Mechanical Seal Piping Plans

Companion Booklet

Single Seals | Dual Seals | Quench Seals | Second. Cont. | Dual Gas

Introduction

A primary factor in achieving highly reliable, effective sealing performance is to create the best fluid environment around the seal. Selection of the right piping plan and associated fluid control equipment requires a knowledge and understanding of the seal design and arrangement, fluids in which they operate, and of the rotating equipment. Providing clean, cool face lubrication, effective heat removal, personnel and environmental safety, leakage management and controlling system costs are among the specific factors that must be considered. API has established standardized piping plans for seals that provide industry guidelines for various seal arrangements, fluids and control equipment. The following pages illustrate and describe features of these plans as an aid to help you determine what support system requirements will maximize the performance reliability of your fluid handling rotating equipment application.

API 682/ISO 21049 standards have default (required) connections and connection symbols for seal chamber and gland plate connections based upon the seal configuration. It is recommended that the latest edition of these standards be reviewed for up-to-date requirements, when these standards are mandated for a piece of rotating equipment. The intent of this booklet is to illustrate the common connections that are utilized for the various piping plans, regardless of the equipment type, and therefore use generic names for connections. The end user and/or equipment manufacturer may have specific requirements that dictate what connections are to be supplied and how they are to be labeled.

In the piping plans illustrated, the “Flush” connection noted for the inboard seal of a dual seal may originate from a number of suitable sources. For example, the “Flush” for piping plans 11/75 or 32/75 may be the product (Plan 11) or an external source (Plan 32).

API682/ISO21049 **General Comments**

Piping Plan **Description**

Plan 01 Single Seals - Internal Flush
Plan 02 Single Seals - No Flush, Large Open Bore
Plan 11 Single Seals - By-Pass From Discharge With Orifice
Plan 12 Single Seals - By-Pass From Discharge With Filter & Orifice
Plan 13 Single Seals - Flush Thru Seal Chamber Thru Orifice To Suction
Plan 14 Single Seals - By-Pass From Discharge Thru Seal Chamber Back To Suction
Plan 21 Single Seals - By-Pass From Discharge Thru Orifice & Heat Exchanger
Plan 23 Single Seals - Closed Loop Circulation Thru Heat Exchanger
Plan 31 Single Seals - By-Pass From Discharge Thru Orifice & Abrasive Separator
Plan 32 Single Seals - External Flush Source To Seal
Plan 41 Single Seals - By-Pass From Discharge Thru Abrasive Separator & Heat Exchanger
Plan 52 Dual Seals, Unpressurized - External Reservoir Unpressurized Liquid Buffer

Plan 53A Dual Seals, Pressurized - External Reservoir Pressurized Liquid Barrier
Plan 53B Dual Seals, Pressurized - Liquid Barrier Thru Heat Exchanger & Pressurized By Accumulator
Plan 53C Dual Seals, Pressurized - Liquid Barrier Thru Heat Exchanger With Differential Tracking Piston Accumulator
Plan 54 Dual Seals, Pressurized - External Pressurized Barrier System/Source
Plan 62 Quench Seals - External Quench On Atmospheric Side Of Seal
Plan 65 Single Seals - External Leakage Detection Reservoir
Plan 72 Secondary Containment Seals - Low Pressure Buffer Gas Injected To Outer Seal Cavity
Plan 74 Dual Gas Seals - Pressurized Dual Gas Seal Thru Conditioning Panel
Plan 75 Secondary Containment Seals - Secondary Cont. Seal With Leakage Collection Reservoir
Plan 76 Secondary Containment Seals - Secondary Cont. Seal Vented To Flare Or Collection System

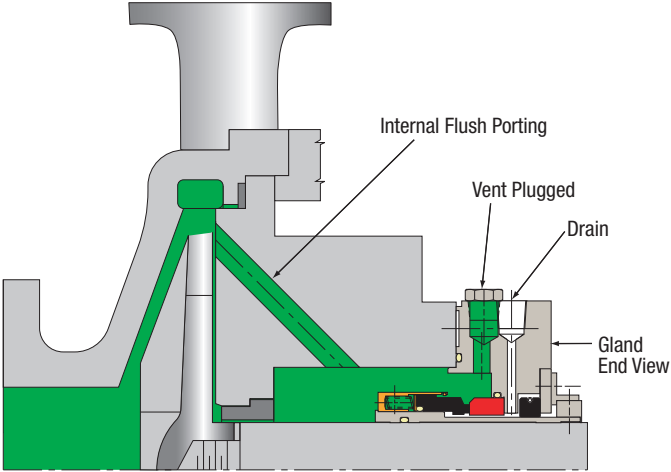
Piping Plan **Description**

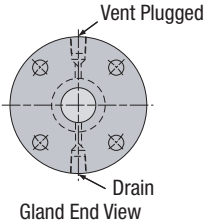
Plan **01** Single Seals

Description: Plan 01 is an internal recirculation from the pump discharge area of the pump into the seal chamber, similar to a Plan 11 but with no exposed piping.

Advantages: No product contamination and no external piping. Advantageous on highly viscous fluids at lower temperatures to minimize the risk of freezing that can occur with exposed piping arrangements.

General: This flush plan should only be used for clean products as dirty products can clog the internal line. Not recommended on vertical pumps.





- Vent (If Req'd.) Plugged
- No External Flush
- Quench Optional

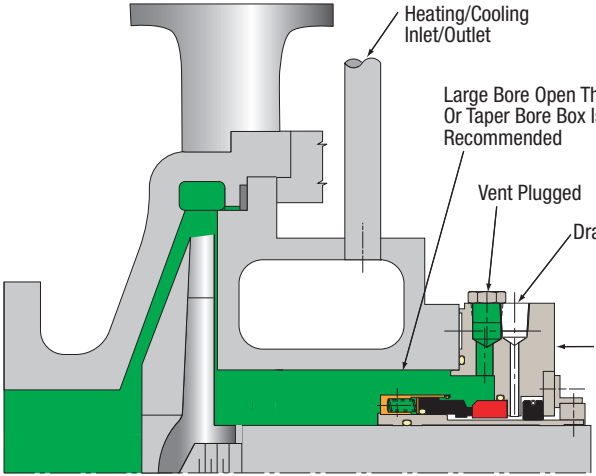
Plan **01** Single Seals

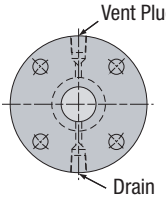
Plan 02 Single Seals

Description: Plan 02 is a non-circulating flush plan recommended only where adequate vapor suppression can be assured.

Advantages: Solids are not continually introduced into the seal chamber, no external hardware is required, and natural venting occurs when used with a tapered bore seal chamber.

General: Ideal with large bore/tapered bore ANSI/ASME B73.1 or ISO 3069 Type “C” seal chambers or with hot process pumps utilizing a cooling jacket. On the latter services, a Plan 62 with steam quench can also provide some additional cooling.





Gland End View

- No Flush
- Vent (If Req'd.) Plugged
- Quench Optional
- Ensure Seal Chamber Is Fully Vented

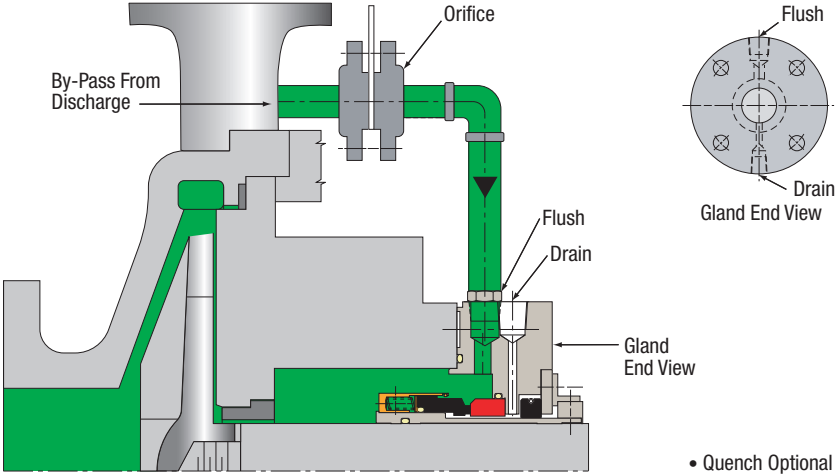
Plan **02** Single Seals

Plan **11** Single Seals

Description: Plan 11 is the most common flush plan in use today. This plan takes fluid from the pump discharge (or from an intermediate stage) through an orifice(s) and directs it to the seal chamber to provide cooling and lubrication to the seal faces.

Advantages: No product contamination and piping is simple.

General: If the seal is setup with a distributed or extended flush, the effectiveness of the system will be improved.



• Quench Optional

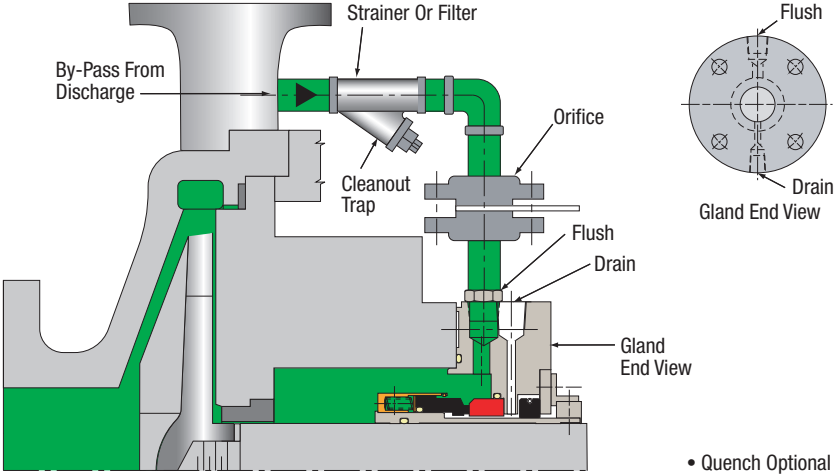
Plan **11** Single Seals

Plan **12** Single Seals

Description: Plan 12 is similar to Plan 11, except that a strainer or filter is added to the flush line.

Advantages: No product contamination and solids are removed from the flush stream keeping the seal clean.

General: If the seal is setup with a distributed or extended flush, the effectiveness of the system will be improved. This plan should be equipped with a differential pressure indicator or alarm to alert the user that the filter or strainer is clogged.



• Quench Optional

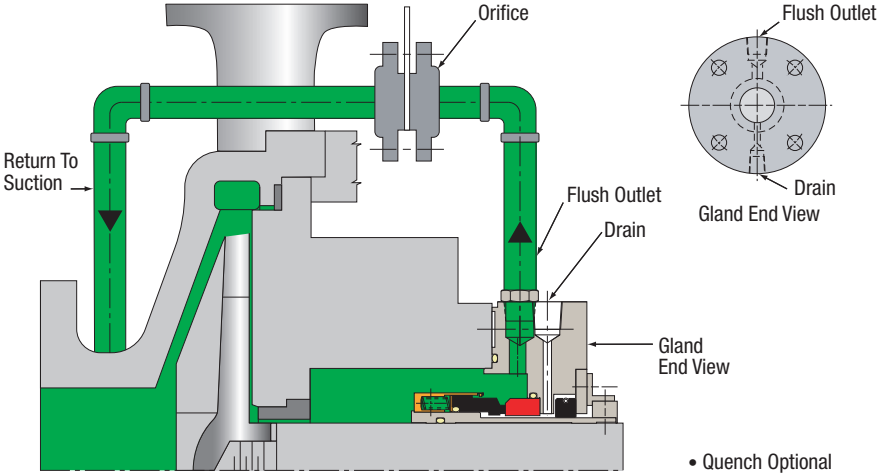
Plan **12** Single Seals

Plan 13 Single Seals

Description: In a Plan 13, the flow exits the seal chamber through an orifice and is routed back to pump suction.

Advantages: With a Plan 13, it is possible to increase or decrease seal chamber pressure with proper sizing of the orifice and throat bushing clearance.

General: Typically Plan 13 is used on vertical turbine pumps since they have the discharge at the top of the pump where the seal is located. Because of the difference in flow patterns, Plan 13 is not as efficient in removing heat as a Plan 11 and thus requires a higher flow rate.



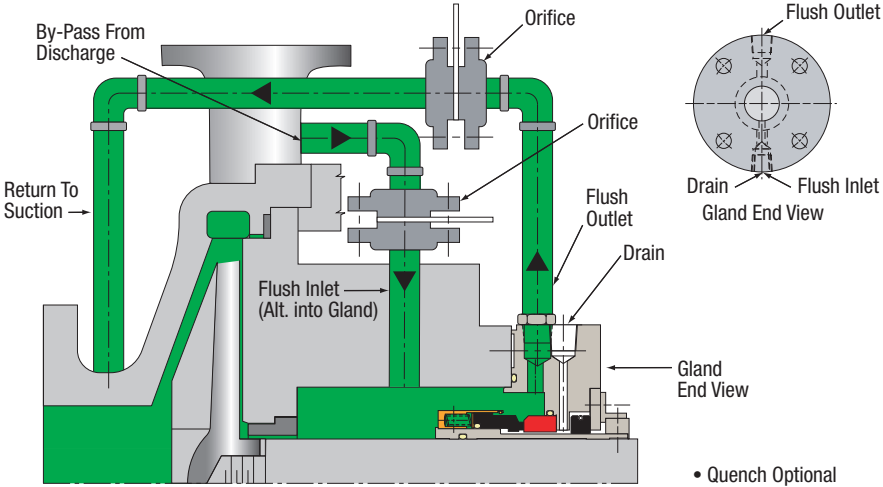
Plan **13** Single Seals

Plan **14** Single Seals

Description: Plan 14 is a combination of Plans 11 and 13. Flush is taken off of pump discharge, sent to the seal chamber, and piped back to pump suction.

Advantages: Cooling can be optimized with the flush directed at the seal faces. Plan allows for automatic venting of the seal chamber.

General: Often used on vertical pumps to provide adequate flow and vapor pressure margin independent of throat bushing design.



• Quench Optional

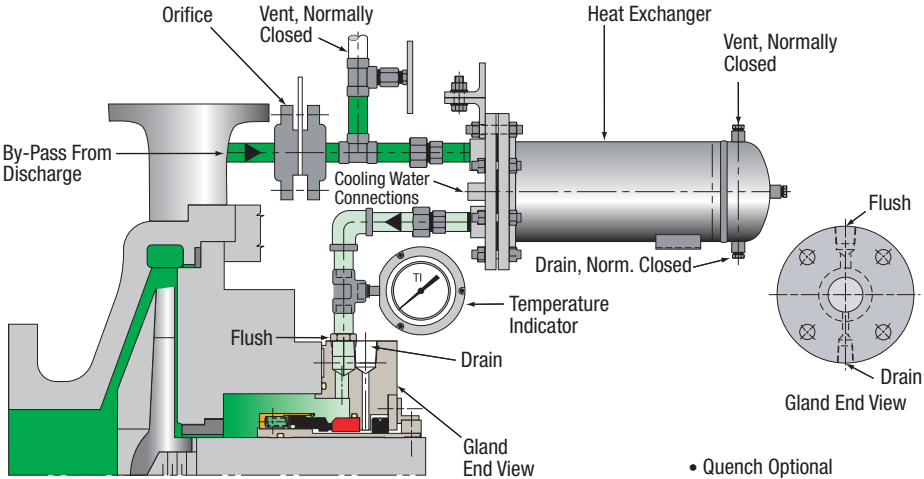
Plan **14** Single Seals

Plan 21 Single Seals

Description: Plan 21 is a cooled version of Plan 11. The product from pump discharge is directed through an orifice, then to a heat exchanger to lower the temperature before being introduced into the seal chamber.

Advantages: Process fluid cools and lubricates the seal, therefore no dilution of process stream. Cooling improves lubricity and reduces the possibility of vaporization in the seal chamber.

General: Plan 21 is not a preferred plan, either by API or many users, due to the high heat load put on the heat exchanger. A Plan 23 is preferred.



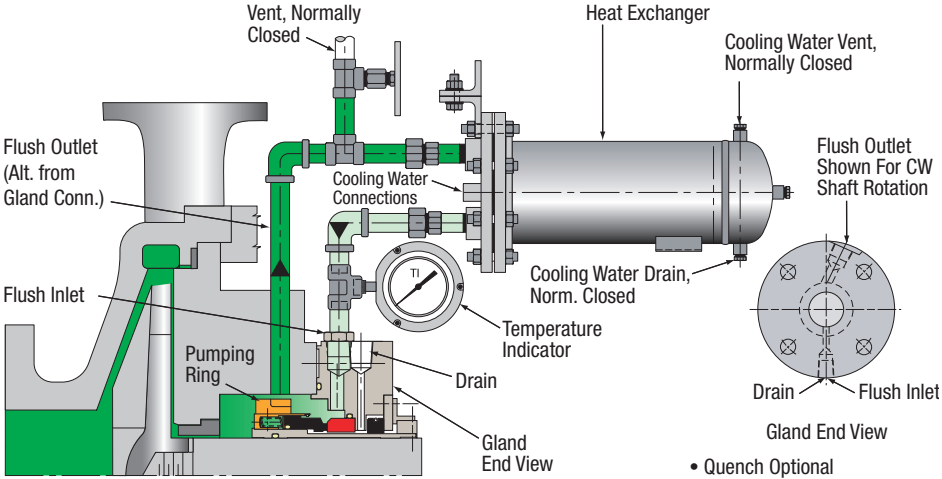
Plan **21** Single Seals

Plan **23** Single Seals

Description: Plan 23 is a closed loop system using a pumping ring to circulate product through a heat exchanger and back to the seal chamber.

Advantages: More efficient than a Plan 21 and less chance of heat exchanger fouling. Reduced temperature improves lubricity and improves vapor pressure margin.

General: Preferred plan for hot applications. Close clearance throat bushing is recommended to reduce mixing of hot product with cooler closed loop system fluid.



Plan **23** Single Seals

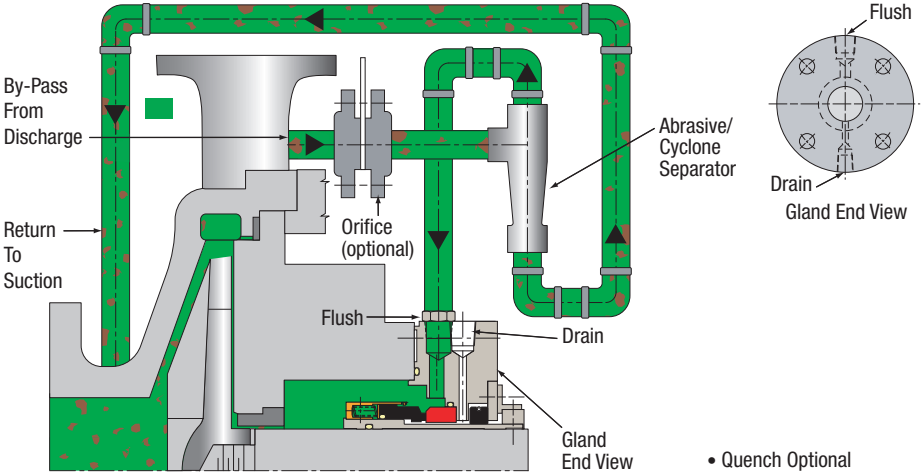
Plan **31** Single Seals

Description: Plan 31 is a variation of Plan 11, where an abrasive separator is added to the flush line. In this plan, the product is introduced to the abrasive separator from the discharge of the pump, clean flush is piped from the separator to the seal chamber and solids are returned to the pump suction.

Advantages: Unlike a strainer or filter, the abrasive separator does not require cleaning. Solids are removed from the flush stream keeping the seal clean.

General: This plan should be used for services containing solids that have a specific gravity at least twice that of the process fluid. Typically the separator requires a minimum pressure differential of 15 psi to operate properly.

Note: A abrasive separator is subject to wear and must be maintained regularly to ensure efficient operation.



• Quench Optional

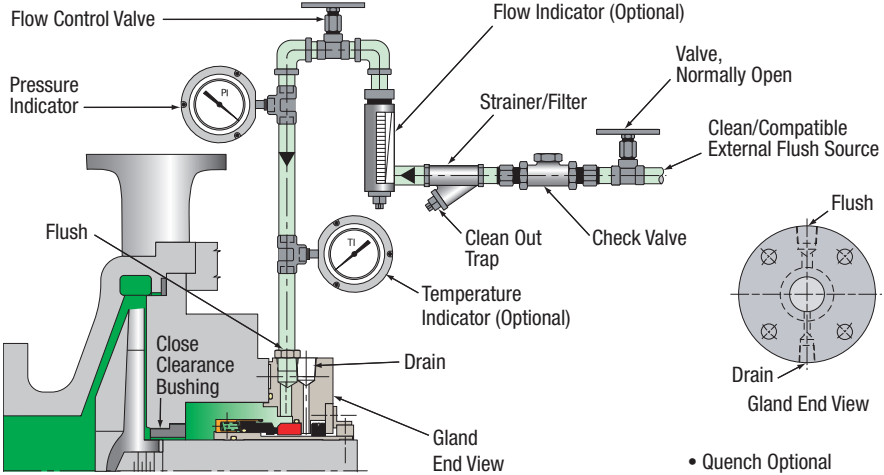
Plan **31** Single Seals

Plan **32** Single Seals

Description: Plan 32 uses a flush stream brought in from an external source to the seal. This plan is almost always used in conjunction with a close clearance throat bushing.

Advantages: The external flush fluid, when selected properly, can result in vastly extended seal life.

General: When an outside flush source is used, concerns regarding product dilution and/or economics must be considered by the user. Source pressure must be maintained a minimum of 15 psig above maximum seal chamber pressure.



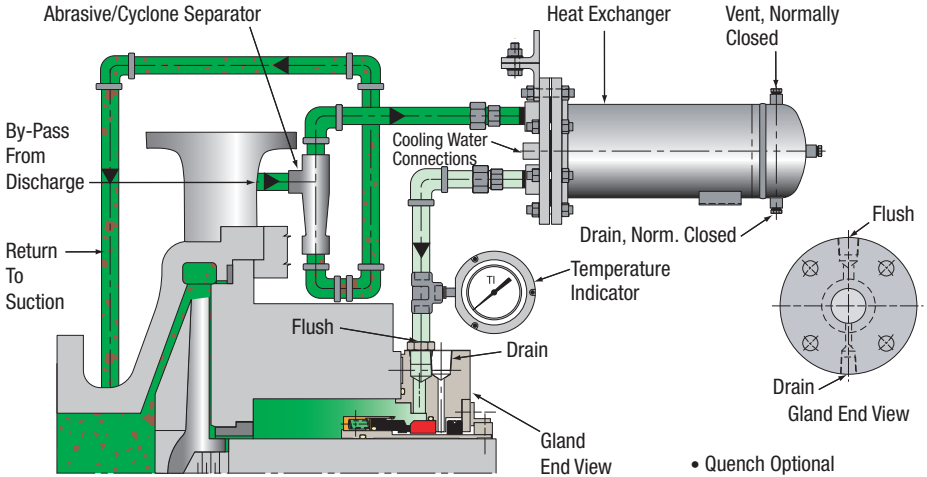
Plan **32** Single Seals

Plan 41 Single Seals

Description: Plan 41 is a combination of Plan 21 and Plan 31. In Plan 41, product from pump discharge is first put through an abrasive separator and then to the heat exchanger before being introduced to the seal chamber.

Advantages: Solids are removed and product temperature is reduced to enhance the seal's environment.

General: Plan 41 is typically used on hot services with solids; however, depending on the temperature of the process, operating costs can be high. This plan should be used for services containing solids that have a specific gravity at least twice that of the process fluid. Typically the separator requires a minimum pressure differential of 15 psi to operate properly.



Plan **41** Single Seals

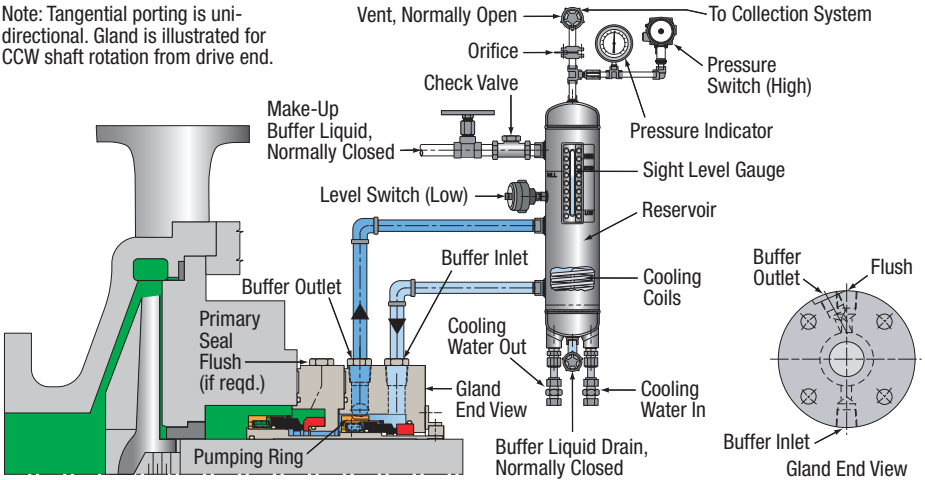
Plan **52** Dual Seals, Unpressurized

Description: Plan 52 uses an external reservoir to provide buffer fluid for the outer seal of an unpressurized dual seal arrangement.

Advantages: In comparison to single seals, dual unpressurized seals can provide reduced net leakage rates as well as redundancy in the event of a primary seal failure.

General: Cooling coils in the reservoir are available for removing heat from the buffer fluid. Plan 52 is often used where process fluid contamination can not be tolerated.

Note: Tangential porting is uni-directional. Gland is illustrated for CCW shaft rotation from drive end.



Plan **52** Dual Seals, Unpressurized

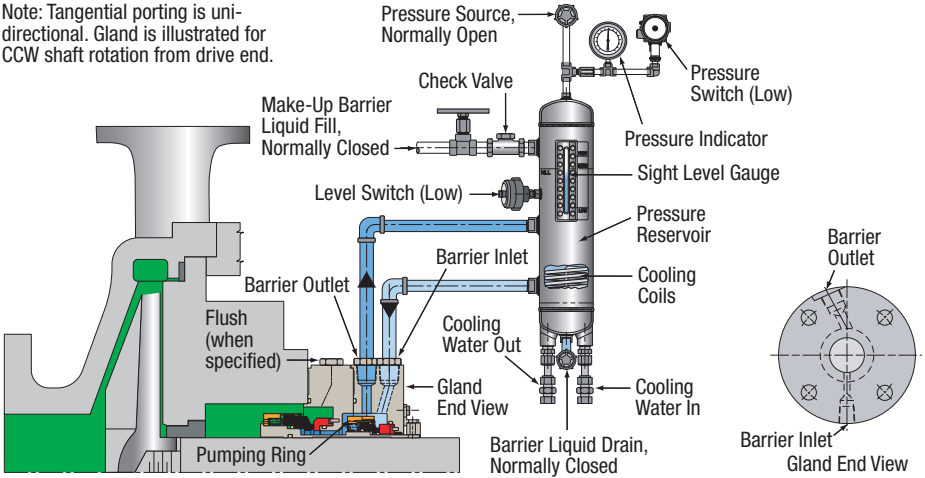
Plan **53A** Dual Seals, Pressurized

Description: Plan 53A uses an external reservoir to provide barrier fluid for a pressurized dual seal arrangement. Reservoir pressure is produced by a gas, usually nitrogen. Flow is induced by a pumping ring.

Advantages: Reservoir size can be optimized dependent on flow rate. Wear particles settle to bottom of reservoir and don't get recirculated.

General: Heat is dissipated by reservoir cooling coils. Barrier fluid is subject to gas entrainment at pressures/temperatures above 300 psi/250^{0}F.

Note: Tangential porting is uni-directional. Gland is illustrated for CCW shaft rotation from drive end.



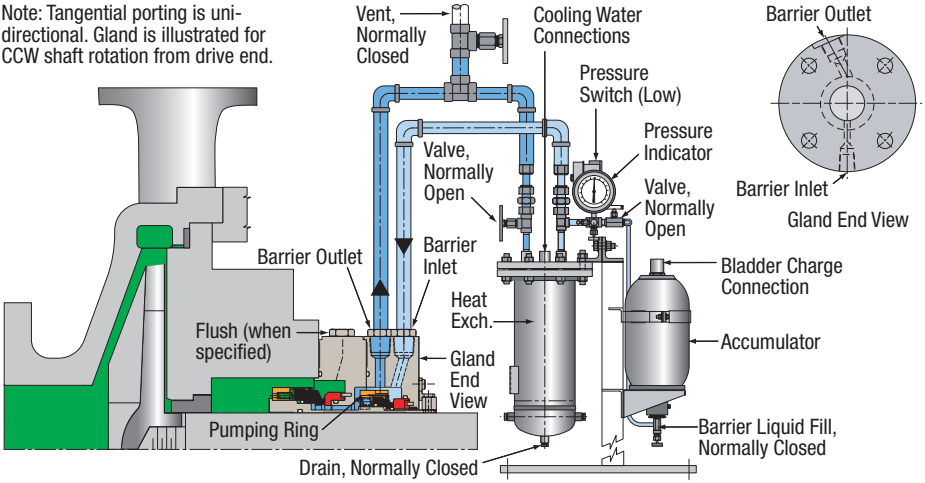
Plan **53A** Dual Seals, Pressurized

Plan **53B** Dual Seals, Pressurized

Description: Plan 53B, previously termed 53 Modified, uses an accumulator to isolate the pressurizing gas from the barrier fluid. A heat exchanger is included in the circulation loop to cool the barrier fluid. Flow is induced by a pumping ring.

Advantages: Should the loop be contaminated for any reason, the contamination is contained within the closed circuit. The make-up system can supply barrier fluid to multiple dual pressurized sealing systems.

General: The bladder accumulator isolates the pressurizing gas from the barrier fluid to prevent gas entrainment. The heat exchanger can be a water-cooled unit, an air-cooled unit, or utilize finned tubing based upon the system heat load.



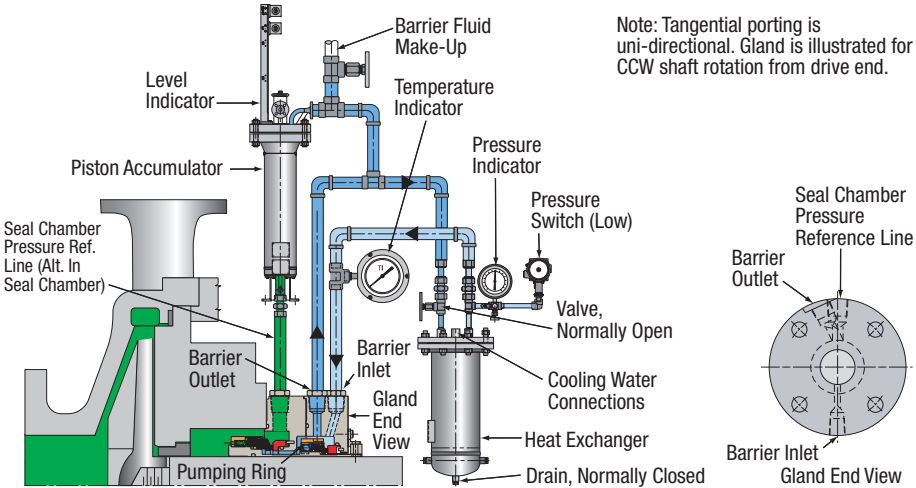
Plan **53B** Dual Seals, Pressurized

Plan **53C** Dual Seals, Pressurized

Description: Plan 53C uses a piston accumulator to provide pressure to the system. It uses a reference line from the seal chamber to provide a constant pressure differential over the chamber's pressure. A water- or air-cooled heat exchanger provides for barrier fluid cooling. Flow is induced by a pumping ring.

Advantages: Provides a tracking system to maintain barrier pressure above seal chamber pressure.

General: The heat exchanger can be a water-cooled unit, an air-cooled unit, or utilize finned tubing based upon the system heat load. The reference line to the accumulator must be tolerant of process contamination without plugging.



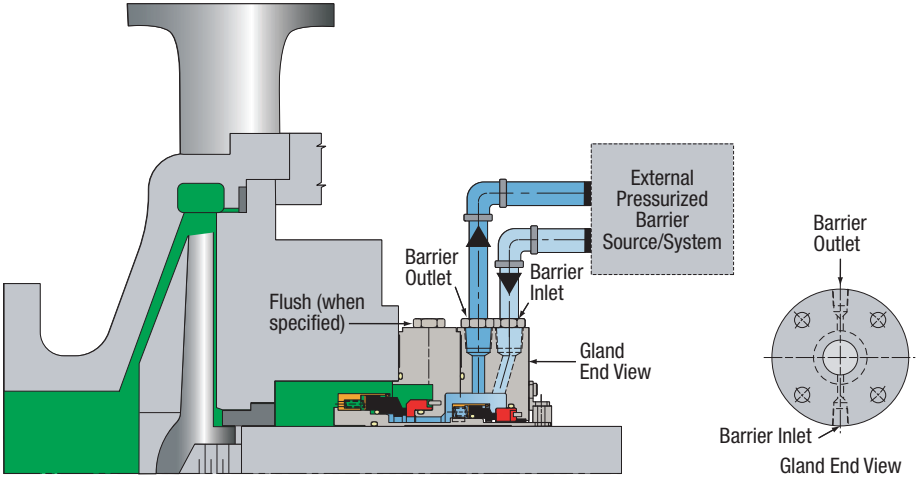
Plan **53C** Dual Seals, Pressurized

Plan **54** Dual Seals, Pressurized

Description: Plan 54 utilizes an external source to provide a clean pressurized barrier fluid to a dual seal.

Advantages: Can provide pressurized flow to multiple seal installations to reduce costs. Positively eliminates fugitive emissions to atmosphere.

General: Plan 54 systems can be custom engineered to suit application or specific plant requirements. Systems can range from the direct connection from other process streams to complex lubrication systems.



Plan **54** Dual Seals, Pressurized

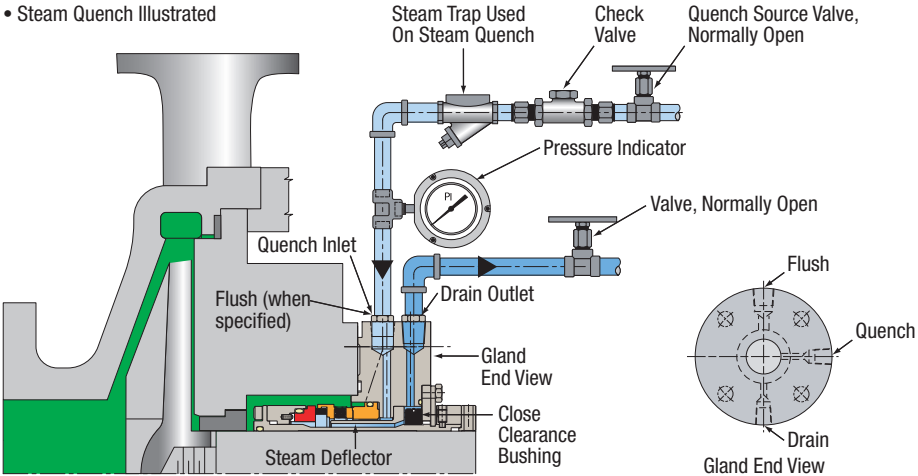
Plan 62 Quench Seals

Description: Plan 62 is a common plan to improve the environment on the atmospheric side of single seals by quenching with steam, nitrogen or water.

Advantages: Plan 62 is a low cost alternative to tandem seals. The quench prevents or retards product crystallization or coking. Quenches can also provide some cooling.

General: Typical applications include; steam quenches on hot services to retard coking; nitrogen quenches on cold or cryogenic service to prevent icing; or water quench to prevent crystallization or accumulation of product on the atmospheric side of the seal.

• Steam Quench Illustrated



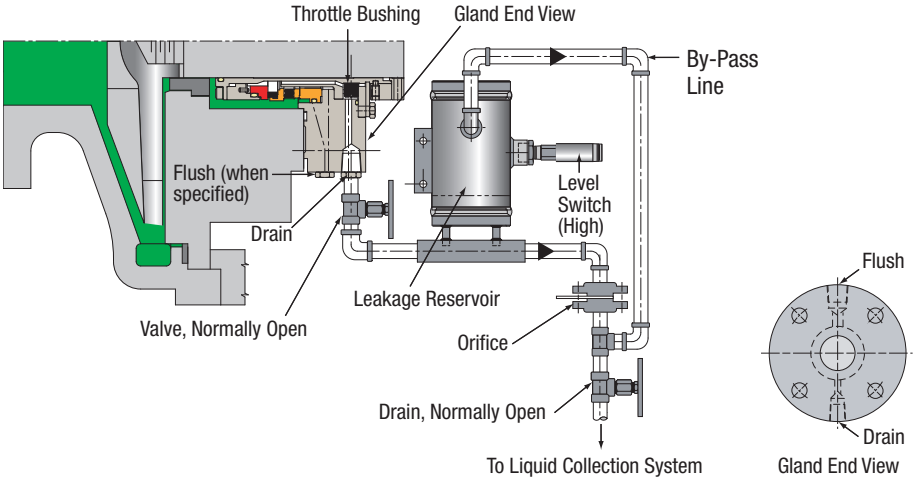
Plan **62** Quench Seals

Plan **65** Single Seals

Description: Plan 65 is a liquid leakage detection plan normally used for single seals. It utilizes a level switch on a reservoir to set off an alarm when excess leakage is detected.

Advantages: Provides an alarmed indication of excessive seal leakage that can shutdown equipment if necessary.

General: The system includes a loop to by-pass the orifice to prevent high pressure on the atmospheric side of the seal. The gland throttle bushing design should be consistent with the fluid's properties. Gland throttle bushing designs can vary from fixed designs to segmented bushings.



Plan **65** Single Seals

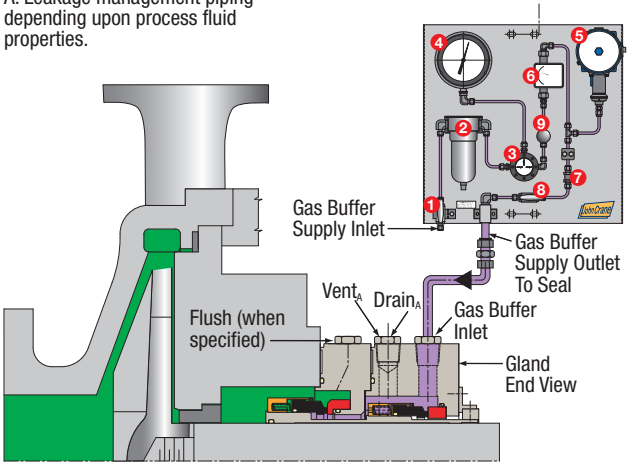
Plan 72 Secondary Containment Seals

Description: Plan 72 for secondary containment uses an external low pressure buffer gas, usually nitrogen, regulated by a control panel that injects it into the outer seal cavity.

Advantages: Introduction of a buffer gas like nitrogen reduces fugitive emissions, prevents icing on cold applications, and provides for some cooling to the outboard seal.

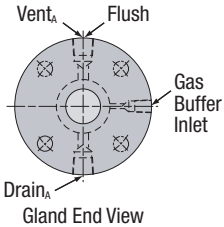
General: Plan 72 is normally used with Plan 75 for primary seal leakage that is condensing, or with Plan 76 for non-condensing leakage.

A: Leakage management piping depending upon process fluid properties.



System Components

1. Shut Off Valve, Norm. Open
2. Coalescing Filter
3. Pressure Regulator
4. Pressure Indicator
5. Pressure Switch
6. Flow Indicator
7. Check Valve
8. Shut Off Valve, Norm. Open
9. Orifice



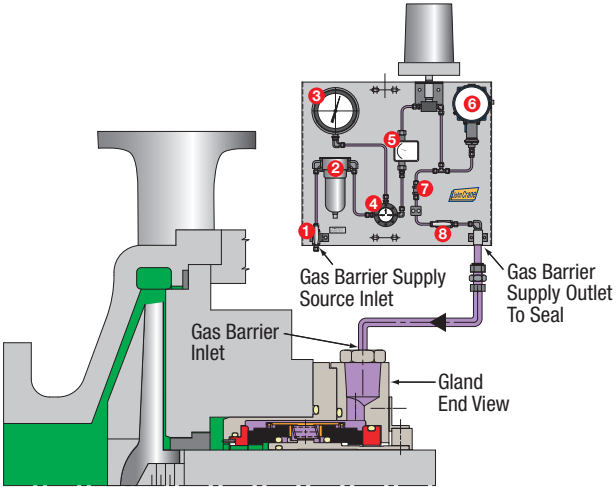
Plan **72** Secondary Containment Seals

Plan 74 Dual Gas Seals

Description: Plan 74 provides a pressurized gas, typically nitrogen, to dual gas seals through the use of a control panel that removes moisture, filters the gas, and regulates the barrier pressure.

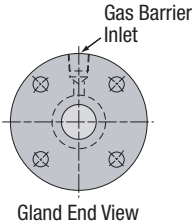
Advantages: Lower costs and maintenance than systems used on dual pressurized liquid systems. Leakage to atmosphere is an inert gas.

General: The barrier gas is usually a pressurized nitrogen line. For higher pressure applications the system pressure can be supplemented with a gas pressure booster/amplifier. Typically dry-running, non-contacting, gas lubricated seals are used with this plan.



System Components

1. Shut Off Valve, Norm. Open
2. Coalescing Filter
3. Pressure Indicator
4. Pressure Regulator
5. Flow Indicator
6. Pressure Switch
7. Check Valve
8. Shut Off Valve, Norm. Open



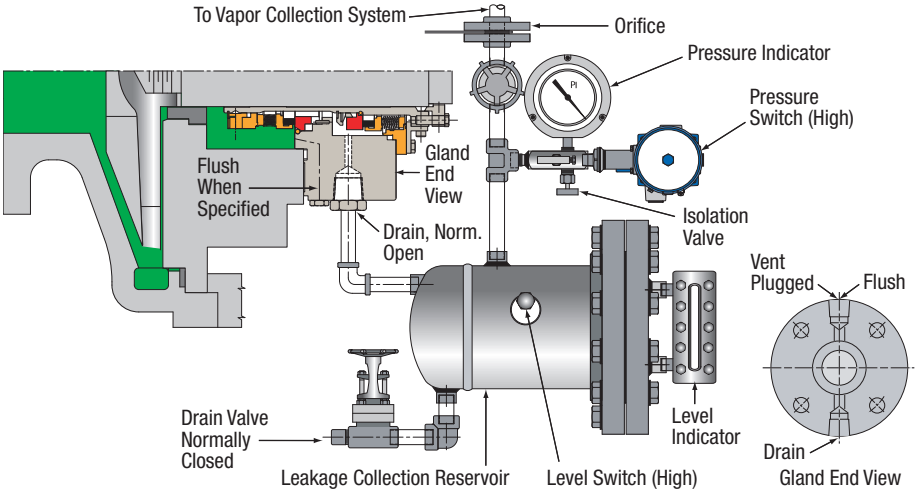
Plan 74 Dual Gas Seals

Plan 75 Secondary Containment Seals

Description: Plan 75 is a collection system used with secondary containment seals for process fluid that will condense at lower temperatures or is always in a liquid state.

Advantages: The collection reservoir contains a pressure gauge and a high pressure switch to indicate a build up in pressure from excessive primary seal leakage or failure.

General: Plan 75 can be used in conjunction with a gas purge from Plan 72. Typically dry-running, contacting secondary containment seals are used with this plan.



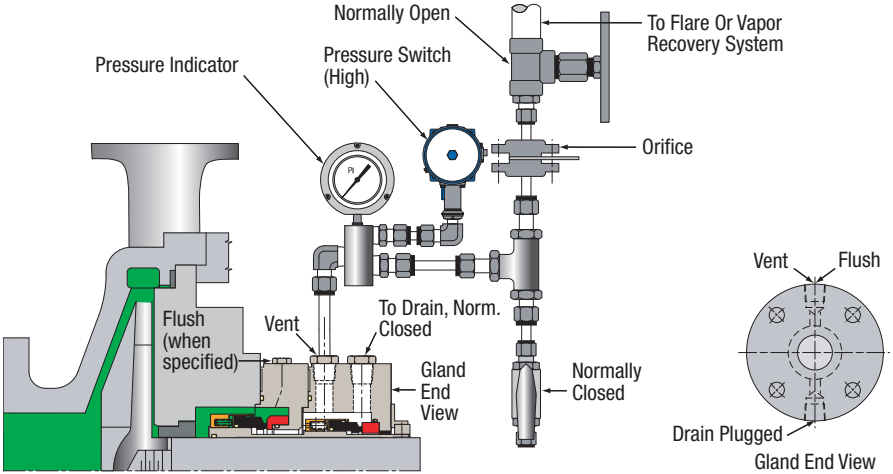
Plan **75** Secondary Containment Seals

Plan **76** Secondary Containment Seals

Description: Plan 76 is a system to divert non-condensing primary seal leakage to a flare or vapor recovery system.

Advantages: Lower initial and maintenance costs than dual unpressurized seals using a Plan 52.

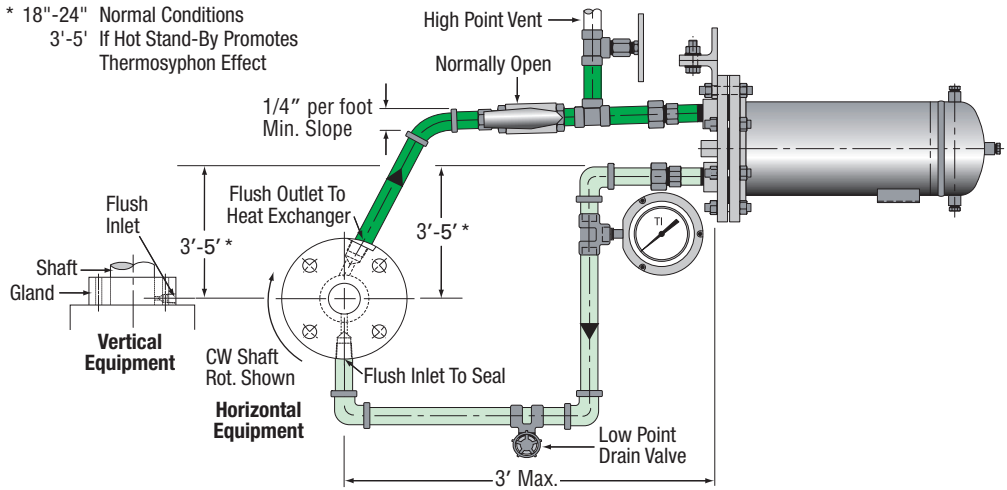
General: Plan 76 can be used in conjunction with a gas purge from Plan 72. Can be used with dry-running, contacting or non-contacting secondary containment seals.



Plan **76** Secondary Containment Seals

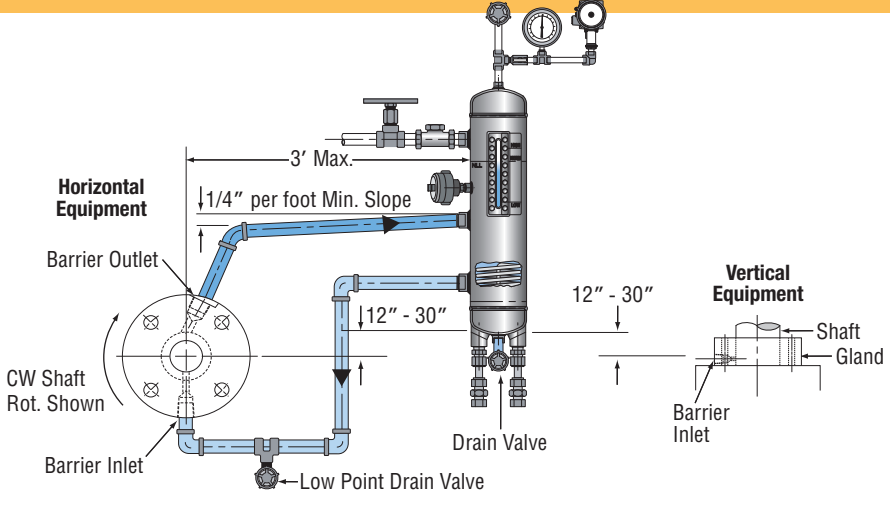
Best Piping Practices

- ☑ Minimize piping line losses.
- ☑ Minimum 1/2″ piping or 5/8″ tubing.
- ☑ Use large radius bends.
- ☑ Tangential outlet ports.
- ☑ Verify shaft rotation direction.
- ☑ Slope horizontal runs upward.
- ☑ Install drain at lowest piping point.
- ☑ Flush is recommended whenever possible.
- ☑ Use forced circulation where possible.
- ☑ Cooling is recommended for buffer/barrier fluid.
- ☑ Always properly vent the system prior to start-up.
- ☑ Always verify pressure and/or level switch set points.
- ☑ Check system for leaks.
- ☑ Contact John Crane for buffer/barrier fluid recommendation.



Best Piping Practices Single Seals - Plan 23 Illustrated

Best Piping Practices Dual Seals - Plan 53A Illustrated



John Crane offers a full range of standard and custom engineered Lemco brand seal support systems. All systems are designed and built to industry standards including ANSI B31.3 for piping; API 610, 682 and 614 for system design; IEC, NEMA, NEC, or CSA for instrumentation and electrical; and pressure vessels in accordance with ASME requirements.

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Lemco Seal Support Systems

Lemco Seal Support

API 682/ISO 21049 Products

API 682 Plans 52 and 53A Reservoirs: These reservoirs are designed for the Refinery, Petrochemical, and Chemical Industries.

API 682 Plan 53B: A dual pressurized system that eliminates direct gas contact with the barrier liquid.

API 682 Plan 53C: This system is ideal for applications that have fluctuating pressures.

API 682 Plan 72 Gas Control Panel: Used in a dual unpressurized seal arrangement where the secondary seal is dry-running.

API 682 Plan 75 Condensate Collection Reservoir: Used in a dual unpressurized seal arrangement where the secondary seal is dry-running.

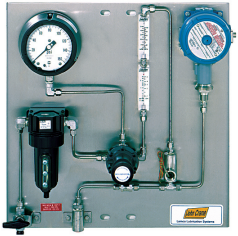
API 682 Plan 76 Vent to Flare Panel: Used in a dual unpressurized seal arrangement where the secondary seal is dry-running.

API 682 Plan 74 Gas Control Panel: Used on non-contacting, dual pressurized seals, this system filters, regulates and monitors the gas supply, typically nitrogen, used to lubricate the seals.

API 682 Plan 52/53A
Reservoirs

API 682 Plan 53B
Reservoirs

API 682 Plan53C
Reservoir



API 682 Plan 72/74
Gas Control Panel

Lemco Seal Support Systems

Compressor Gas Panels and Seal Oil Systems

Type 28 Gas Panel

Gas Conditioning Unit

Seal Oil System with Air-Cooled Heat Exchanger

Heat Exchangers and Auxiliary Equipment

Water-Cooled Heat Exchanger

Air-Cooled Heat Exchanger

Leakage Detection Systems

Abrasive Separators

Lemco Seal Support Systems

Non-API Reservoirs and Mobile Refill Carts

RE-1203/RE-1205

RE-1603

RE-1518

RE-1618

50 Gallon

ORIFICE

BLOCK VALVE

CHECK VALVE

FLOW REGULATING VALVE

PRESSURE CONTROL VALVE

CYCLONE SEPARATOR

FILTER/STRAINER

HEAT EXCHANGER

RESERVOIR

PISTON ACCUMULATOR

BLADDER ACCUMULATOR

FIL COALESCING FILTER

PSH PRESSURE SWITCH HIGH

PSL PRESSURE SWITCH LOW

PI PRESSURE INDICATOR

LI LEVEL INDICATOR

TI TEMPERATURE INDICATOR

LSH LEVEL SWITCH HIGH

FI FLOW INDICATOR

LSL LEVEL SWITCH LOW

FM FLOW METER

FSH FLOW SWITCH HIGH

Instrumentation **References**

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