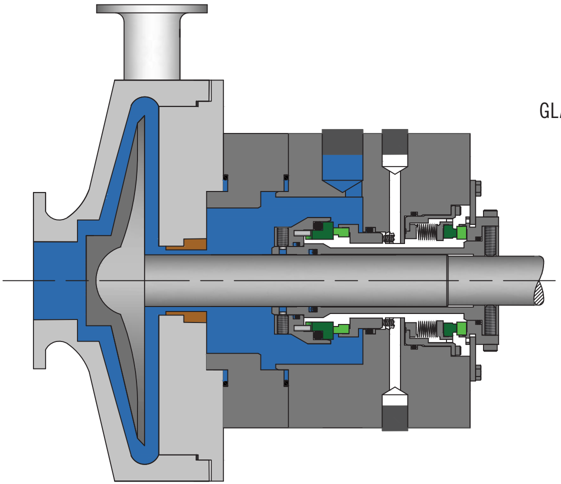


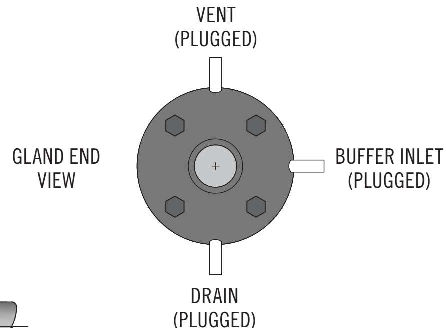
PLAN 55

Application Notes:

- Used with Arrangement 2 seals.
- Buffer liquid shall be maintained at a pressure less than seal chamber pressure.
- Buffer liquid is circulated by an external pump.
- Plan 55 is similar to Plan 54 except the barrier liquid is unpressurized (buffer liquid).
- Process fluid is not contaminated.
- Near zero process emissions.
- Provides buffer liquid cooling and circulation even if the process pump is not active.
- Sensors and flowmeters may be added within the external system to readily identify seal failure based on support system conditions.

Tapped connections for the purchaser's use in the future for buffer gas applications.



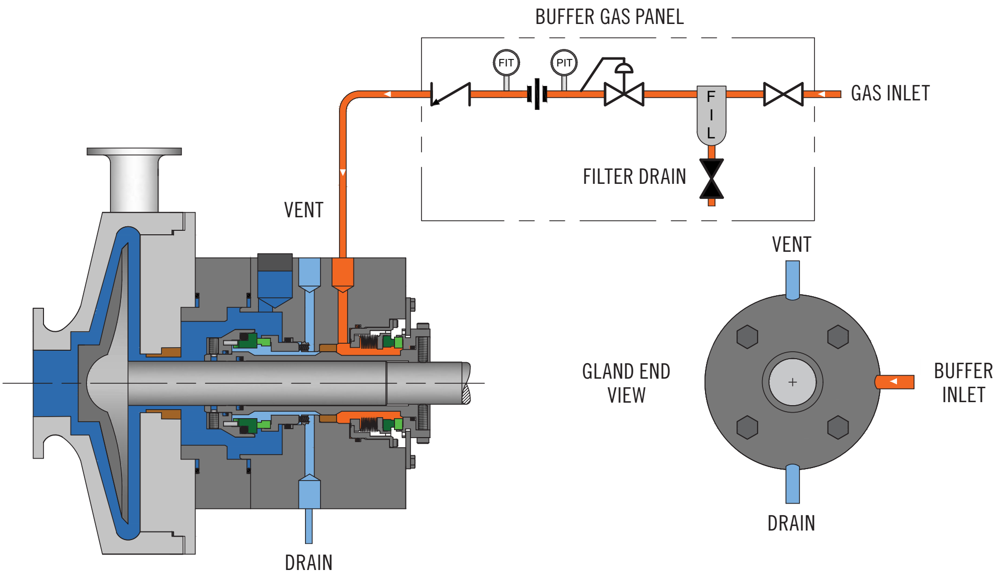


PLAN 71

Application Notes:

- Used on Arrangement 2 seals, where the potential for use of a buffer gas system in the future is desired, even though no buffer gas system is provided at the time.
- All seal ports should be connected to piping or metallic plugs must be used if a seal is to be put into service.
- Ensure vent port is oriented to the 12 o'clock position and the drain is oriented to the 6 o'clock position.
- May be modified as needed into several other plans such as Plan 72, 75, and 76.

Externally supplied buffer gas maintained at a pressure less than the seal chamber pressure.

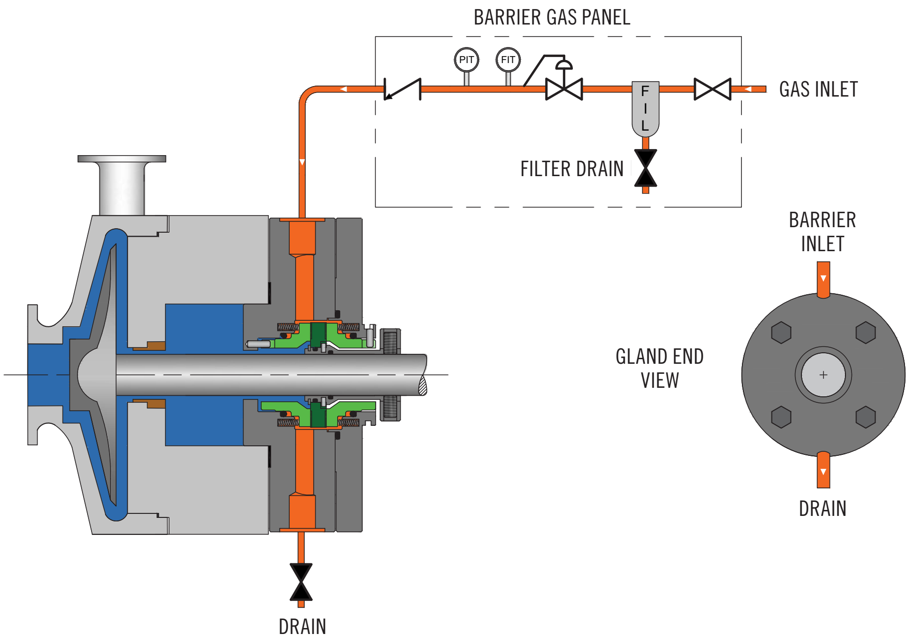


PLAN 72

Application Notes:

- Used in Arrangement 2 dual unpressurized seals, where the buffer medium is a gas. In normal operation, the buffer gas pressure should not exceed 10 psi [0.7 bar].
- Plan 72 may be used alone or partnered with a Plan 75 (for condensing leakage) or Plan 76 (for non-condensing leakage).
- Forward pressure regulator should be set to at least 5 psi [0.4 bar] above the normal flare pressure.
- Most common buffer gas is nitrogen. Ensure a reliable supply and avoid the use of bottles if possible.
- Buffer gas can be used to sweep inner seal leakage away from outer seal into a collection system and/or dilute the leakage so the emissions from the containment seal are reduced.
- Ensure vent port is oriented to the 12 o'clock position and the drain is oriented to the 6 o'clock position.
- Buffer gas can act to prevent icing in cryogenic applications.

Externally supplied barrier gas maintained at a pressure greater than the seal chamber pressure.

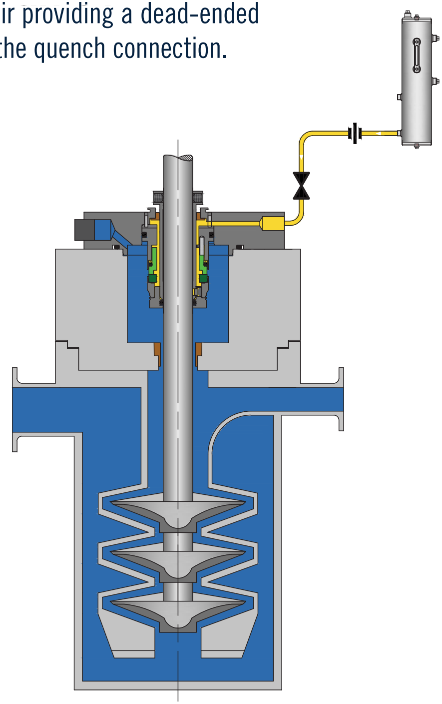


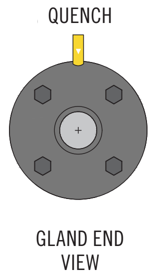
PLAN 74

Application Notes:

- Used in Arrangement 3 dual pressurized seals, where the barrier medium is a gas.
- Most common barrier gas is nitrogen. Ensure a reliable supply and avoid the use of bottles if possible.
- Barrier gas must be pressurized prior to filling the pump and this pressure must be maintained at all times, including during standby.
- Used with non-contacting and contacting mechanical seal solutions.
- Typically used in applications that may contain toxic or hazardous materials whose leakage cannot be tolerated.
- Barrier-fluid leakage to atmosphere is an inert gas (e.g. N_2). Drainage and cleanup is not an issue as with dual liquid systems.
- Inert barrier gas can be easily separated from the process stream.
- Not recommended for services where sticky or polymerizing agents will be in direct contact with the seal faces; similarly, avoid applications that may lead to solids buildup.

External reservoir providing a dead-ended fluid blanket to the quench connection.



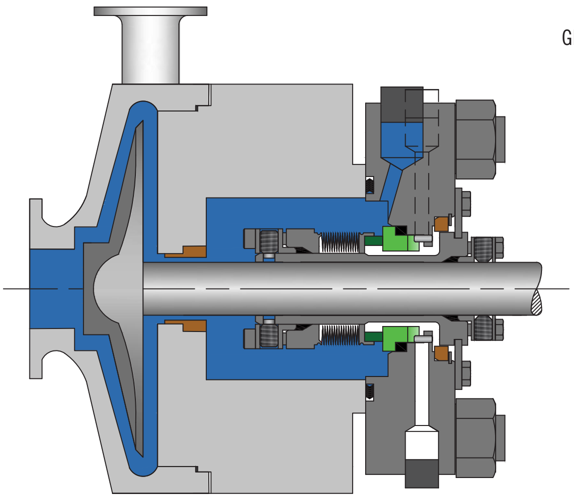


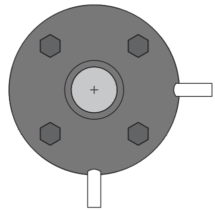
PLAN 51

Application Notes:

- Typically used when a dead-ended atmospheric quench is needed.
- Can be used to prevent or remove any ice formation on the atmospheric side of the seal of a pump operating with a fluid below 32°F [0°C].
- Continuous quench supply such as steam is not needed.

Tapped and plugged atmospheric-side connections for the purchaser's use.



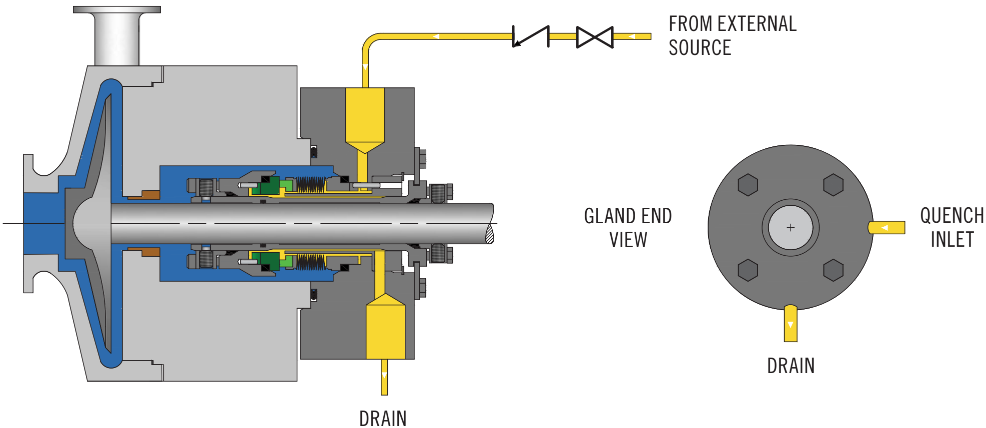


PLAN 61

Application Notes:

- Metallic plugs must be used if seal is being put into service without piping into a connection.
- Ensure atmospheric-side ports are plugged when not in use. Open ports can lead to foreign particles entering the seal and potential seal failure.
- Plan 62 can be readily installed with no seal modifications required.

Quench stream is brought from an external source to the atmospheric side of the seal.

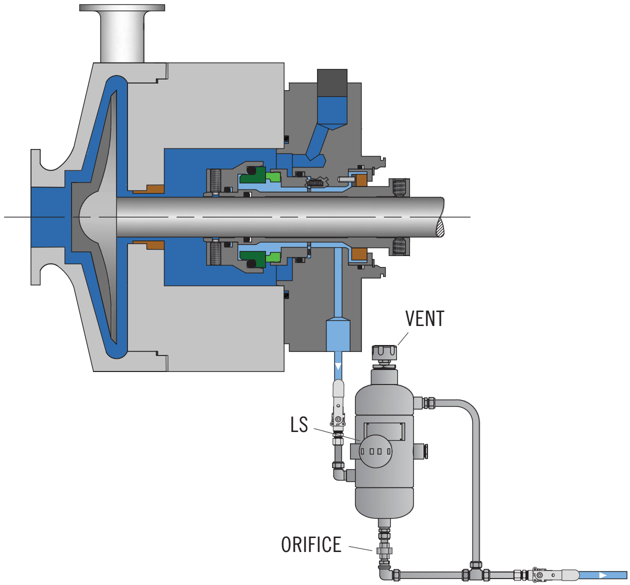


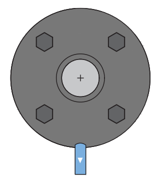
PLAN 62

Application Notes:

- Quench is used to prevent unwanted material buildup on the atmospheric side of the seal faces.
- Must be used with a close clearance bushing or containment device in the seal gland to concentrate the quench to the desired target area.
- Quench pressure should be maintained between 2 to 7 psi [0.14 to 0.48 bar] to ensure purging of atmospheric gases.
- Often used with steam to avoid coking or crystallization in hot hydrocarbon services. Often used with nitrogen to avoid icing in cryogenic applications.
- Low-cost alternative to double seals to improve conditions on low-pressure side of process seal.
- Bushing contains the quench in the seal gland and also provides protection for personnel if a high temperature quench is being used.
- Proper controls must be in place to ensure steam does not condense and then boil, which could cause seal damage on hot processes.

Atmospheric leakage collection and detection system for condensing leakage. Seal failure is detected by an excessive flow rate into the leakage collection system.



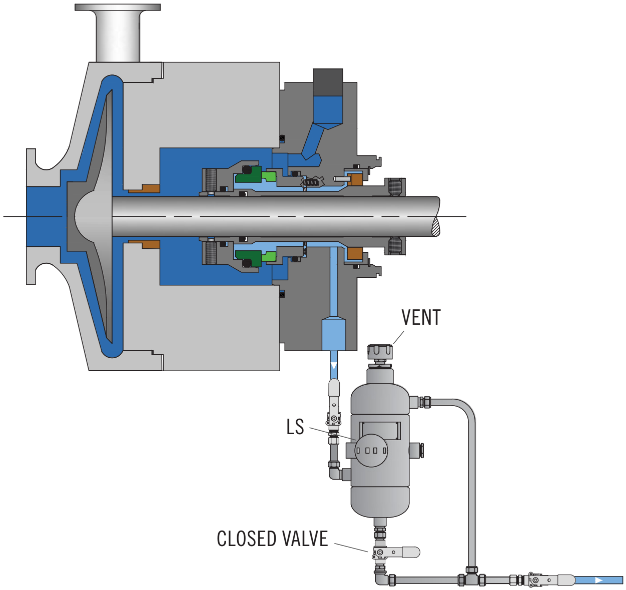


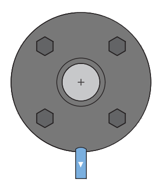
PLAN 65A

Application Notes:

- Normally used with Arrangement 1 seals in services where seal leakage is expected to be mostly liquid.
- Leakage is directed from the drain connection in the seal gland past or through a reservoir and then through an orifice, exiting into a liquid collection system.
- Valve below the gland must always remain open during pump operation to allow leakage to flow to the reservoir.
- The orifice, typically 0.20 in. [5 mm], should be located in a vertical piping leg to avoid accumulation of fluid in the drain piping.
- If flow rates are too high, the orifice will restrict the flow and the level transmitter will trigger an alarm.
- Reservoir typically includes a level transmitter and a local level indicator to monitor conditions.
- Reservoir must be mounted below the seal gland to allow leakage to readily flow to the reservoir.
- Provides an indication of excessive seal leakage and seal failure without manual inspection.

Atmospheric leakage collection and detection system for condensing leakage. Seal failure is detected by cumulative leakage into the leakage collection system.



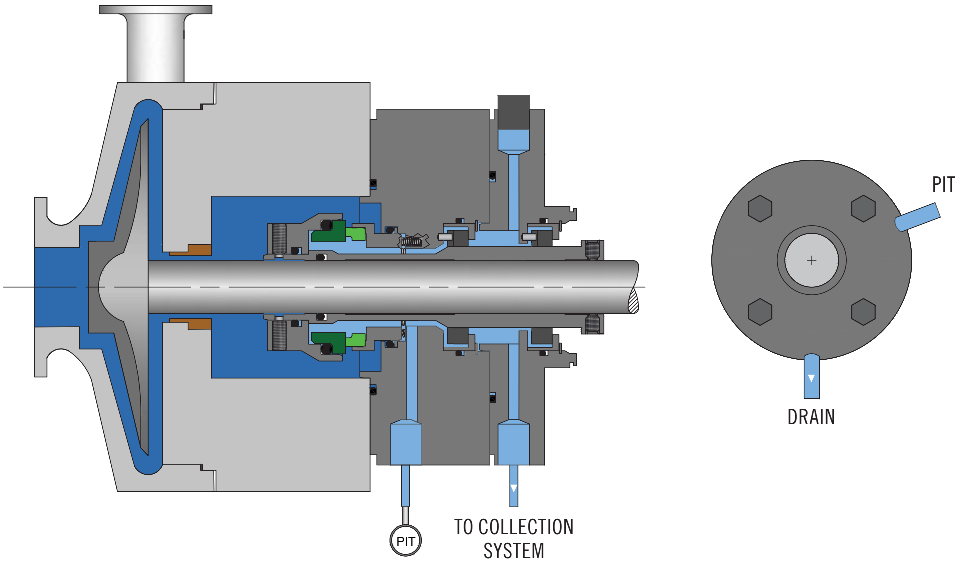


PLAN 65B

Application Notes:

- Normally used with Arrangement 1 seals in services where seal leakage is expected to be mostly liquid.
- Identical to Plan 65A except that the orifice is exchanged for a normally closed valve.
- Leakage is directed from the drain connection in the seal gland into a reservoir resulting in an increase in level of process fluid in the reservoir.
- Valve below the gland must always remain open during pump operation to allow leakage to flow to the reservoir.
- Valve below the reservoir should normally be closed during operation but can be periodically opened to drain collected leakage from the reservoir.
- Reservoir must be mounted below the seal gland to allow leakage to readily flow to the reservoir.
- A liquid level increase will be monitored by the level transmitter and will activate an alarm.
- Provides an indication of excessive seal leakage and seal failure without manual inspection.
- Normal leakage may trigger the alarm over extended periods of time; system requires scheduled draining of reservoir.

Throttle bushings in the seal gland minimize the leakage leaving the seal gland and allows for detection of a seal failure.

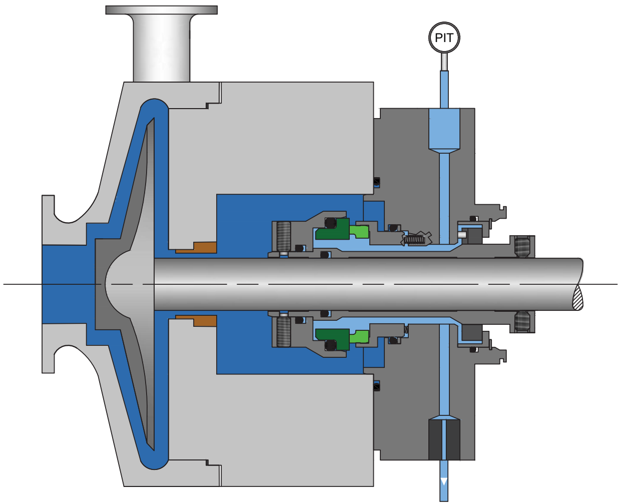


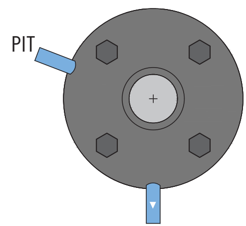
PLAN 66A

Application Notes:

- Intended for use in Arrangement 1 applications where it is required to limit leakage in case of a seal failure or it is required to monitor excessive leakage.
- Leakage out of the drain port is collected and piped to a liquid recovery system or sump.
- As the leakage rate increases, the pressure will increase on the upstream side of the inner bushing which is in line with the pressure transmitter.
- Pressure in the drain cavity will be monitored by the pressure transmitter and can be used to monitor seal performance and trigger an alarm.

An orifice plug in the drain port minimizes the seal leakage leaving the seal gland and allows for detection of a seal failure.



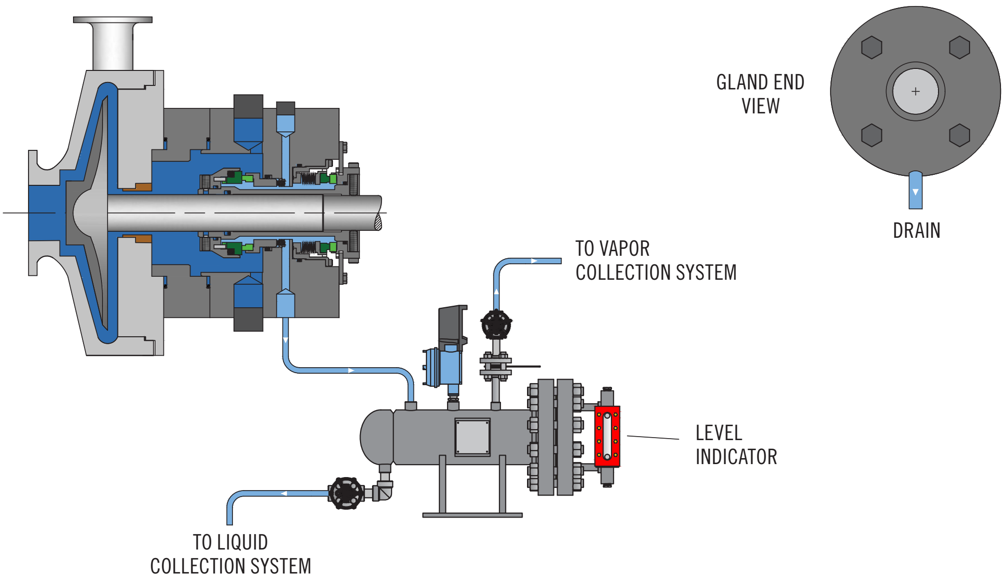


PLAN 66B

Application Notes:

- Intended for use in Arrangement 1 applications where it is required to limit leakage in case of a seal failure or it is required to monitor excessive leakage.
- Replaces one of the bushings from Plan 66A with an orifice in the drain connection.
- Leakage out of the drain port is collected and piped to a liquid recovery system or sump.
- As the leakage rate increases, the pressure will increase on the upstream side of the orifice plug. Orifice plug is used to limit the amount of leakage out of the seal gland.
- Pressure in the drain cavity will be monitored by the pressure transmitter and can be used to monitor seal performance and trigger an alarm.
- Properties of the process fluid should be verified to avoid possible blockage at the orifice plug.

Leakage collection system for condensing or mixed phase leakage with a contacting containment seal.

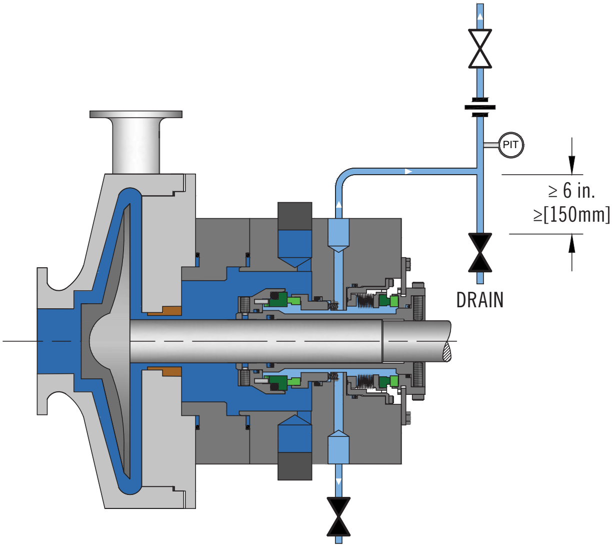


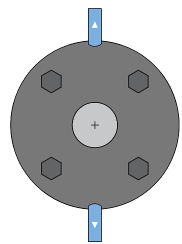
PLAN 75

Application Notes:

- Used with Arrangement 2 seals. May be used with a buffer gas (Plan 72) or without a buffer gas (Plan 71).
- Ensure that the line to the vapor collection system is open and an orifice is present to generate back pressure.
- Leakage collection system should always be mounted below pump centerline.
- Provides an indication of seal performance based on leakage accumulation.
- Avoids direct leakage of pumped media into the atmosphere.
- Liquid and vapor leakage are both collected and separated.
- Excessive leakage and increased pressure can signal an alarm.
- Normal condensing leakage may trigger the alarm over extended periods of time; system requires scheduled draining of reservoir.

Vent for non-condensing leakage with a contacting containment seal.





PLAN 76

Application Notes:

- Typically used on Arrangement 2 unpressurized dual seals, which also utilize a dry running containment seal.
- Used if the pumped fluid does not condense at ambient temperatures.
- Ensure condensate drain is at a low point.
- Ensure vent line is open and orifice is present to generate back pressure.
- May be used with a buffer gas (Plan 72) or without a buffer gas (Plan 71).
- Lower initial/maintenance cost than dual unpressurized seals using Plan 52 by eliminating sometimes costly support systems.
- Leakage from inner seal is contained and vented safely.

Engineered piping plan not defined by other existing plans.

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General Statement of Terms and Data Included in this Booklet

Information presented in this booklet is provided for general guidance only and may not apply to specific seal applications. Every effort has been made to ensure the information presented is correct and current as of October 2021.

Variables including pressure, temperature, installation, and materials of construction will affect seal performance. Please contact Flexaseal for specific details and recommendations.

Temperature Ratings for Secondary Sealing Elements

	CELSIUS (°C)		FAHRENHEIT (°F)	
	Min.	Max.	Min.	Max.
Nitrile (general service)	-34	121	-30	250
Fluorocarbon/Fluoroelastomer	-26	205	-15	400
Ethylene Propylene	-57	121	-70	250
Perfluoroelastomer	-26	320	-15	608
TFE-P / TFE-Propylene	-9	232	15	450
25% Glass-filled PTFE	-73	260	-100	500
Graphite	-212	500	-350	932
Flexitallic®	-240	450	-400	842

NOTE: Limits noted are for reference only. Actual temperature limits and secondary sealing material selection are dependent on the product, temperature, and pressure. Contact Flexaseal for specific application requirements and recommendations.

Gland Bolt Torque Ratings

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The following torque ratings and recommendations are provided to ensure glands without a register fit or metal-to-metal mate with the seal chamber are adequately aligned and square with the shaft. Considerable power losses can occur if the threads are damaged or in the dry condition. Lubrication of the threads with a suitable lubricant is critical for accurate bolt tensioning and gasket compression. Lubricants with additives like molybdenum, nickel, copper, ceramic, PTFE, and graphite are suitable and superior to regular SAE oils. Studs with damaged threads should be replaced or repaired before installation. Tensioning of the bolt should be done using the Legacy Method (Star Pattern) in even ¼ turn increments until the correct torque is achieved. A final check of all four bolts is always recommended.

Shaft Size	1.000–2.000 in. [24–50 mm]	2.125–3.250 in. [53–80 mm]	3.375–4.000 in. [85–100 mm]
Recommended Torque	20 lbf·ft 27 N·m	25 lbf·ft 34 N·m	30 lbf·ft 41 N·m

For mechanical seals with a register fit or metal-to-metal mate with the seal chamber, standard torque-tension specification for bolts and studs is sufficient.

Cup Point Set Screw Torque Ratings

SCREW SIZE	ALLOY STEEL	STAINLESS
#10	36 lbf·in	26 lbf·in
1/4	87 lbf·in	70 lbf·in
5/16	165 lbf·in	130 lbf·in
3/8	290 lbf·in	230 lbf·in
1/2	620 lbf·in	500 lbf·in

SCREW SIZE	ALLOY STEEL	STAINLESS
M4	2.0 N·m	1.5 N·m
M6	7.9 N·m	6.1 N·m
M8	19.6 N·m	15.4 N·m
M10	37.0 N·m	29.5 N·m
M12	60.3 N·m	48.3 N·m

Recommended Lubricant Selection for Seal Installation

Application	Lubricant
Elastomeric O-rings (excluding ethylene propylene – see below)	Petrolatum Glycerin Dow Corning™ 111 (FDA Approved) Dow Corning™ 55
Ethylene propylene O-rings	Glycerin
Elastomeric bellows	Soapy water
Bolts, screws, nuts, fasteners (excluding cup and cone point set screws)	Molybdenum, Graphite or PTFE-based anti-seize compounds

Buffer/Barrier Fluid Guidelines

	CELSIUS (°C)		FAHRENHEIT (°F)	
	Min.	Max.	Min.	Max.
Water	2	85	35	185
Glycol mixtures	-29	82	-20	180
Propanol (n-propanol)	-85	70	-121	158
Kerosene/Diesel	-18	82	0	180
Lubricating oils	-29	150	-20	302
Synthetic oils	-32	250	-25	482
Heat-Transfer fluids	-18	340	0	644

Courtesy of the Hydraulic Institute, www.pumps.org
Mechanical Seals for Pumps: Application Guidelines. First Edition. Hydraulic Institute, 2006, p. 222

NOTE: These are general outlines for different barrier/buffer fluid families. Specific fluids may have temperature ratings that vary from this guide. Contact Flexaseal for specific application notes.

Buffer/Barrier Fluids

Buffer/ Barrier Bluid	Notes	Advantages	Disadvantages
Water	■ Tap water can scale or plate out at elevated temperatures. Use distilled or demineralized water when possible.	■ Can be used in a large variety of applications. ■ Cost effective, easy to handle and store, limited material compatibility issues. ■ Readily available at most sites. ■ Easy to remove from most products.	■ Limited temperature range: potential for freezing if used in cold applications. ■ Potential for flashing if used in hot applications. ■ Can be corrosive if not pure. While most seal components will use stainless steels, some reservoirs can be made of carbon steel to reduce cost. Ensure systems use non-rusting materials.

Buffer/ Barrier Bluid	Notes	Advantages	Disadvantages
Glycol Mixtures	■ Propylene glycol is recommended. Ethylene glycol is now listed as a VHAP and no longer recommended. ■ Typical mixture ratios are in the 30-60% range. Mixtures with a glycol content greater than 50% are not recommended due to a significant increase in viscosity. ■ Use of distilled or deionized water is recommended. Tap water is not recommended for mixing because impurities can scale or add to corrosion. ■ Automotive antifreeze is not recommended because it has additives which can damage the seal.	■ Cost effective. ■ Freezing and boiling points can be controlled by solution ratios.	■ Pure glycol/water mixtures are recommended; however uninhibited mixtures do not provide any additional corrosion resistance. ■ Uninhibited glycol/water mixtures can be subject to foaming in highly pressurized systems.

continued →

Buffer/Barrier Fluids, cont.

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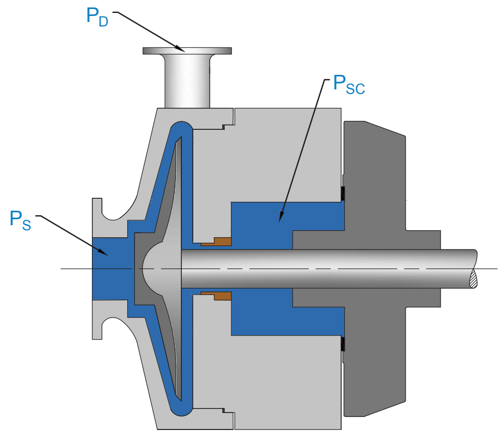
Buffer/ Barrier Bluid	Notes	Advantages	Disadvantages
Propanol (n-propanol)	▪ Replaces methanol which is now classified as a VHAP.	▪ Performs well in low-temperature applications.	▪ Limited high temperature limit. ▪ High vapor pressures and tendencies to evaporate quickly make propanol and other alcohols unsuitable for many applications.
Kerosene/ Diesel	▪ Consult local regulations for emissions and health restrictions. ▪ Typically used in refinery and petrochemical applications.	▪ Available in a variety of viscosities and temperature ranges.	▪ Flammable in high temperature applications. ▪ Potentially explosive in high temperature and high pressure applications.
Petroleum-Based Lubricating Oils	▪ Anti-wear additives can plate out on the seal faces. ▪ Traditionally used with viscosities between ISO VG5 to ISO VG20. ▪ Higher viscosity oils are used for higher temperatures and/or lower shaft speeds.	▪ Available in a variety of viscosities.	▪ Can contain additives that can damage a mechanical seal. ▪ Oils above an ISO VG32 can cause blistering with carbon seal faces and decrease pumping ring performance.

Buffer/ Barrier Bluid	Notes	Advantages	Disadvantages
Synthetic Oils	■ Traditionally used with viscosities ranging between ISO VG5 to ISO VG20. ■ Higher viscosity oils are used for higher temperatures and/or lower shaft speeds.	■ Some oils are designed specifically for mechanical seal applications. Perform better than traditional lubricating oils. ■ Available in a variety of viscosities.	■ Can contain additives that can damage a mechanical seal. ■ Oils above an ISO VG32 can cause blistering with carbon seal faces and decrease pumping ring performance. ■ Expensive.
Heat Transfer Fluids	■ Typically used in hot refinery applications.	■ Available in a variety of viscosities and temperature ranges. ■ Available in a variety of base chemicals and compounds for different applications. ■ Can be used in very high temperature applications.	■ Potentially toxic. ■ If exposed to cold atmospheric conditions, the viscosity can be very high which may result in poor circulation and/or damage to the seal faces. ■ Typically not formulated as a lubricating fluid. May not provide adequate support to the seal faces, resulting in excessive wear or damage.

Single Stage, Single Suction, Overhung Process Pumps

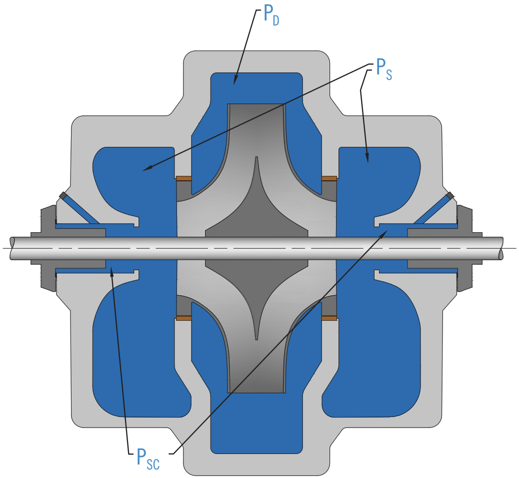
$$P_{SC} = P_S + K(P_D - P_S)$$

IMPELLER TYPE	K
IMPELLER MINIMUM DIAMETER	0.30
IMPELLER MAXIMUM DIAMETER	0.10
ENCLOSED, NO PUMP-OUT VANES, NO BALANCE HOLES	0.70
ENCLOSED, BALANCE HOLES, BACK RING	0
SCALLOPED SHROUD, PUMP-OUT VANES	0.15
SEMI-OPEN, PUMP-OUT VANES, BALANCE HOLES	0.10



Single Stage, Double Suction Pumps

$P_{SC} = P_S$



Two Stage Horizontal Pumps

Back to back impellers (SHOWN):

$P_{SCL} = P_S$

$P_{SCH} = P_S + .5(P_D - P_S)$

With balancing line:

$P_{SCH} = P_S$

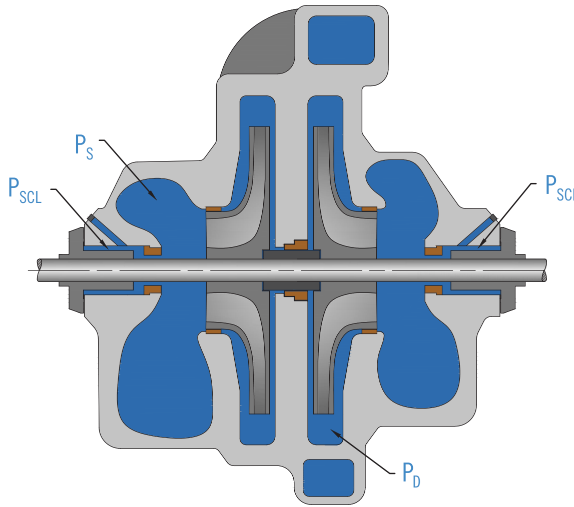
Eye to eye impellers:

$P_{SCL} = P_S + .5(P_D - P_S)$

$P_{SCH} = P_D$

With balancing line:

$P_{SCH} = P_S$



Multistage Horizontal Pumps

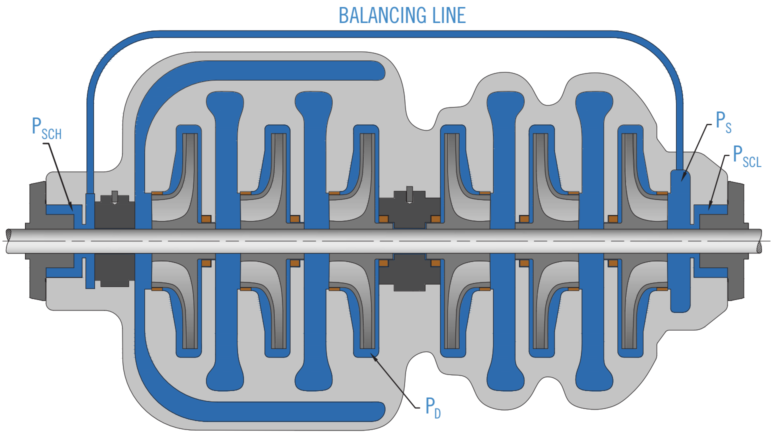
$P_{SCL} = P_S$
$P_{SCH} = P_S$

Without balancing line:

$P_{SCH} = P_S + n(P_D - P_S)/N$

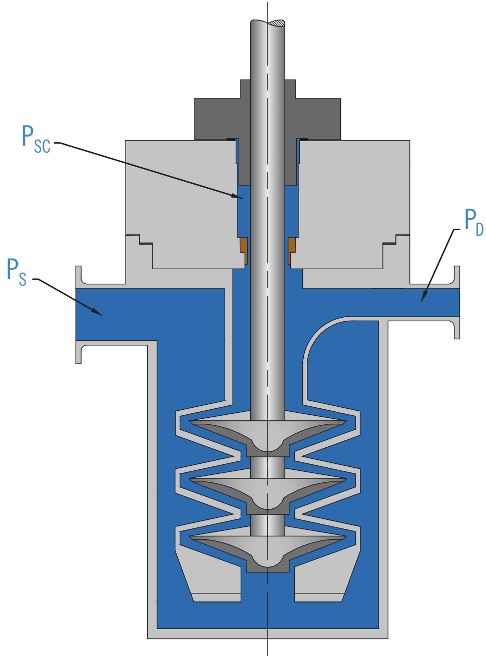
n = stage closest to high pressure seal chamber

N = total number of stages



Vertical Multistage Pumps

$P_{SC} = P_D$



Commonly Used Unit Conversions

LENGTH

From	To	Multiply by	From	To	Multiply by
inches	mm	25.4	mm	inches	0.03937
inches	m	0.0254	m	inches	39.37
feet	mm	304.8	mm	feet	0.00328
feet	m	0.3048	m	feet	3.281
yards	m	0.9144	m	yards	1.0936
miles	km	1.6093	km	miles	0.6214
µin	mm	2.54×10^{-5}	mm	µin	39370
µin	nm	25.4	nm	µin	0.03937

continued →

Commonly Used Unit Conversions, cont.

AREA

From	To	Multiply by	From	To	Multiply by
$inches^2$	mm^2	645.16	mm^2	$inches^2$	0.00155
$feet^2$	m^2	0.0929	m^2	$feet^2$	10.7639
$yards^2$	m^2	0.8361	m^2	$yards^2$	1.1960
acres	hectares	0.4047	hectares	acres	2.4711
$miles^2$	km^2	2.59	km^2	$miles^2$	0.3861

PRESSURE/HEAD

From	To	Multiply by	From	To	Multiply by
psi	bar	0.06895	bar	psi	14.5038
psi	kg/cm^2	0.07031	kg/cm^2	psi	14.2233
psi	N/m^2 (Pa)	6894.757	N/m^2 (Pa)	kg/cm^2	1.4504×10^{-4}
kg/cm^2	bar	0.9807	bar	kg/cm^2	1.01972
atms.	psi	14.6959	psi	atms.	0.06805
atms.	kg/cm^2	1.03323	kg/cm^2	atms.	0.96784
atms.	bar	1.01325	bar	atms.	0.98692
N/m^2 (Pa)	bar	1×10^{-5}	bar	N/m^2 (Pa)	1×10^{5}
kPa	bar	0.01	bar	kPa	100
MPa	bar	10	bar	MPa	0.1

continued →

Commonly Used Unit Conversions, cont.

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PRESSURE/HEAD, CONT.

From	To	Multiply by	From	To	Multiply by
bar	torr (mm Hg)	750.062	torr (mm Hg)	bar	0.001333
psi	ft (liquid)	2.307 ÷ SG	ft (liquid)	psi	0.4335 x SG
psi	m (liquid)	0.703 ÷ SG	m (liquid)	psi	1.4223 x SG
bar	ft (liquid)	33.4552 ÷ SG	ft (liquid)	bar	0.02989 x SG
bar	m (liquid)	10.1972 ÷ SG	m (liquid)	bar	0.09806 x SG
kg/cm^2	m (liquid)	10 ÷ SG	m (liquid)	kg/cm^2	0.1 x SG

VOLUME

From	To	Multiply by	From	To	Multiply by
ft^3	m^3	0.028317	m^3	ft^3	35.3147
ft^3	liters (dm^3)	28.317	liters (dm^3)	ft^3	0.035315
in^3	m^3	1.6387×10^{-5}	m^3	in^3	61023.74
gallons (Imp)	gallons (US)	1.20095	gallons (US)	gallons (Imp)	0.83267
gallons (Imp)	m^3	4.5461×10^{-3}	m^3	gallons (Imp)	219.9692
gallons (Imp)	liters (dm^3)	4.54609	liters (dm^3)	gallons (Imp)	0.21997
gallons (US)	m^3	0.003785	m^3	gallons (US)	264.1721
gallons (US)	liters (dm^3)	3.7854	liters (dm^3)	gallons (US)	0.26417
barrels (bbl) oil	gallons (Imp)	34.9723	gallons (Imp)	barrels (bbl) oil	0.028594
barrels (bbl) oil	gallons (US)	42	gallons (US)	barrels (bbl) oil	0.02381

continued →

Commonly Used Unit Conversions, cont.

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VOLUME, CONT.

From	To	Multiply by	From	To	Multiply by
barrels (bbl) oil	m^3	0.1590	m^3	barrels (bbl) oil	6.2898
barrels (bbl) oil	liters (dm^3)	158.9873	liters (dm^3)	barrels (bbl) oil	0.006290

VOLUME FLOW RATE

From	To	Multiply by	From	To	Multiply by
gals (Imp)/min	liters/min	4.5461	liters/min	gals (Imp)/min	0.21997
gals (US)/min	liters/min	3.7854	liters/min	gals (US)/min	0.26417
ft^3/min	liters/min	28.3168	liters/min	ft^3/min	0.03532
m^3/hour	liters/min	16.6667	liters/min	m^3/hour	0.06
barrels oil/day	liters/min	0.1104	liters/min	barrels oil/day	9.0573
ft^3/sec	liters/min	1699.01	liters/min	ft^3/sec	5.866×10^{-4}

WEIGHT/FORCE VOLUME

From	To	Multiply by	From	To	Multiply by
lbs	kg	0.4536	kg	lbs	2.2046
tons (long)	kg	1016.05	kg	tons (long)	9.842×10^{-4}
tons (short)	kg	907.19	kg	tons (short)	1.102×10^{-3}
tons (long)	tonne	1.016047	tonne	tons (long)	0.9842
tons (short)	tonne	0.9072	tonne	tons (short)	1.1023
lbf	N	4.4482	N	lbf	0.2248
kgf	N	9.8067	N	kgf	0.10197
kiloponds	N	9.8067	N	kiloponds	0.10197
tonf (long)	kN	9.96402	kN	tonf (long)	0.10036

continued →

Commonly Used Unit Conversions, cont.

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POWER

From	To	Multiply by	From	To	Multiply by
hp	kW	0.7457	kW	hp	1.34102
hp (metric) also PS, CV or ch	kW	0.7355	kW	hp (metric) also PS, CV or ch	1.35962
Btu/hr k	kW	2.9307×10^{-4}	kW	Btu/hr	3412.1416
ft·lbf/sec	kW	0.001356	kW	ft·lbf/sec	737.5622

TORQUE

From	To	Multiply by	From	To	Multiply by
lbf·ft	N·m	1.3558	N·m	lbf·ft	0.73756
lbf·in	N·m	0.112985	N·m	lbf·in	8.85075
ozf·in	N·m	0.007062	N·m	ozf·in	141.6119
kgf·m	N·m	9.80665	N·m	kgf·m	0.10197

DENSITY/ SPECIFIC GRAVITY (SG)

From	To	Multiply by	From	To	Multiply by
lbs/ft^3	kg/m^3	16.01846	kg/m^3	lbs/ft^3	0.06243
$grams/cm^3$	kg/m^3	1000	kg/m^3	$grams/cm^3$	0.001
lbs/gal (US)	kg/m^3	119.8264	kg/m^3	lbs/gal (US)	0.008345

API GRAVITY (°API)

°API = (141.5/SG)-131.5

SG = 141.5/(°API+131.5)

DEGREES BAUMÉ

Formulas for degrees Baumé apply to solutions with a SG > 1 (more dense than water)

°Bé = 145 - 145/SG

SG = 145/(45-°Bé)

continued →

Commonly Used Unit Conversions, cont.

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VISCOSITY - DYNAMIC & KINEMATIC

From	To	Multiply by	From	To	Multiply by
cPs	N·sec/m^2	0.001	N·sec/m^2	cPs	1000
cPs	Pa·sec	0.001	Pa·sec	cPs	1000
lbf.sec/ft^2	N·sec/m^2	47.8803	N·sec/m^2	lbf·sec/ft^2	0.02089
lbf.sec/ft^2	cPs	47880.259	cPs	lbf·sec/ft^2	2.0885×10^{-5}
cSt	m^2/sec	1.0×10^{-6}	m^2/sec	cSt	1.0×10^{6}
ft^2/sec	cSt	9.2903×10^{4}	cSt	ft^2/sec	1.0764×10^{-5}

Approximate conversions: $cSt = 0.226 \times SSU - (195/SSU)$ for $32 < SSU < 100$

$cSt = 0.22 \times SSU - (135/SSU)$ for $SSU \geq 100$

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