

MECHANICAL SEAL PIPING PLANS POCKET GUIDE — 4TH EDITION

INTRODUCTION AND PIPING KEY	SINGLE SEALS	DUAL SEALS	QUENCH SEAL	SECONDARY Containment Seals	DUAL GAS SEALS	USEFUL INFORMATION
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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, guench seals, secondary containment seals & dual gas seals - defines an engineered piping plan not defined by any existing plans

INTRODUCTION

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



PIPING KEY

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.
- $ec{\mathbf{M}}$ 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 (1/2") interconnecting piping/tubing for plans where flow is produced by pump differential pressures

SINGLE SEALS - PLAN 23 ILLUSTRATED



DUAL SEALS - PLAN 53A ILLUSTRATED





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.





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.



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.



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.



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.

• Quench optional Orifice Return to suction **PLAN 13** Flush outlet Flush Quench/Drain outlet 끲 \otimes \otimes agg de la companya d \otimes \odot 出 Drain Gland End View

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.



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.

• 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.

• Quench optional



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."

• Quench optional

Cooling water

vent, plugged

Flush outlet

shown for CW



indicator ain Drain Flush inlet Gland End View

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Heat exchanger

Cooling water

drain, plugged

Temperature

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.





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.



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.



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.


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



Gland End View

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.



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 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.



PLAN 53B

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.



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.



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.



Buffer outlet/ Flush [not illustrated]

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.





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.

Steam quench illustrated



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; 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.

Throttle bushing i 🛋 💻 n**a** Ti Level transmitter with local indicator Flush (not illustrated) ORTEST ST STREET Quench \otimes Quench \otimes Flanged orifice Flanged connection \otimes 曲 \otimes Valve, locked open Drain To liquid collection system Gland End View

PLAN 65A

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



PLAN 65B

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



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.

PLAN 66B



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.



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.



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.



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.

To vapor collection system Orifice→ Valve, normally open Pressure transmitter with local indicator Level transmitter • ← 2 valve manifold PLAN 75 with local indicator Test point (optional) 5 valve manifold onternern Flush Drain CSV, (not plugged illustrated) ←Level gauge Drain valve, \otimes \otimes normally closed -<u>-</u>[]-To liquid \otimes Gas collection 出 \odot buffer system Leakage inlet. CSD collection plugged reservoir 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.



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.

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.

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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DRIVE SCREW TIGHTENING TORQUES

Socket Head Cup Point Set Screw				
Tightenir	g Torques [N	m] (µ= 0.125	lubricated)	
Thread	High Tensile Steel, Gr 14.9	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 Tore	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

DRIVE SCREW TIGHTENING TORQUES

Socket Head Cup Point Set Screw (UNRC)						
Tightenin	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				
Tightenin	g 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		

TEMPERATURE LIMITATIONS OF FLEXIBLE MEMBERS

	ts 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 25°C to Plus 215°C (Minus 13°F to Plus 420°F)

These elastomeric materials have a limited tolerance to abrasion and movement

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.

INSTALLATION CRITERIA & LIMITS

	1	1
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)	

LENGTH

From	То	Multiply by	From	То	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	2.54x10⁻⁵	mm	μin	39370
µin	nm	25.4	nm	μin	0.03937

AREA

From	То	Multiply by	From	То	Multiply by
inches ²	mm ²	645.16	mm ²	inches ²	0.00155
feet ²	m²	0.0929	m ²	feet ²	10.7639
yards²	m ²	0.8361	m²	yards²	1.1960
acres	hectares	0.4047	hectares	acres	2.4711
miles ²	km ²	2.59	km²	miles ²	0.3861

PRESSURE/HEAD

From	То	Multiply by	From	То	Multiply by
psi	bar	0.06895	bar	psi	14.5038
psi	kg/cm²	0.07031	kg/cm ²	psi	14.2233
psi	N/m²(Pa)	6894.757	N/m ²	psi	1.4504 x 10 ⁻⁴
kg/cm²	bar	0.09807	bar	kg/cm²	1.01972
atms.	psi	14.6959	psi	atms.	0.06805
atms.	kg/cm²	1.03323	kg/cm ²	atms	0.96784
atms.	bar	1.01325	bar	atms.	0.98692
N/m² (Pa)	bar	1x10 ⁻⁵	bar	N/m ²	1x10⁵
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

VOLUME

From	То	Multiply by	From	То	Multiply by
ft ³	m ³	0.028317	m ³	ft ³	35.3147
ft ³	liters(dm³)	28.317	liters(dm³)	ft ³	0.035315
in ³	m ³	1.6387x10 ⁻⁵	m ³	in ³	61023.74
gallons(Imp)	gallons(US)	1.20095	gallons(US)	gallons(Imp)	0.83267
gallons(Imp)	m ³	4.5461x10 ⁻³	m ³	gallons(Imp)	219.9692
gallons(Imp)	liters(dm³)	4.54609	liters	gallons(Imp)	0.21997
gallons(US)	m ³	0.003785	m ³	gallons(US)	264.1721
gallons(US)	liters(dm³)	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(dm³)	158.9873	liters(dm ³)	barrels(bbl) oil	0.006290

VOLUME FLOW RATE

From	То	Multiply by	From	То	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	
ft³/min	liters/min	28.3168	liters/min	ft³/min	0.03532	
m³/hour	liters/min	16.6667	liters/min	m³/hour	0.06	
barrels oil/day	liters/min	0.1104	liters/min	barrels oil/day	9.0573	
ft³/sec	liters/min	1699.01	liters/min	ft ³ /sec	5.886x10-4	

WEIGHT/FORCE

From	То	Multiply by	From	То	Multiply by
lbs	kg	0.4536	kg	lbs	2.2046
tons(long)	kg	1016.05	kg	tons(long)	9.842x10-4
tons(short)	kg	907.19	kg	tons(short)	1.102x10 ⁻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

POWER

From	То	Multiply by	From	То	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	2.9307x10 ⁻⁴	kW	Btu/hr	3412.1416
ft.lbf/sec	kW	0.001356	kW	ft.lbf/sec	737.5622

TORQUE

From	То	Multiply by	From	То	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	То	Multiply by	From	То	Multiply by
lbs/ft³	kg/m³	16.01846	kg/m³	lbs/ft³	0.06243
grms/cm³	kg/m³	1000	kg/m³	grms/cm³	0.001
lbs/gal(US)	kg/m³	119.8264	kg/m³	lbs/gal(US)	0.008345

API GRAVITY - °API

ADI 141.5 121 5	sc _ 141.5
$-AFT = \frac{-131.3}{SG}$	30 = [•] API + 131.5

Degrees Baumé

$$^{\circ}Be = 145 - \frac{145}{5G}$$
 $SG = \frac{145}{45 - ^{\circ}Be}$

The above °Bé formulae apply to solutions denser than water

VISCOSITY - DYNAMIC & KINEMATIC

From	То	Multiply by	From	То	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/ft²	N.sec/m ²	47.8803	lbf.sec/ft ²	N.sec/m ²	0.02089
lbf.sec/ft²	cPs	47880.259	cPs	lbf.sec/ft²	2.0885x10 ⁻⁵
cSt	m²/sec	1.0 x 10 ⁻⁶	m²/sec	cSt	1.0 x 10 ⁶
ft²/sec	cSt	9.2903 x 104	cSt	ft²/sec	1.0764 x 10 ⁻⁵

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

VISCOSITY/TEMPERATURE - PETROLEUM PRODUCTS



Temperature - °C

USEFUL INFORMATION

SPECIFIC GRAVITY VS TEMPERATURE - PETROLEUM FRACTIONS



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