MECHANICAL SEAL PIPING PLANS

POCKET GUIDE — 4TH EDITION

PIPING PLAN

Plan 01	Single seals – internal flush
Plan 02	Single seals – no flush
Plan 03	Single seals – circulation between seal chamber and pump created by design of the seal chamber
Plan 11	Single seals – by-pass from discharge with orifice
Plan 12	Single seals – by-pass from discharge with strainer & orifice
Plan 13	Single seals – flush through seal chamber through orifice to suction
Plan 14	Single seals – by-pass from discharge through seal chamber back to suction
Plan 21	Single seals – by-pass from discharge through orifice & heat exchanger
Plan 22	Single seals – by-pass from discharge through strainer, orifice & heat exchanger
Plan 23	Single seals – closed loop circulation through heat exchanger
Plan 31	Single seals – by-pass from discharge through abrasive separator
Plan 32	Single seals – external flush source to seal
Plan 41	Single seals – by-pass from discharge through abrasive separator & heat exchanger
Plan 51	Single seals – Dead-ended atmospheric quench
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 through heat exchanger & pressurized by accumulator
Plan 53C	Dual seals, pressurized – liquid barrier through heat exchanger with differential pressure tracking piston accumulator

PIPING PLAN

Plan 54 Dual seals, pressurized – external pressurized barrier system/source
Plan 55 Dual seals, unpressurized – external, unpressurized buffer system/source
Plan 61 Quench seals – quench connection for purchasers use
Plan 62 Quench seals – external quench on atmospheric side of seal
Plan 65A Single seals – atmospheric leakage collection/detection for condensing leakage with failure detection by excess flow into system
Plan 65B Single seals – atmospheric leakage collection/detection for condensing leakage with failure detection by cumulative leakage into system
Plan 66A Single seals – external leakage detection arrangement with throttle bushings
Plan 66B Single seals – external leakage detection arrangement with orifice plug
Plan 71 Secondary containment seals – tap connection for purchasers use
Plan 72 Secondary containment seals – low pressure buffer gas injected to outer seal cavity
Plan 74 Dual gas seals – pressurized barrier gas system for dual gas seals
Plan 75 Secondary containment seals – Leakage collection system for condensing or mixed phase leakage
Plan 76 Secondary containment seals – secondary containment seal vented to flare or collection system
Plan 99 Single seals, dual seals, quench seals, secondary containment seals & dual gas seals – defines an engineered piping plan not defined by any existing plans

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 to which they are fitted. Provision of clean, cool face lubrication, effective heat removal and consideration of 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 illustrations included are based upon API 682.

The following pages illustrate and describe features of these plans as an aid to help determine what support system requirements will maximize the performance reliability of your fluid handling rotating equipment application.

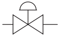
API 682 standard has connections and symbols for the seal chamber and gland plate based upon the seal configuration. It is recommended that the latest edition of the standard be reviewed for up-to-date requirements when this standard is mandated for a piece of rotating equipment. The intent of this booklet is to illustrate the common connections that are utilized for the various piping plans, regardless of the equipment type, and therefore generic names for connections are used. 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 labelled. In a piping plan 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).

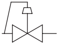
PIPING KEY

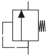

ORIFICE

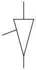

BLOCK VALVE

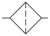

CHECK VALVE


FLOW REGULATING VALVE

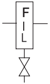

PRESSURE CONTROL VALVE


PRESSURE RELIEF VALVE

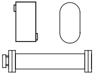

CYCLONE SEPARATOR

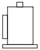

STRAINER

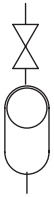

HEAT EXCHANGER



COALESCING FILTER


RESERVOIR


PISTON ACCUMULATOR


BLADDER ACCUMULATOR

PI	PRESSURE INDICATOR
TI	TEMPERATURE INDICATOR
LI	LEVEL INDICATOR
FI	FLOW INDICATOR
FM	FLOW METER
PIT	PRESSURE TRANSMITTER WITH LOCAL INDICATOR
PDIT	DIFFERENTIAL PRESSURE TRANSMITTER WITH LOCAL INDICATOR
TIT	TEMPERATURE TRANSMITTER WITH LOCAL INDICATOR
LIT	LEVEL TRANSMITTER WITH LOCAL INDICATOR
FIT	FLOW TRANSMITTER WITH LOCAL INDICATOR
PSL	PRESSURE SWITCH LOW
LSH	LEVEL SWITCH HIGH
LSL	LEVEL SWITCH LOW
FSH	FLOW SWITCH HIGH

HLA - HIGH LEVEL ALARM SET POINT

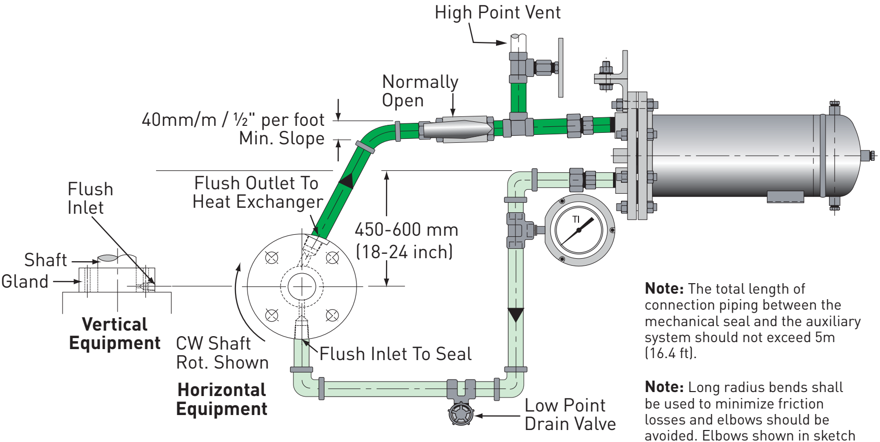
LLA - LOW LEVEL ALARM SET POINT

NLL - NORMAL LIQUID LEVEL

BEST PIPING PRACTICES

- ☑ Minimize piping line losses.
- ☑ Use large radius bends.
- ☑ Tangential outlet ports.
- ☑ Verify shaft rotation direction.
- ☑ Slope horizontal runs upward (40 mm/m (1/2 in/ft)).
- ☑ 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.
- ☑ Check compatibility of buffer/barrier fluid with the end product.
- ☑ Long radius bends shall be used to minimize friction losses and elbows should be avoided.
- ☑ Elbows shown in sketches are for illustrative purpose only.
- ☑ Use 20mm (¾") interconnecting piping/tubing for plans where flow is produced by an internal circulation device (pumping ring or scroll)
- ☑ Use 12mm (½") interconnecting piping/tubing for plans where flow is produced by pump differential pressures

SINGLE SEALS - PLAN 23 ILLUSTRATED



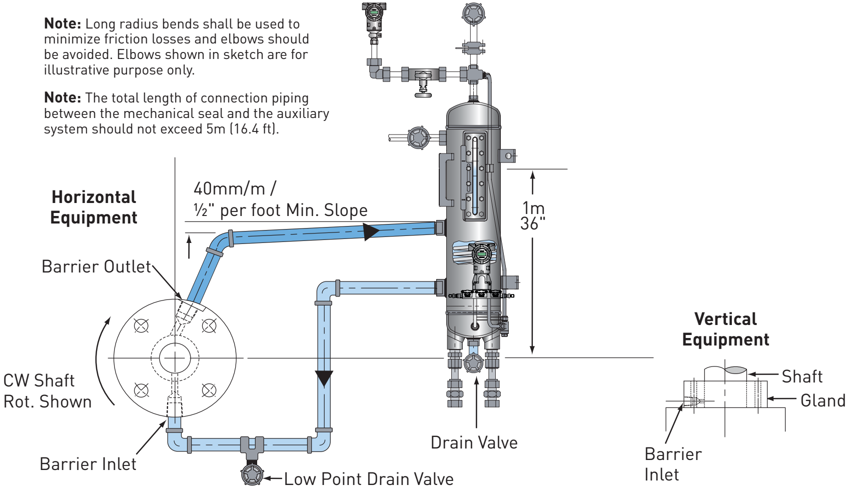
Note: The total length of connection piping between the mechanical seal and the auxiliary system should not exceed 5m (16.4 ft).

Note: Long radius bends shall be used to minimize friction losses and elbows should be avoided. Elbows shown in sketch are for illustrative purpose only.

DUAL SEALS - PLAN 53A ILLUSTRATED

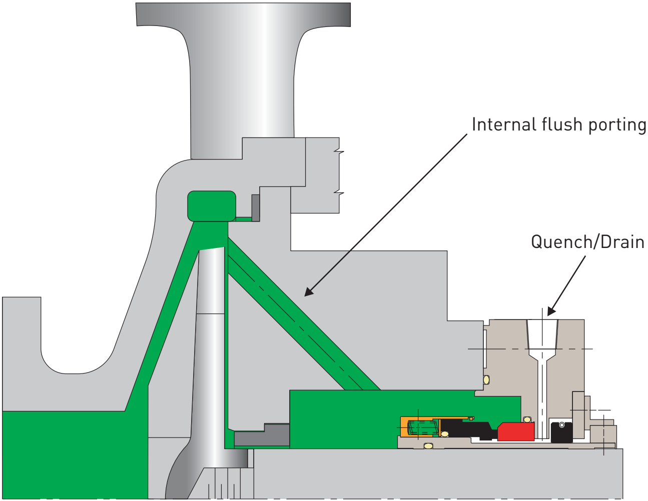
Note: Long radius bends shall be used to minimize friction losses and elbows should be avoided. Elbows shown in sketch are for illustrative purpose only.

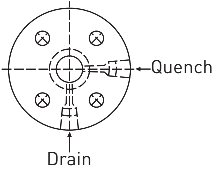
Note: The total length of connection piping between the mechanical seal and the auxiliary system should not exceed 5m (16.4 ft).



PLAN 01

- No external flush
- Quench optional





Gland End View

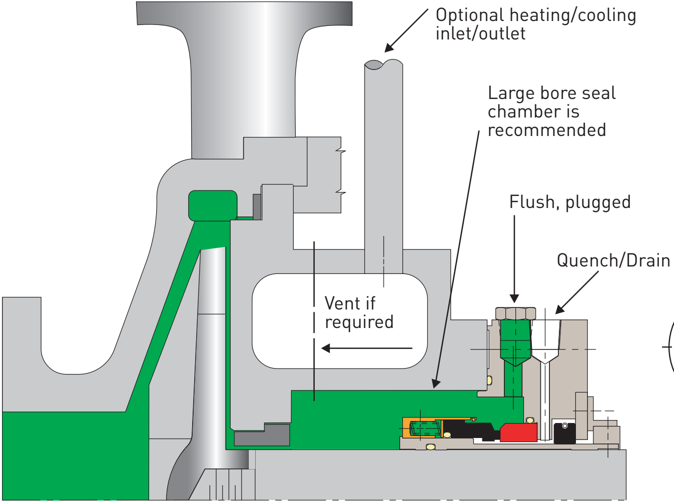
SINGLE SEALS

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.

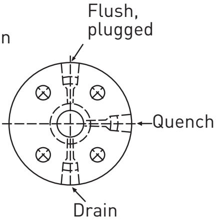
Advantages: No product contamination and no external piping, which is advantageous on highly viscous fluids at lower temperatures to minimize the risk of freezing that can occur with exposed piping.

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

PLAN 02



- No flush - normal
- Vent/Flush (If req'd) plugged
- Quench optional
- Ensure seal chamber is fully vented



Gland End View

SINGLE SEALS

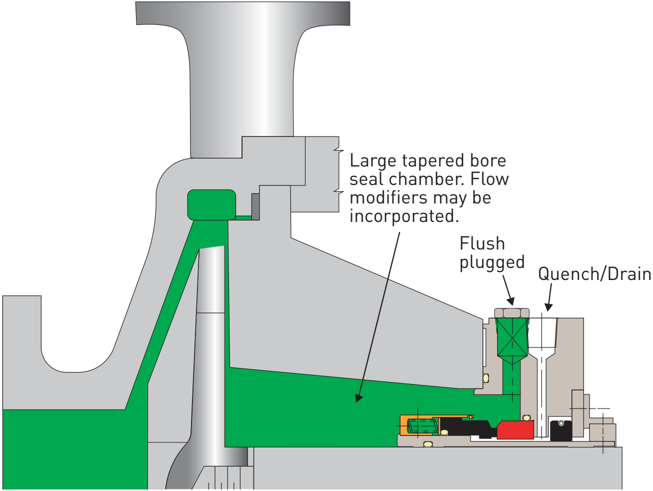
Description: Plan 02 is a non-circulating flush plan where adequate vapor suppression can be assured.

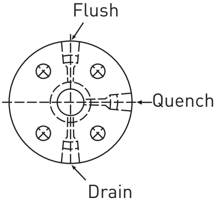
Advantages: Solids are not continually introduced into the seal chamber, no external hardware is required.

General: Most commonly used on large bore pumps utilizing a cooling jacket. The use of a Plan 62 with a steam quench can also provide some additional cooling on hot applications. Success on hot applications depends upon keeping the cooling jacket clean which is prone to fouling.

PLAN 03

- Quench optional
- Tapered bore seal chambers are self venting





Gland End View

SINGLE SEALS

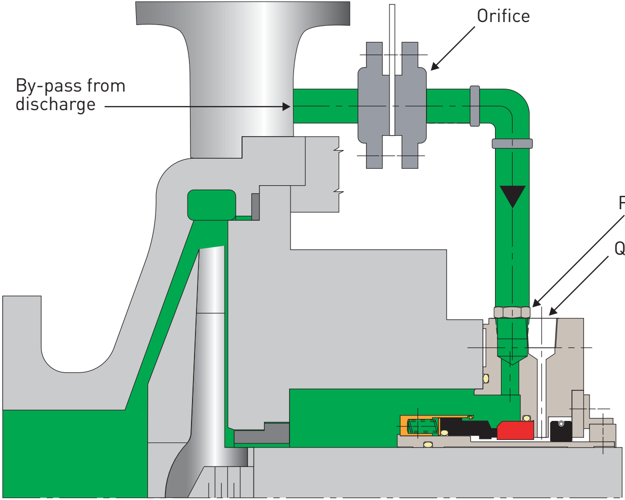
Description: Plan 03 is circulation between seal chamber and pump created by design of the seal chamber.

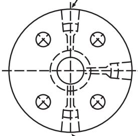
Advantages: Circulation for cooling and venting of the seal is achieved by design of the seal chamber geometry or flow enhancement features.

General: Commonly used on ASME/ANSI or specialized ISO 3069 tapered bore seal chambers, without a throat bushing, for applications where there is not significant heat generated by the seal or where solids may collect in a traditional seal chamber.

PLAN 11

- Quench optional





Gland End View

SINGLE SEALS

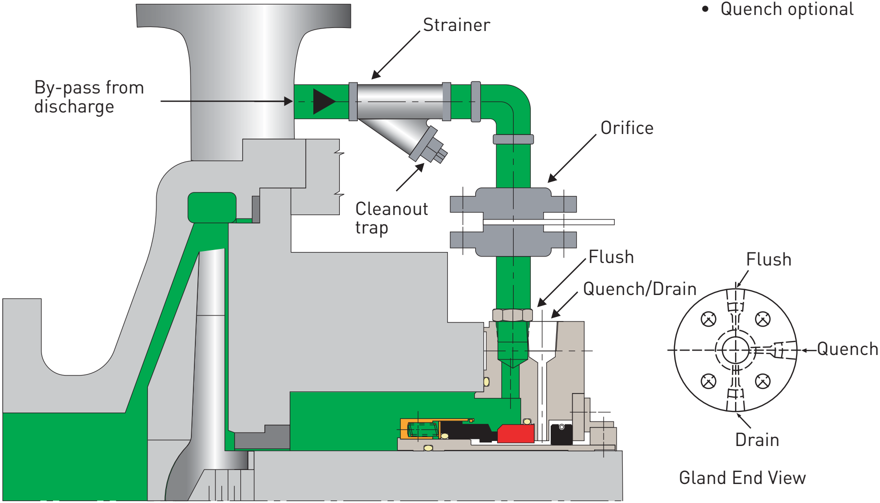
Description: Plan 11 is the most common flush plan in use today. This plan takes fluid from the pump discharge (or from an intermediate stage) through an orifice(s) and directs it to the seal chamber to provide cooling and lubrication to the seal faces.

Advantages: No product contamination and piping is simple.

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

Note: See John Crane Technical Report TRP-11-14/ENG for additional information.

PLAN 12



- Quench optional

SINGLE SEALS

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

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

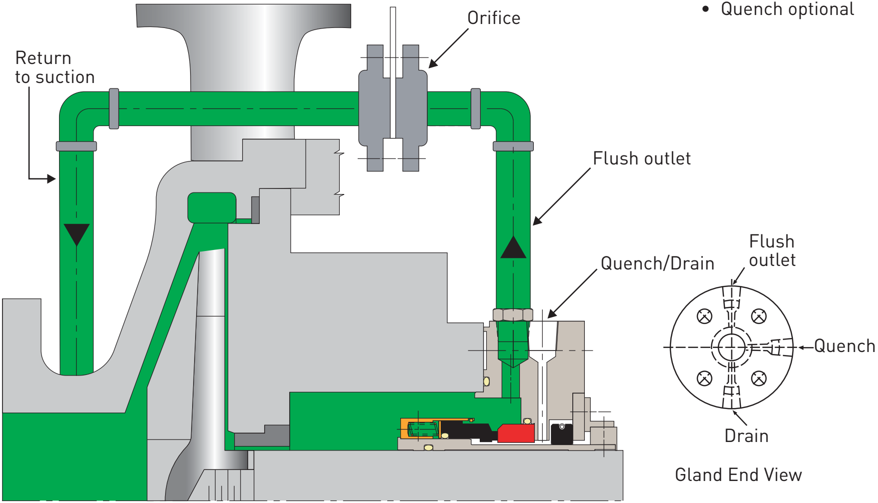
General: If the seal is set up with a distributed or extended flush, the effectiveness of the system will be improved. This plan should be equipped with a differential pressure indicator or alarm to alert the user that the strainer is clogged.

Note: API 682 4th edition comments "This plan has not been proven to achieve a 3-year operating life."

Note: See John Crane Technical Report TRP-11-14/ENG for additional information.

PLAN 13

- Quench optional



SINGLE SEALS

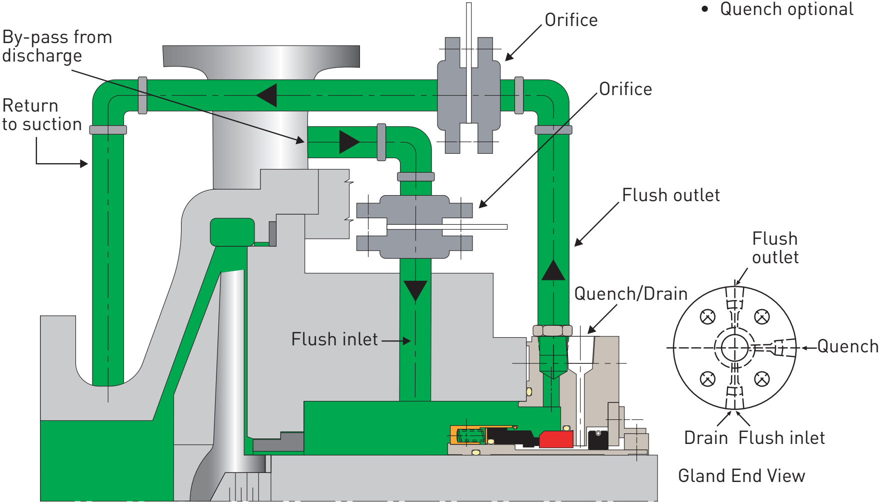
Description: In a Plan 13 the flow exits the seal chamber and is routed back to pump suction. Standard arrangement for vertical and high head pumps.

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

General: Typically Plan 13 is used on vertical 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.

Note: See John Crane Technical Report TRP-11-14/ENG for additional information.

PLAN 14



Orifice
Quench optional
By-pass from discharge
Orifice
Return to suction
Flush outlet
Flush outlet
Quench/Drain
Flush inlet
Quench
Drain
Flush inlet
Gland End View

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.

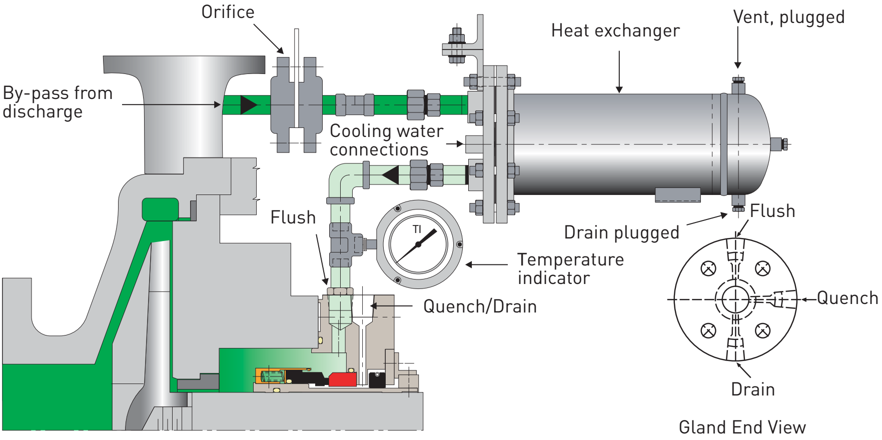
Advantages: Cooling can be optimized with the flush directed at the seal faces. Plan 14 allows for automatic venting of the seal chamber.

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

Note: See John Crane Technical Report TRP-11-14/ENG for additional information.

PLAN 21

- Quench optional



SINGLE SEALS

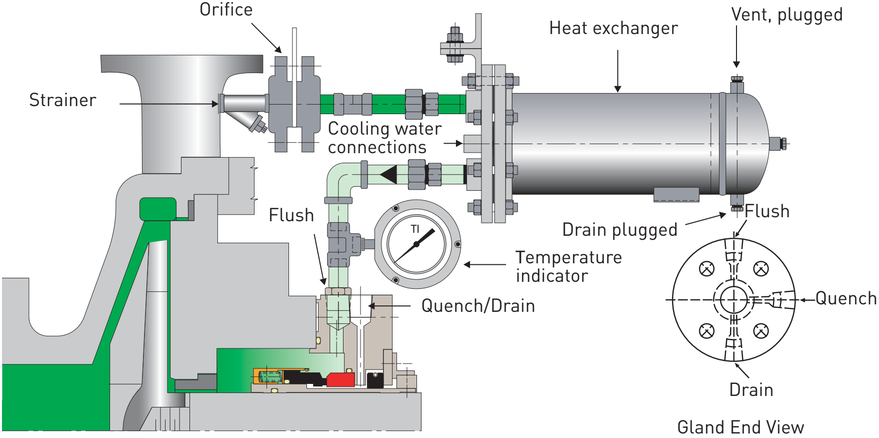
Description: Plan 21 is a cooled version of Plan 11. The product from pump discharge is directed through an orifice, then to a heat exchanger to lower the temperature before being introduced into the seal chamber.

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 on the heat exchanger. Plan 23 is preferred.

PLAN 22

- Quench optional



SINGLE SEALS

Description: Plan 22 is a modified version of a Plan 21 with the addition of a strainer before the orifice.

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

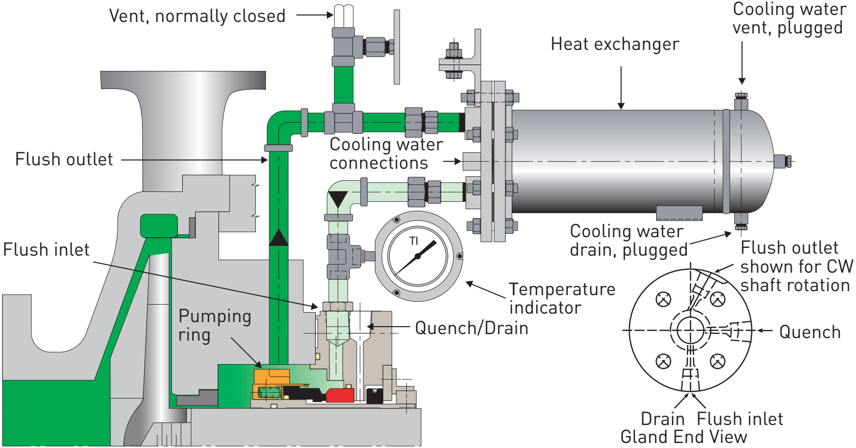
Disadvantage: Plan 22 should be used with caution as strainers can clog and result in seal failure.

General: If the seal is set up 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 strainer is clogged.

NOTE: API 682 4th edition comments "This plan has not been proven to achieve a 3-year operating life."

PLAN 23

• Quench optional



SINGLE SEALS

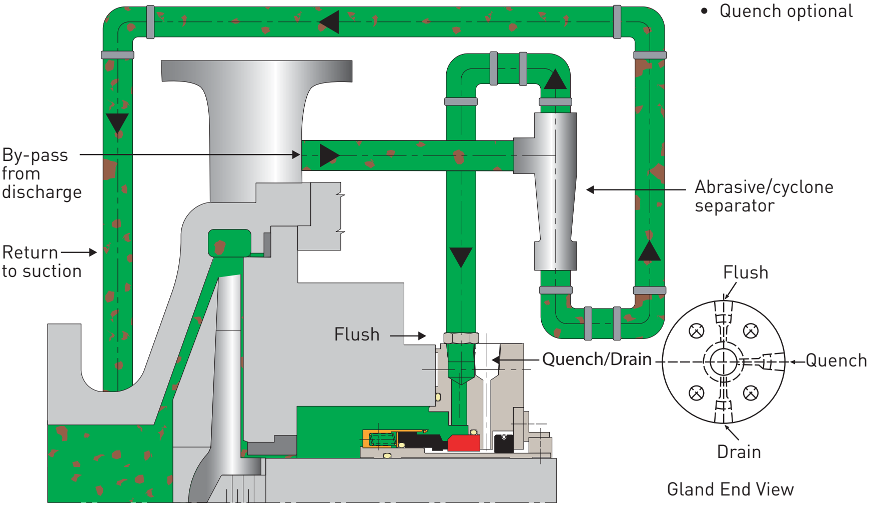
Description: Plan 23 is a closed loop system using a pumping ring to circulate product through a heat exchanger and back to the seal chamber.

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 application. Close clearance throat bushing is recommended to reduce mixing of hot product with cooler closed loop system.

Note: See John Crane Technical Report TRP-API23 for additional information.

PLAN 31



By-pass
from
discharge
Return
to suction
Flush
Quench/Drain
Abrasive/cyclone
separator
• Quench optional
Flush
Quench
Drain
Gland End View

SINGLE SEALS

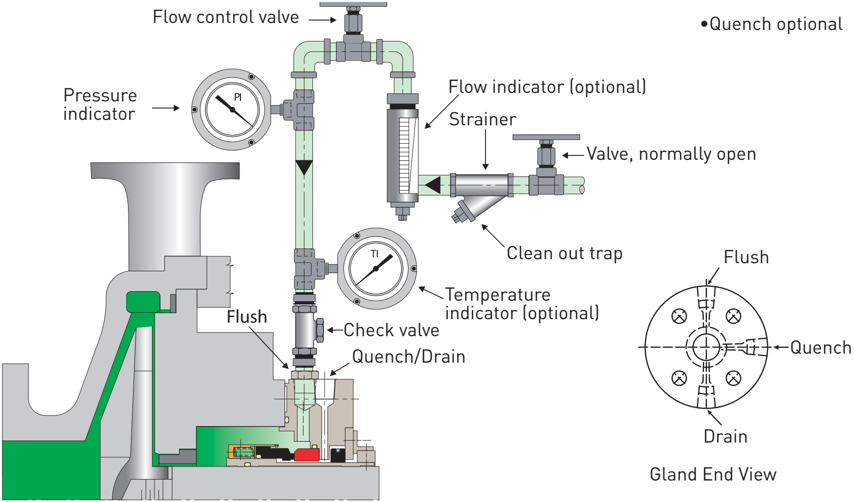
Description: Plan 31 is a variation of Plan 11, where an abrasive separator is added to the flush line. In this plan, the product is introduced to the abrasive separator from the discharge of the pump.

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 1 bar (15 psi) to operate properly. Orifices may be used to optimize flow rates and separation efficiency.

Note: See John Crane Technical Report TRP-31,41 for additional information.

PLAN 32


Flow control valve
•Quench optional
Pressure indicator
PI
Flow indicator (optional)
Strainer
Valve, normally open
TI
Clean out trap
Flush
Temperature indicator (optional)
Check valve
Quench/Drain
Flush
Quench
Drain
Gland End View

SINGLE SEALS

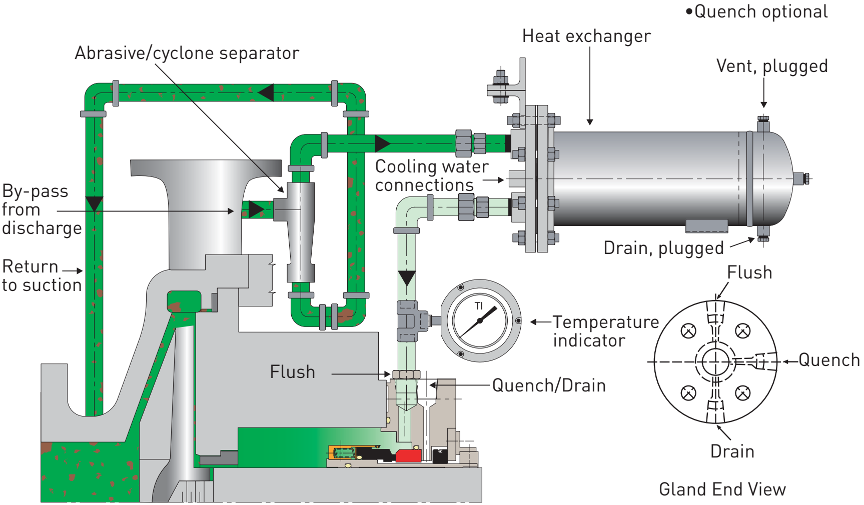
Description: Plan 32 uses a flush stream brought in from an external source to the seal. This plan is almost always used in conjunction with a close clearance throat bushing.

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.

Note: See John Crane Technical Report TRP-32 for additional information.

PLAN 41



•Quench optional
Heat exchanger
Abrasive/cyclone separator
Vent, plugged
Cooling water connections
By-pass from discharge
Return to suction
Drain, plugged
Flush
TI
Temperature indicator
Quench
Flush
Quench/Drain
Drain
Gland End View

SINGLE SEALS

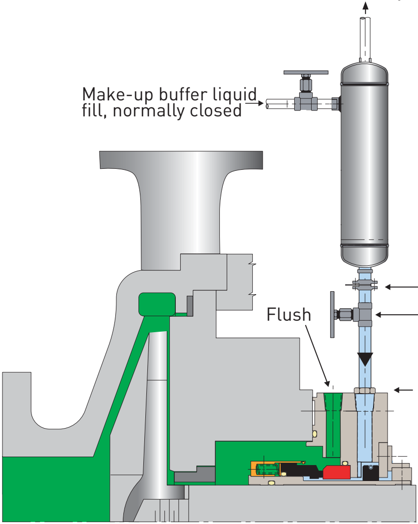
Description: Plan 41 is a combination of Plan 21 and Plan 31. In Plan 41, product from pump discharge is first put through an abrasive separator and then to the heat exchanger before being introduced to the seal chamber.

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

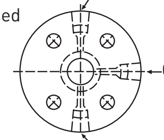
General: Plan 41 is typically used on hot services with solids however, depending on the temperature of the process, operating costs can be high. Orifices may be used to optimize flow rates and separation efficiency.

Note: See John Crane Technical Report TRP-31,41 for additional information.

PLAN 51



Note: Per API 682 this piping plan is only recommended for vertical pumps, but in practice has also been used on horizontal pumps.



Gland End View

SINGLE SEALS, QUENCH

Description: Plan 51 external reservoir providing a dead-ended blanket of fluid to the quench connection of the gland. Typically used with an auxiliary sealing device.

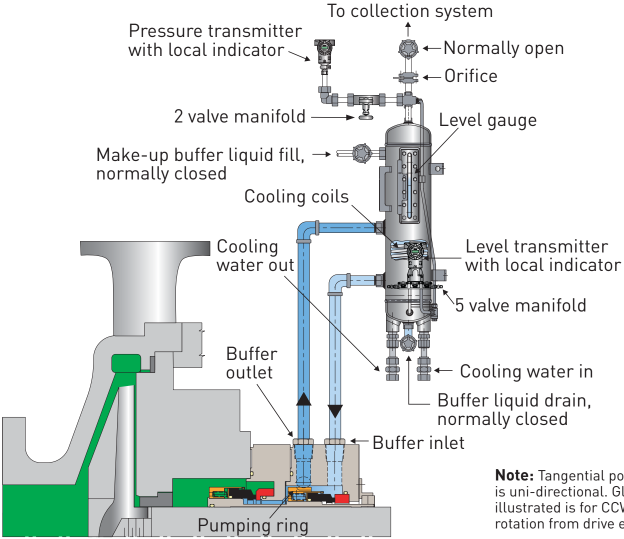
Advantages: Can be used to retard/prevent crystallization or icing on atmospheric side of seal.

General: Careful selection of auxiliary sealing device required to prevent escape of blanket fluid from reservoir.

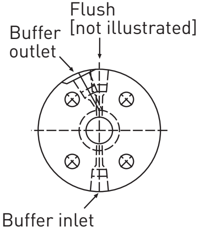
May not be possible to achieve a 3-year operating life dependant on type of auxiliary sealing device used.

Note: See John Crane Technical Report TRP-51 for additional information.

PLAN 52



Note: A buffer fluid drain is located on the low point of the buffer inlet (not illustrated). See Best Piping Practices.



Gland End View

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

DUAL SEALS, UNPRESSURIZED

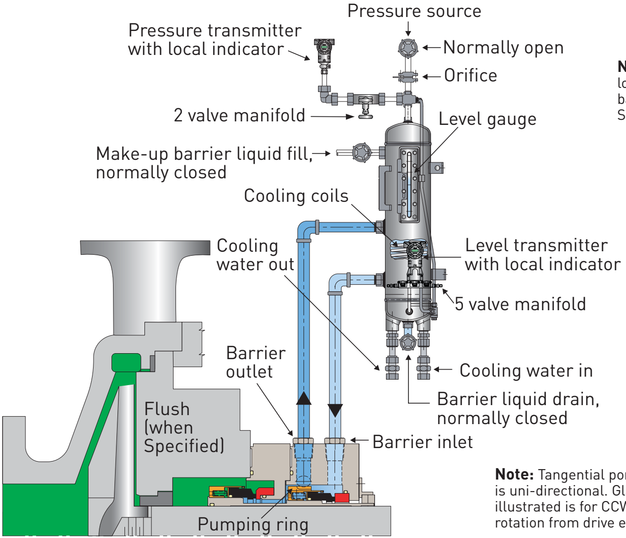
Description: Plan 52 uses an external reservoir to provide buffer fluid for the outer seal of an unpressurized dual seal arrangement. Flow is induced by a pumping ring.

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

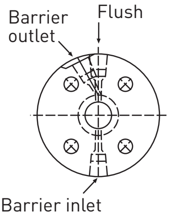
General: Cooling coils in the reservoir are available for removing heat from the buffer fluid.

Note: See John Crane Technical Report TRP-52-55 for additional information.

PLAN 53A



Note: A barrier fluid drain is located on the low point of the barrier inlet (not illustrated). See Best Piping Practices.



Gland End View

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

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.

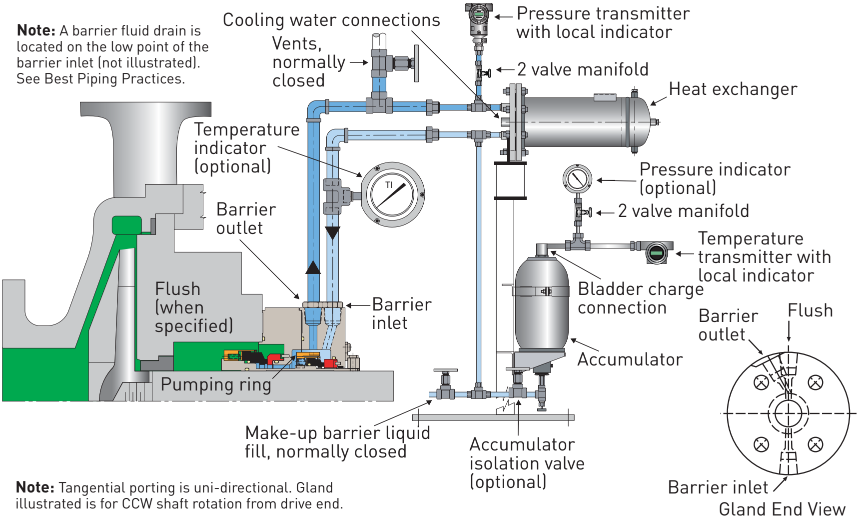
Advantages: Reservoir size can be optimized dependent on flow rate. Wear particles settle to bottom of reservoir and do not get recirculated.

General: Heat is dissipated by reservoir cooling coil. Barrier fluid is subject to gas entrainment at pressures/temperatures above 21 bar(g)/300 psi(g) and 120°C/250°F. While API 682 4th edition suggests a limit of 10 bar(g)/150 psi(g) to avoid gas entrainment, properly selected barrier fluids can be used to the limit suggested above.

Note: See John Crane Technical Report TRP-DualWet for additional information.

PLAN 53B

Note: A barrier fluid drain is located on the low point of the barrier inlet (not illustrated). See Best Piping Practices.



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

DUAL SEALS, PRESSURIZED

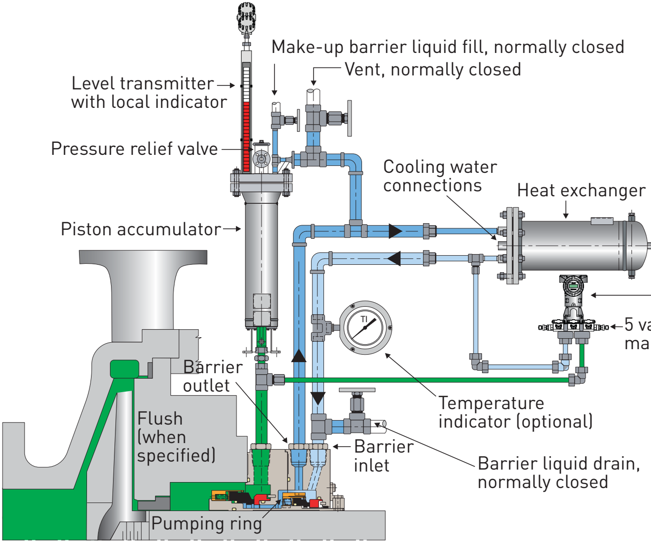
Description: Plan 53B uses an accumulator to isolate the pressurizing gas from the barrier fluid. A heat exchanger is included in the circulation loop to cool the barrier fluid. Flow is induced by a pumping ring.

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.

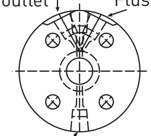
General: The bladder accumulator isolates the pressurizing gas from the barrier fluid to prevent gas entrainment. The heat exchanger can be water-cooled, finned tubing or an air-cooled unit, based upon the system heat load.

Note: See John Crane Technical Report TRP-DualWet for additional information.

PLAN 53C



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



Gland End View

DUAL SEALS, PRESSURIZED

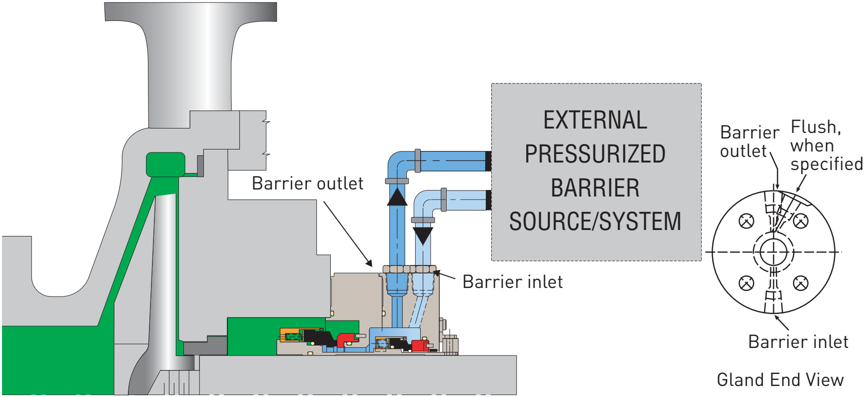
Description: Plan 53C uses a piston accumulator to provide pressure to the system. It uses a reference line from the seal chamber to provide a constant pressure differential over the chamber's pressure. A water or air-cooled heat exchanger provides for barrier fluid cooling. Flow is induced by a pumping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

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

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

Note: See John Crane Technical Report TRP-DualWet for additional information.

PLAN 54


Barrier outlet
EXTERNAL PRESSURIZED BARRIER SOURCE/SYSTEM
Barrier inlet
Barrier outlet
Flush, when specified
Barrier inlet
Gland End View

DUAL SEALS, PRESSURIZED

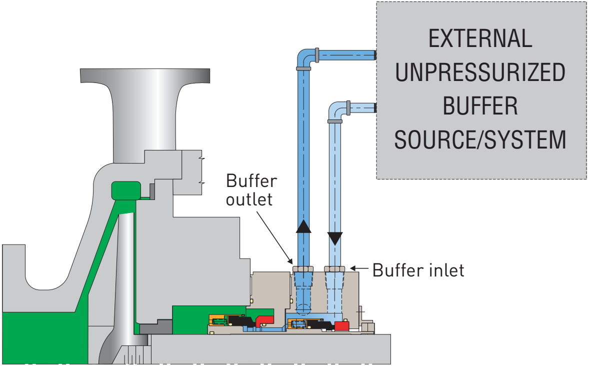
Description: Plan 54 utilizes an external source to provide a clean pressurized barrier fluid to a dual pressurized seal.

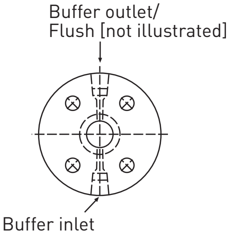
Advantages: Can provide pressurized flow to multiple seal installations to reduce costs. Positively eliminates fugitive emissions to atmosphere.

General: Plan 54 systems can be custom engineered to suit application requirements. Systems can range from the direct connection from other process streams to complex API 614 systems.

Note: See John Crane Technical Report TRP-DualWet for additional information.

PLAN 55





Gland End View

DUAL SEALS, UNPRESSURIZED

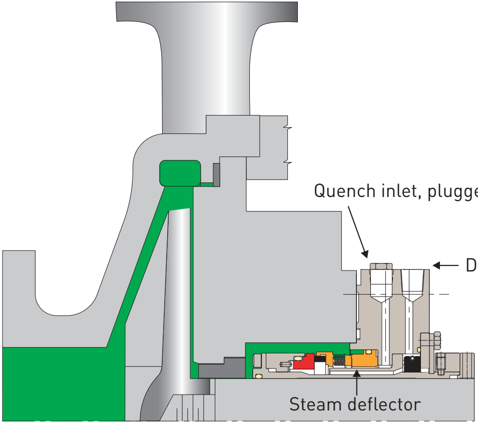
Description: Plan 55 utilizes an external source to provide a clean unpressurized buffer fluid to a dual unpressurized seal.

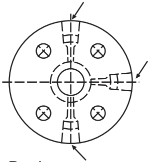
Advantages: Can provide unpressurized flow to multiple seal installations to reduce costs. Positively eliminates fugitive emissions to atmosphere.

General: Plan 55 systems can be custom engineered to suit application requirements. Systems can range from the direct connection from other process streams to complex API 614 systems.

Note: See John Crane Technical Report TRP-52-55 for additional information.

PLAN 61





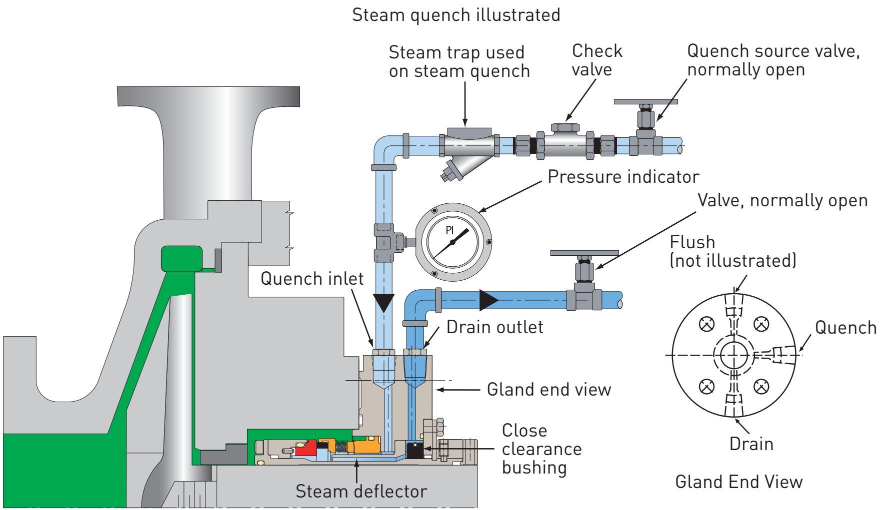
Gland End View

QUENCH SEALS

Description: Tapped connections for purchaser's use. Typically this plan is used when the purchaser may use a quench in the future.

General: Allows the user to connect tubing to the drain port and direct leakage to the collection point.

PLAN 62



Steam quench illustrated
Steam trap used on steam quench
Check valve
Quench source valve, normally open
Pressure indicator
PI
Valve, normally open
Flush (not illustrated)
Quench inlet
Drain outlet
Quench
Gland end view
Close clearance bushing
Drain
Steam deflector
Gland End View

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.

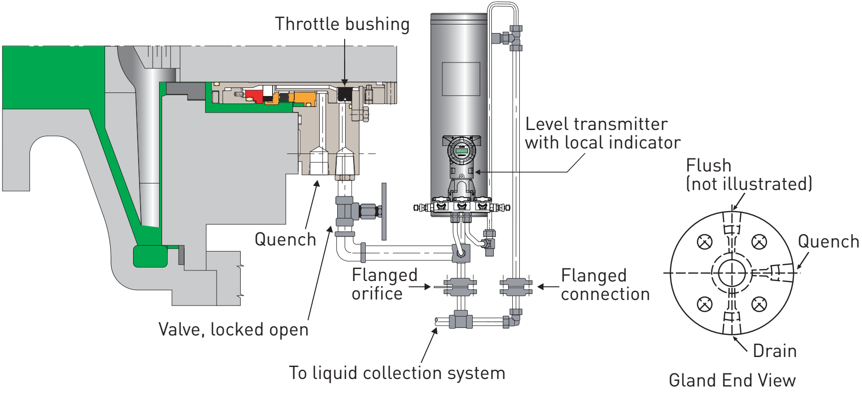
The quench prevents or retards product crystallization or coking. Quenches can also provide some cooling.

General: Typical applications; steam quench on hot services to retard coking, nitrogen quench on cold or cryogenic service to prevent icing, or water quench to prevent crystallization or accumulation of product on the atmosphere side of the seal. May be used with or without a steam deflector.

For steam quenches a steam trap is recommended. A pressure indicator is optional.

NOTE: See John Crane Technical Report TRP-Quench for additional information.

PLAN 65A



Throttle bushing
Level transmitter with local indicator
Flush (not illustrated)
Quench
Quench
Flanged orifice
Flanged connection
Valve, locked open
To liquid collection system
Drain
Gland End View

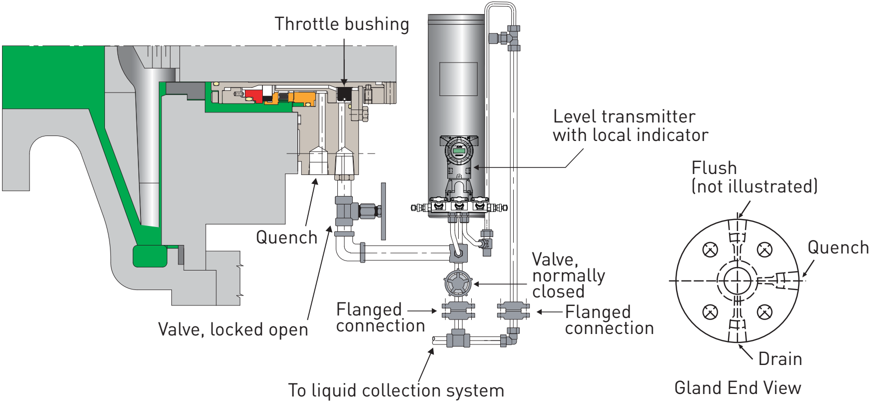
SINGLE SEAL

Description: Plan 65A is a liquid leakage detection plan normally used for single seals. It utilizes a level transmitter 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 consider the fluid's properties.

PLAN 65B


Throttle bushing
Level transmitter
with local indicator
Flush
(not illustrated)
Quench
Valve, locked open
Quench
Valve,
normally
closed
Flanged
connection
Flanged
connection
To liquid collection system
Drain
Gland End View

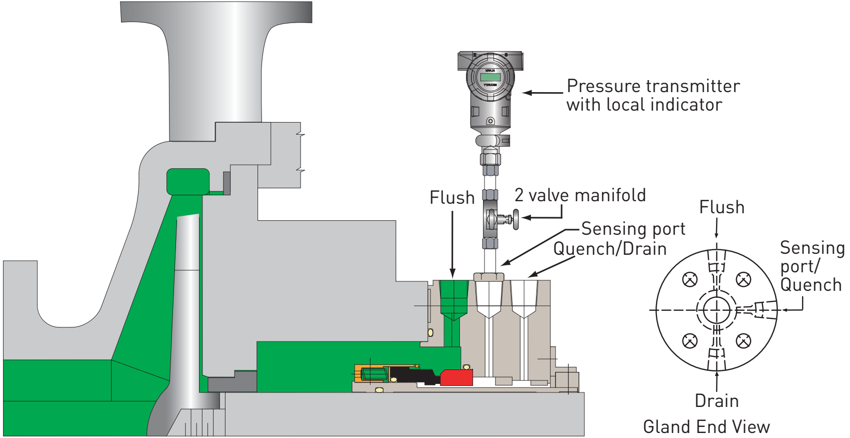
SINGLE SEAL

Description: Plan 65B is a liquid leakage detection plan normally used for single seals. It utilizes a level transmitter on a reservoir to set off an alarm when the reservoir is full.

Advantages: Provides an alarmed indication that can shutdown equipment if necessary.

General: The system includes a loop to by-pass the isolation valve to prevent high pressure on the atmospheric side of the seal. The gland throttle bushing design should consider the fluid's properties.

PLAN 66A


Pressure transmitter with local indicator
Flush
2 valve manifold
Sensing port
Quench/Drain
Flush
Sensing port/ Quench
Drain
Gland End View

SINGLE SEAL

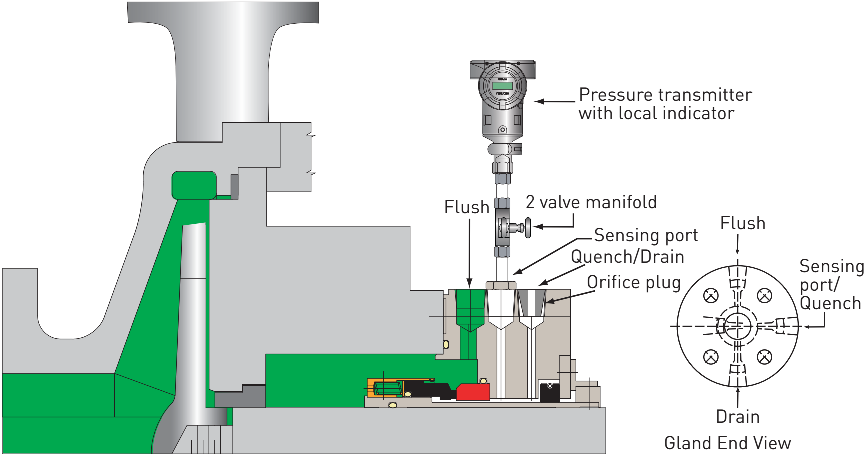
Description: Plan 66A is a leakage detection plan for single seals, commonly applied in pipeline applications. It utilizes a pressure transmitter to monitor seal leakage and set off an alarm when leakage becomes excessive or in the case of seal failure.

Advantages: Utilizes a throttle bushing inboard of the drain port to restrict the flow of excessive leakage to drain, allowing a pressure increase to be monitored or trigger an alarm on seal failure.

General: Leakage from the drain port should be collected and piped to a liquid recovery system or sump. Gland throttle bushings should consider the fluid properties.

Note: See John Crane Technical Report TRP-66A-66B for additional information.

PLAN 66B



Pressure transmitter
with local indicator
Flush
2 valve manifold
Sensing port
Quench/Drain
Orifice plug
Flush
Sensing
port/
Quench
Drain
Gland End View

SINGLE SEAL

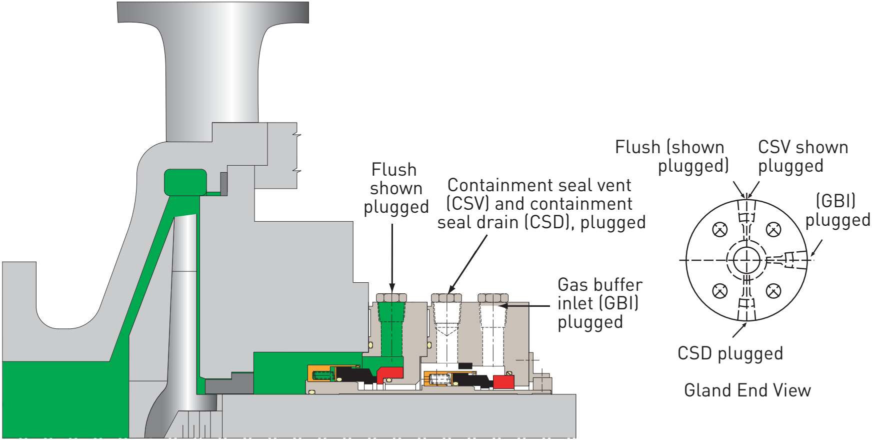
Description: Plan 66B is a leakage detection plan for single seals, commonly applied in pipeline applications. It utilizes a pressure transmitter to monitor seal leakage and set off an alarm when leakage becomes excessive or in the case of seal failure.

Advantages: Utilizes an orifice plug in the drain port to restrict the flow of excessive leakage to drain, allowing a pressure increase to be monitored or trigger an alarm on seal failure.

General: Leakage from the drain port should be collected and piped to a liquid recovery system or sump. The orifice plug should consider the fluid properties.

Note: See John Crane Technical Report TRP-66A-66B for additional information.

PLAN 71



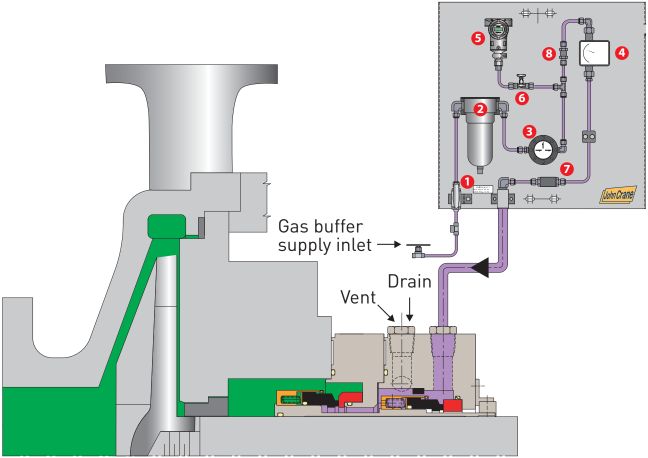
Gland End View

SECONDARY CONTAINMENT SEALS

Description: Tapped connections for purchaser's use. Typically this plan is used when the purchaser may use buffer gas in the future.

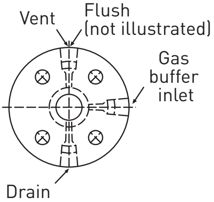
Advantages: Allows the user to add a buffer gas in the future.

PLAN 72



System components

1. Shut off valve, norm. open
2. Coalescing filter
3. Pressure control valve
4. Flow transmitter with local indicator
5. Pressure transmitter with local indicator
6. 2 valve manifold
7. Check valve
8. Orifice



Gland End View

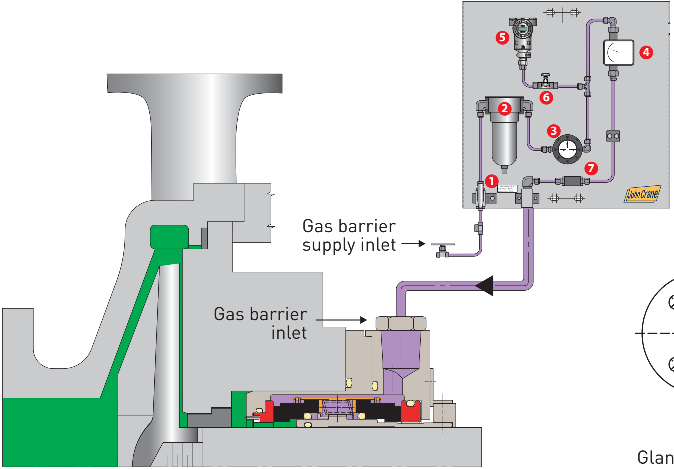
SECONDARY CONTAINMENT SEALS

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.

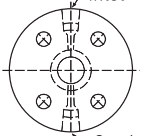
General: Plan 72 is normally used with Plan 75 for primary seal leakage that is condensing, or with Plan 76 for non-condensing leakage.

PLAN 74



System components

1. Shut off valve, norm. open
2. Coalescing filter
3. Pressure control valve
4. Flow transmitter with local indicator
5. Pressure transmitter with local indicator
6. 2 valve manifold
7. Check valve



Gland End View

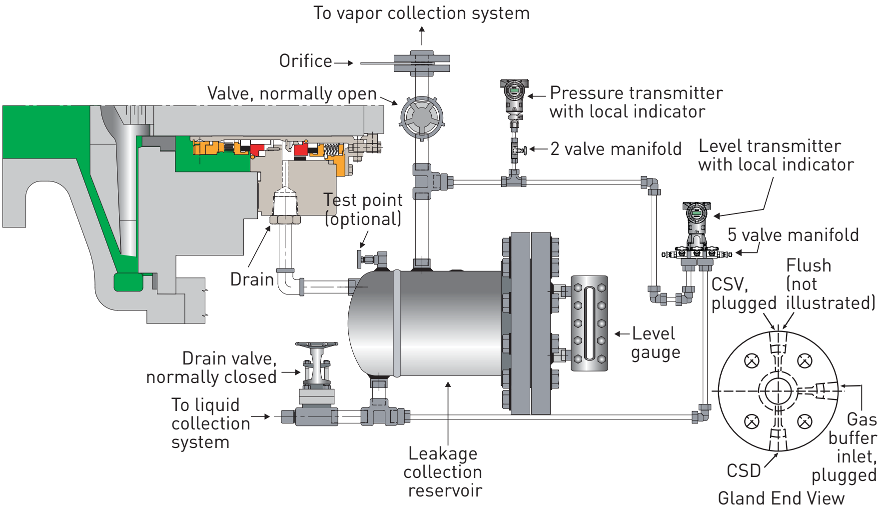
DUAL GAS SEALS

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. Zero emissions.

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.

PLAN 75



To vapor collection system
Orifice
Valve, normally open
Pressure transmitter with local indicator
2 valve manifold
Level transmitter with local indicator
Test point (optional)
5 valve manifold
Drain
Flush (not illustrated)
CSV, plugged
Level gauge
Drain valve, normally closed
To liquid collection system
Gas buffer inlet, plugged
Leakage collection reservoir
CSD
Gland End View

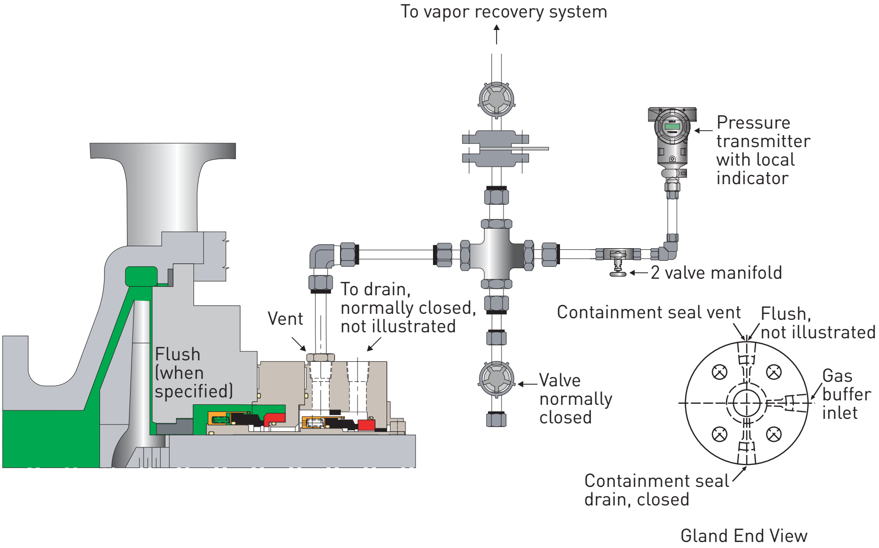
SECONDARY CONTAINMENT SEALS

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 transmitter 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.

PLAN 76


To vapor recovery system
Pressure transmitter with local indicator
2 valve manifold
To drain, normally closed, not illustrated
Vent
Flush (when specified)
Containment seal vent
Flush, not illustrated
Gas buffer inlet
Valve normally closed
Containment seal drain, closed
Gland End View

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.

PLAN 99

USE OF PLAN 99
TO BE DECIDED BY
PURCHASER OR WITH
PURCHASER'S APPROVAL

SINGLE SEALS, DUAL SEALS, QUENCH SEALS, SECONDARY CONTAINMENT SEALS & DUAL GAS SEALS

Description: Plan 99 defines an engineered piping plan not defined by any existing plans.

General: The description and requirements of this plan must be clearly defined in specifications outside API 682 but wherever possible, applicable requirements should be incorporated in the new piping plan.

USEFUL INFORMATION

Data included in this section is provided for guidance only and must not be used for performance calculations of individual seals. Seal and material performance can vary with application, pressure, temperature and installation. For application specific calculations consult John Crane.

LUBRICANTS

The following lubricants are recommended by John Crane

Application	Lubricant	Note
Elastomeric O-rings except silicone rubber	DuPont™ Krytox® GPL 206 Dow Corning® 111 Glycerine	Apply thinly by hand
O-rings of silicone rubber	Glycerine	Apply thinly by hand
Elastomeric bellows	Glycerine Propylene Glycol Soapy water	Apply by brush
Bolts, screws, nuts & fasteners	DuPont Krytox GPL 206 Dow Corning 111 Nickel or silver based anti-seize compounds	Minimal application by brush or hand

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Dow Corning is a Registered trademark of Dow Corning Corporation.

USEFUL INFORMATION

DRIVE SCREW TIGHTENING TORQUES

Socket Head Cup Point Set Screw			
Tightening Torques [Nm] (μ= 0.125 lubricated)			
Thread	**High Tensile Steel, Gr 14.9**	**316 St. Steel Gr A4/70**	**ASTM A453- Gr 660 C**
M4	2.3	1.5	
M5	4.5	3	
M6	7.5	4	
M8	18	11	
M10	36	16	30
M12	60	40	50
1/4 - 20	8.8	4.5	6
5/16 - 18	17.5	10	
3/8 - 16	30	13.5	
7/16 - 14	48	32	
1/2 - 13	69	45	

Socket Head Cap Screw		
Tightening Torques [Nm] (μ= 0.125 lubricated)		
Thread	**Steel Screw**	**Steel Screw**
Size	**(Class 12.9)**	**(316 A4-70)**
M4	4.5	2
M5	9.4	4
M6	16	6,5
M8	38	16
M10	77	32
M12	135	55
M14	215	90
M16	340	140
M20	663	275

Torques are for drive screws only and should not be applied to other screws in the seal assembly

USEFUL INFORMATION

DRIVE SCREW TIGHTENING TORQUES

Socket Head Cup Point Set Screw (UNRC)		
Tightening Torque [in-lb] [μ=0.125]		
Size	Steel ASTM-F912	316 SS ASTM-A193
#10	33	18
1/4"	78	40
5/16"	156	85
3/8"	273	120
7/16"	428	280
1/2"	615	400

Torques are for drive screws only and should not be applied to other screws in the seal assembly

Socket Head Cap Screw		
Tightening Torque [in-lb] [μ=0.125]		
Size	Steel ASTM-A574	316 SS ASTM-A193
#6	30	15
#8	55	28
#10	80	40
1/4"	180	95
5/16"	390	170
3/8"	700	300
7/16"	1125	485
1/2"	1700	750
5/8"	3000	1270
3/4"	5500	2260

USEFUL INFORMATION

TEMPERATURE LIMITATIONS OF FLEXIBLE MEMBERS

	Temperature limits when used as:-	
Rubber	**Bellows, Sliding & Static O-Rings °C**	**Bellows, Sliding & Static O-Rings °F**
Medium Nitrile	Minus 40˚C to Plus 120˚C +	Minus 40˚F to Plus 250˚F +
Low Temp Nitrile	Minus 55˚C to Plus 100˚C	Minus 65˚F to Plus 212˚F
Neoprene	Minus 40˚C to Plus 100˚C	Minus 40˚F to Plus 212˚F
Fluorocarbon/Fluoroelastomer	Minus 30˚C to Plus 205˚C †	Minus 20˚F to Plus 400˚F †
Fluorocarbon GLT	Minus 45˚C to Plus 205˚C †	Minus 50˚F to Plus 400˚F †
EPDM Rubber	Minus 40˚C to Plus 150˚C *	Minus 40˚F to Plus 300˚F *
Fluorosilicone	Minus 60˚C to Plus 175˚C ▼	Minus 75˚F to Plus 350˚F ▼
Silicone	Minus 55˚C to Plus 200˚C ▼	Minus 65˚F to Plus 390˚F ▼
TFE-P/TFE-Propylene	0˚C to Plus 205˚C	32˚F to Plus 400˚F
HT-FFKM (was Perfluoroelastomer 1)	Minus 20˚C to Plus 260˚C ■	Minus 4˚F to Plus 500˚F ■
LT-FFKM (was Perfluoroelastomer 2)	Minus 20˚C to Plus 215˚C ●	Minus 4˚F to Plus 420˚F ●

+ For water duties the upper limit is 100°C (212°F)
† For water duties the upper limit is 135°C (275°F)
* Not for use in contact with hydrocarbon based products
■ For water duties the upper limit is 90°C (194°F)
● For static Applications Minus 25ºC to Plus 215ºC (Minus 13ºF to Plus 420ºF)
▼ These elastomeric materials have a limited tolerance to abrasion and movement

USEFUL INFORMATION

TEMPERATURE LIMITATIONS OF FLEXIBLE MEMBERS

	Temperature limits when used as:-	
PTFE / Graphite	**Fully Constrained Ring (i.e. Metal Bellows Packing)**	**Seat Rings**
Pure PTFE	Minus 60˚C to Plus 260˚C Minus 76˚F to Plus 500˚F	Minus 20˚C to Plus 180˚C Minus 4˚F to Plus 356˚F
25% Glass Filled PTFE	Minus 100˚C to Plus 280˚C Minus 148˚F to Plus 536˚F	Minus 50˚C to Plus 230˚C Minus 58˚F to Plus 446˚F
25% Carbon Filled PTFE	Minus 80˚C to Plus 250˚C Minus 112˚F to Plus 482˚F	Minus 40˚C to Plus 200˚C Minus 40˚F to Plus 392˚F
Graphite/Stainless Steel Mesh	Minus 212˚C to Plus 500˚C Minus 350˚F to Plus 932˚F	
Graphite or Cranfoil	Minus 212˚C to Plus 500˚C Minus 350˚F to Plus 932˚F	Minus 40˚C to Plus 400˚C Minus 40˚F to Plus 752˚F

NOTE: When using either FEP covered fluorocarbon o-rings or PTFE / Graphite seat rings, the seat must be fitted with an anti-rotation pin.

NOTE: The limits shown are for guidance only, and do not take into account any site experience.

USEFUL INFORMATION

INSTALLATION CRITERIA & LIMITS

Installation Criterion Concentricity	General value/Limit	Remarks
Shaft to seal chamber	Less than 125 µm (0.005") TIR (Total Indicator Reading)	TIR is sometimes also referred to as Full Indicator Movement (FIM)
Shaft run out measured from a casing mounted indicator	Less than 25 µm (0.001") TIR	
Run-out of sleeve outer diameter to inner diameter	Less than 25 µm (0.001") TIR	
Squareness of seal chamber face to shaft	Less than 0.5 µm/mm of seal chamber bore (0.0005"/inch of seal chamber bore)	
Centering of the seal is to be by a register fit. The register fit surface shall be concentric to the shaft	Less than 125 µm (0.005") TIR	
Shaft Axial Float/End play	Less than 0.08 mm (0.003") TIR	This is the maximum movement during dynamic operation
Shaft tolerance **Shaft Surface** Texture/Finish	h6 1.6 µm Ra (64 µin Ra)	

USEFUL 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

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

USEFUL CONVERSIONS

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	psi	1.4504×10^{-4}
kg/cm^2	bar	0.09807	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	$1x10^{-5}$	bar	N/m^2	$1x10^{5}$
kPa	bar	0.01	bar	kPa	100
MPa	bar	10	bar	MPa	0.1
bar	torr(mm Hg)	750.0638	torr(mm Hg)	bar	0.001333
psi	ft(liquid)	2.307 ÷ SG	ft(liquid)	psi	0.4335xSG
psi	m(liquid)	0.703 ÷ SG	m(liquid)	psi	1.4223xSG
bar	ft(liquid)	33.4552 ÷ SG	ft(liquid)	bar	0.02989xSG
bar	m(liquid)	10.1972 ÷ SG	m(liquid)	bar	0.09806xSG
kg/cm^2	m(liquid)	10 ÷ SG	m(liquid)	kg/cm^2	0.1xSG

USEFUL CONVERSIONS

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	gallons(Imp)	0.21997
gallons(US)	m^3	0.003785	m^3	gallons(US)	264.1721
gallons(US)	liters(dm^3)	3.7854	liters	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
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

USEFUL CONVERSIONS

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	5.886×10^{-4}

WEIGHT/FORCE

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
lbsf	N	4.4482	N	lbsf	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

USEFUL CONVERSIONS

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)	1.35962
Btu/hr	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

USEFUL CONVERSIONS

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
$grms/cm^3$	kg/m^3	1000	kg/m^3	$grms/cm^3$	0.001
lbs/gal(US)	kg/m^3	119.8264	kg/m^3	lbs/gal(US)	0.008345

API GRAVITY - °API

$$°API = \frac{141.5}{SG} - 131.5$$

$$SG = \frac{141.5}{°API + 131.5}$$

Degrees Baumé

$$°Bé = 145 - \frac{145}{SG}$$

$$SG = \frac{145}{45 - °Bé}$$

The above °Bé formulae apply to solutions denser than water

USEFUL CONVERSIONS

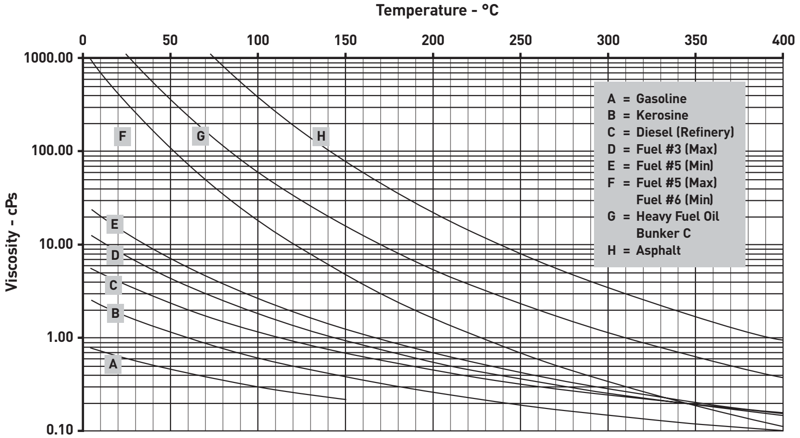
VISCOSITY - DYNAMIC & KINEMATIC

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	lbf.sec/ft^2	N.sec/m^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}

approximately: $cSt = 0.226 \times SSU - \frac{195}{SSU}$ $32 < SSU < 100$ $cSt = 0.22 \times SSU - \frac{135}{SSU}$ $SSU \geq 100$

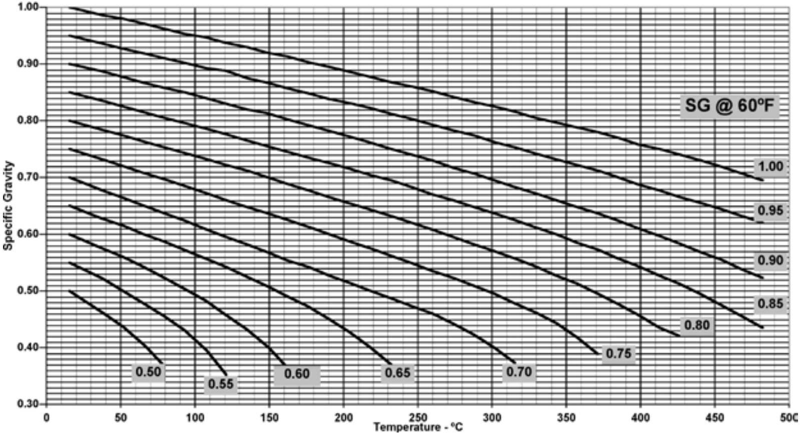
USEFUL INFORMATION

VISCOSITY/TEMPERATURE - PETROLEUM PRODUCTS



USEFUL INFORMATION

SPECIFIC GRAVITY VS TEMPERATURE - PETROLEUM FRACTIONS



www.johncrane.com

USEFUL INFORMATION

North America
United States of America
Tel: 1-847-967-2400
Fax: 1-847-967-3915

Europe
United Kingdom
Tel: 44-1753-224000
Fax: 44-1753-224224

Latin America
Brazil
Tel: 55-11-3371-2500
Fax: 55-11-3371-2599

Middle East & Africa
United Arab Emirates
Tel: 971-481-27800
Fax: 971-488-62830

Asia Pacific
Singapore
Tel: 65-6518-1800
Fax: 65-6518-1803

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