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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

DIT 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

FSL 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

- **High Point Vent**
- **40mm/m / ½” per foot Min. Slope**
- **CW Shaft Rot. Shown**
- **450-600 mm (18-24 inch)**
- **Low Point Drain Valve**
- **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).

**Horizontal Equipment**

- **40mm/m / ½” per foot Min. Slope**
- **1m 36”**
- **Barrier Outlet**
- **CW Shaft Rot. Shown**
- **Barrier Inlet**
- **Drain Valve**
- **Low Point Drain Valve**

**Vertical Equipment**

- **Shaft Gland**
- **Barrier Inlet**
PLAN 01

- No external flush
- Quench optional

Internal flush porting

Quench/Drain

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.
Large bore seal chamber is recommended

Optional heating/cooling inlet/outlet

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

Flush, plugged

Quench/Drain

Vent if required

Flush, plugged

Quench/Drain

Flush, plugged

Quench

Drain

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.
Large tapered bore seal chamber. Flow modifiers may be incorporated.

- Quench optional
- Tapered bore seal chambers are self venting
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.
• Quench optional

By-pass from discharge

Orifice

Flush

Quench/Drain

Gland End View

Quench

Drain
**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.
• Quench optional

- By-pass from discharge
- Strainer
- Orifice
- Cleanout trap
- Flush
- Quench/Drain

Gland End View
**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

Return to suction

Flush outlet

Quench/Drain

Flush outlet

Quench

Drain

Gland End View
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.
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

Gland End View

Orifice

By-pass from discharge

Flush

Cooling water connections

Heat exchanger

Vent, plugged

Drain plugged

Flush

Temperature indicator

Quench/Drain

Quench

Drain
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

- Drain plugged

- Heat exchanger Vent, plugged

- Strainer

- Orifice

- Cooling water connections

- Flush outlet

- Quench/Drain

- Temperature indicator

- Gland End View

- Drain

- Gland

- Quench
**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.”
Quench optional

Temperature indicator

Heat exchanger

Cooling water vent, plugged

Cooling water connections

Vent, normally closed

Flush outlet

Flush inlet

Pumping ring

Quench/Drain

Temperature drain, plugged

Flush outlet shown for CW shaft rotation

Quench

Drain Flush inlet

Gland End View
**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.
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.
• Quench optional

Flow control valve

Pressure indicator

Flow indicator (optional)

Strainer

Valve, normally open

Clean out trap

Temperature indicator (optional)

Check valve

Flush

Quench/Drain

Flush

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.
Temperature indicator

Quench/Drain

Heat exchanger

Drain, plugged

Vent, plugged

Flush

Gland End View

Abrasive/cyclone separator

By-pass from discharge

Return to suction

Cooling water connections

Quench optional

Flush

Quench/Drain

Temperature indicator

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.
Make-up buffer liquid fill, normally closed

To collection system

Orifice

To seal, normally closed

Flush

Quench inlet

Note: Per API 682 this piping plan is only recommended for vertical pumps, but in practice has also been used on horizontal pumps.
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.
Note: Tangential porting is uni-directional. Gland illustrated is for CCW rotation from drive end.

Note: A buffer fluid drain is located on the low point of the buffer inlet (not illustrated). See Best Piping Practices.
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: Tangential porting is uni-directional. Gland illustrated is for CCW rotation from drive end.

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

**Barrier outlet**

**Cooling water connections**

**Vents, normally closed**

**Pressure transmitter with local indicator**

**2 valve manifold**

**Heat exchanger**

**Temperature indicator (optional)**

**Barrier inlet**

**Make-up barrier liquid fill, normally closed**

**Accumulator**

**Accumulator isolation valve (optional)**

**Pressure indicator (optional)**

**2 valve manifold**

**Temperature transmitter with local indicator**

**Barrier outlet**

**Flush**

**Barrier inlet**

**Gland End View**

**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.
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.
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.
EXTERNAL UNPRESSURIZED BUFFER SOURCE/SYSTEM

Buffer outlet
Buffer inlet

Buffer outlet/Flush [not illustrated]
Buffer inlet

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.
Drain, open - connected to metal tubing

Flush (not illustrated)

Quench, plugged

Drain

Quench inlet, plugged

Steam deflector

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.
Steam quench illustrated

Steam trap used on steam quench

Check valve, normally open

Quench source valve, normally open

Pressure indicator

Valve, normally open

Flush (not illustrated)

Quench inlet

Drain outlet

Gland end view

Close clearance bushing

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.
Flush (not illustrated)

Quench

Drain

Gland End View

Valve, locked open

To liquid collection system

Throttle bushing

Level transmitter with local indicator

Flanged orifice

Flanged connection
**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.
Throttle bushing

Level transmitter with local indicator

Valve, normally closed

Flanged connection

To liquid collection system

Flanged connection

Valve, locked open

Quench

Flush (not illustrated)

Gland End View

Quench

Drain
**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.
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.

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

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.
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

Gas buffer supply inlet → Vent → Drain

Vent
Flush (not illustrated)
Gas buffer inlet
Drain
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.
**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

**Gas barrier outlet**

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.
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.
To vapor recovery system

To drain, normally closed, not illustrated

Vent

Flush (when specified)

Containment seal vent

Containment seal drain, closed

Flush, not illustrated

Valve normally closed

2 valve manifold

Pressure transmitter with local indicator

Gland End View

Gas buffer inlet

Gas buffer inlet

Containment seal vent

Valve normally closed

Flush, not illustrated

To drain, normally closed, not illustrated

Vent

Flush (when specified)
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
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

<table>
<thead>
<tr>
<th>Application</th>
<th>Lubricant</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elastomeric O-rings except silicone rubber</td>
<td>DuPont™ Krytox® GPL 206&lt;br&gt;Dow Corning® 111&lt;br&gt;Glycerine</td>
<td>Apply thinly by hand</td>
</tr>
<tr>
<td>O-rings of silicone rubber</td>
<td>Glycerine</td>
<td>Apply thinly by hand</td>
</tr>
<tr>
<td>Elastomeric bellows</td>
<td>Glycerine&lt;br&gt;Propylene Glycol&lt;br&gt;Soapy water</td>
<td>Apply by brush</td>
</tr>
<tr>
<td>Bolts, screws, nuts &amp; fasteners</td>
<td>DuPont Krytox GPL 206&lt;br&gt;Dow Corning 111&lt;br&gt;Nickel or silver based anti-seize compounds</td>
<td>Minimal application by brush or hand</td>
</tr>
</tbody>
</table>

Dupont and Krytox are registered trademarks of E. I. du Pont de Nemours and Company. Dow Corning is a Registered trademark of Dow Corning Corporation.
# USEFUL INFORMATION

## DRIVE SCREW TIGHTENING TORQUES

### Socket Head Cup Point Set Screw

<table>
<thead>
<tr>
<th>Thread</th>
<th>High Tensile Steel, Gr 14.9</th>
<th>316 St. Steel Gr A4/70</th>
<th>ASTM A453-Gr 660 C</th>
</tr>
</thead>
<tbody>
<tr>
<td>M4</td>
<td>2.3</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>M5</td>
<td>4.5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>M6</td>
<td>7.5</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>M8</td>
<td>18</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>M10</td>
<td>36</td>
<td>16</td>
<td>30</td>
</tr>
<tr>
<td>M12</td>
<td>60</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>1/4 - 20</td>
<td>8.8</td>
<td>4.5</td>
<td>6</td>
</tr>
<tr>
<td>5/16 - 18</td>
<td>17.5</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>3/8 - 16</td>
<td>30</td>
<td>13.5</td>
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<tr>
<td>7/16 - 14</td>
<td>48</td>
<td>32</td>
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</tr>
<tr>
<td>1/2 - 13</td>
<td>69</td>
<td>45</td>
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### Socket Head Cap Screw

<table>
<thead>
<tr>
<th>Thread</th>
<th>Steel Screw (Class 12.9)</th>
<th>Steel Screw (316 A4-70)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M4</td>
<td>4.5</td>
<td>2</td>
</tr>
<tr>
<td>M5</td>
<td>9.4</td>
<td>4</td>
</tr>
<tr>
<td>M6</td>
<td>16</td>
<td>6.5</td>
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<tr>
<td>M8</td>
<td>38</td>
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<td>M10</td>
<td>77</td>
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<td>M12</td>
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<td>215</td>
<td>90</td>
</tr>
<tr>
<td>M16</td>
<td>340</td>
<td>140</td>
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<tr>
<td>M20</td>
<td>663</td>
<td>275</td>
</tr>
</tbody>
</table>

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

DRIVE SCREW TIGHTENING TORQUES

<table>
<thead>
<tr>
<th>Socket Head Cup Point Set Screw (UNRC)</th>
<th>Tightening Torque [in-lb] [µ=0.125]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steel ASTM-F912</td>
</tr>
<tr>
<td>Size</td>
<td></td>
</tr>
<tr>
<td>#10</td>
<td>33</td>
</tr>
<tr>
<td>1/4&quot;</td>
<td>78</td>
</tr>
<tr>
<td>5/16&quot;</td>
<td>156</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>273</td>
</tr>
<tr>
<td>7/16&quot;</td>
<td>428</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>615</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Socket Head Cap Screw</th>
<th>Tightening Torque [in-lb] [µ=0.125]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steel ASTM-A574</td>
</tr>
<tr>
<td>Size</td>
<td></td>
</tr>
<tr>
<td>#6</td>
<td>30</td>
</tr>
<tr>
<td>#8</td>
<td>55</td>
</tr>
<tr>
<td>#10</td>
<td>80</td>
</tr>
<tr>
<td>1/4&quot;</td>
<td>180</td>
</tr>
<tr>
<td>5/16&quot;</td>
<td>390</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>700</td>
</tr>
<tr>
<td>7/16&quot;</td>
<td>1125</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>1700</td>
</tr>
<tr>
<td>5/8&quot;</td>
<td>3000</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>5500</td>
</tr>
</tbody>
</table>

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

### TEMPERATURE LIMITATIONS OF FLEXIBLE MEMBERS

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

+ 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
**USEFUL INFORMATION**

**TEMPERATURE LIMITATIONS OF FLEXIBLE MEMBERS**

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

**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

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

### LENGTH

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Multiply by</th>
<th>From</th>
<th>To</th>
<th>Multiply by</th>
</tr>
</thead>
<tbody>
<tr>
<td>inches</td>
<td>mm</td>
<td>25.4</td>
<td>mm</td>
<td>inches</td>
<td>0.03937</td>
</tr>
<tr>
<td>inches</td>
<td>m</td>
<td>0.0254</td>
<td>m</td>
<td>inches</td>
<td>39.37</td>
</tr>
<tr>
<td>feet</td>
<td>mm</td>
<td>304.8</td>
<td>mm</td>
<td>feet</td>
<td>0.00328</td>
</tr>
<tr>
<td>feet</td>
<td>m</td>
<td>0.3048</td>
<td>m</td>
<td>feet</td>
<td>3.281</td>
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<tr>
<td>yards</td>
<td>m</td>
<td>0.9144</td>
<td>m</td>
<td>yards</td>
<td>1.0936</td>
</tr>
<tr>
<td>miles</td>
<td>km</td>
<td>1.6093</td>
<td>km</td>
<td>miles</td>
<td>0.6214</td>
</tr>
<tr>
<td>µin</td>
<td>mm</td>
<td>2.54x10⁻⁵</td>
<td>mm</td>
<td>µin</td>
<td>39370</td>
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<tr>
<td>µin</td>
<td>nm</td>
<td>25.4</td>
<td>nm</td>
<td>µin</td>
<td>0.03937</td>
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### AREA

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<thead>
<tr>
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<th>To</th>
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<th>From</th>
<th>To</th>
<th>Multiply by</th>
</tr>
</thead>
<tbody>
<tr>
<td>inches²</td>
<td>mm²</td>
<td>645.16</td>
<td>mm²</td>
<td>inches²</td>
<td>0.00155</td>
</tr>
<tr>
<td>feet²</td>
<td>m²</td>
<td>0.0929</td>
<td>m²</td>
<td>feet²</td>
<td>10.7639</td>
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<tr>
<td>yards²</td>
<td>m²</td>
<td>0.8361</td>
<td>m²</td>
<td>yards²</td>
<td>1.1960</td>
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<td>acres</td>
<td>hectares</td>
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<td>hectares</td>
<td>acres</td>
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<td>km²</td>
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<td>km²</td>
<td>miles²</td>
<td>0.3861</td>
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</table>
## USEFUL CONVERSIONS

### PRESSURE/HEAD

<table>
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<tr>
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<th>Multiply by</th>
<th>From</th>
<th>To</th>
<th>Multiply by</th>
</tr>
</thead>
<tbody>
<tr>
<td>psi</td>
<td>bar</td>
<td>0.06895</td>
<td>bar</td>
<td>psi</td>
<td>14.5038</td>
</tr>
<tr>
<td>psi</td>
<td>kg/cm²</td>
<td>0.07031</td>
<td>kg/cm²</td>
<td>psi</td>
<td>14.2233</td>
</tr>
<tr>
<td>psi</td>
<td>N/m²(Pa)</td>
<td>6894.757</td>
<td>N/m²(Pa)</td>
<td>psi</td>
<td>1.4504 x 10⁻⁴</td>
</tr>
<tr>
<td>kg/cm²</td>
<td>bar</td>
<td>0.09807</td>
<td>bar</td>
<td>kg/cm²</td>
<td>1.01972</td>
</tr>
<tr>
<td>atms.</td>
<td>psi</td>
<td>14.6959</td>
<td>psi</td>
<td>atms.</td>
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<tr>
<td>atms.</td>
<td>kg/cm²</td>
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<td>kg/cm²</td>
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<td>bar</td>
<td>atms.</td>
<td>0.98692</td>
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<tr>
<td>N/m²(Pa)</td>
<td>bar</td>
<td>1 x 10⁻⁵</td>
<td>bar</td>
<td>N/m²(Pa)</td>
<td>1 x 10⁵</td>
</tr>
<tr>
<td>kPa</td>
<td>bar</td>
<td>0.01</td>
<td>bar</td>
<td>kPa</td>
<td>100</td>
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<td>MPa</td>
<td>bar</td>
<td>10</td>
<td>bar</td>
<td>MPa</td>
<td>0.1</td>
</tr>
<tr>
<td>bar</td>
<td>torr(mm Hg)</td>
<td>750.0638</td>
<td>torr(mm Hg)</td>
<td>bar</td>
<td>0.001333</td>
</tr>
<tr>
<td>psi</td>
<td>ft(liquid)</td>
<td>2.307 ÷ SG</td>
<td>ft(liquid)</td>
<td>psi</td>
<td>0.4335xSG</td>
</tr>
<tr>
<td>psi</td>
<td>m(liquid)</td>
<td>0.703 ÷ SG</td>
<td>m(liquid)</td>
<td>psi</td>
<td>1.4223xSG</td>
</tr>
<tr>
<td>bar</td>
<td>ft(liquid)</td>
<td>33.4552 ÷ SG</td>
<td>ft(liquid)</td>
<td>bar</td>
<td>0.02989xSG</td>
</tr>
<tr>
<td>bar</td>
<td>m(liquid)</td>
<td>10.1972 ÷ SG</td>
<td>m(liquid)</td>
<td>bar</td>
<td>0.09806xSG</td>
</tr>
<tr>
<td>kg/cm²</td>
<td>m(liquid)</td>
<td>10 ÷ SG</td>
<td>m(liquid)</td>
<td>kg/cm²</td>
<td>0.1xSG</td>
</tr>
</tbody>
</table>
## VOLUME

<table>
<thead>
<tr>
<th>From</th>
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<th>Multiply by</th>
<th>From</th>
<th>To</th>
<th>Multiply by</th>
</tr>
</thead>
<tbody>
<tr>
<td>ft³</td>
<td>m³</td>
<td>0.028317</td>
<td>m³</td>
<td>ft³</td>
<td>35.3147</td>
</tr>
<tr>
<td>ft³</td>
<td>liters(dm³)</td>
<td>28.317</td>
<td>liters(dm³)</td>
<td>ft³</td>
<td>0.035315</td>
</tr>
<tr>
<td>in³</td>
<td>m³</td>
<td>1.6387x10⁻⁵</td>
<td>m³</td>
<td>in³</td>
<td>61023.74</td>
</tr>
<tr>
<td>gallons(Imp)</td>
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<td>1.20095</td>
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<td>m³</td>
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<td>gallons(Imp)</td>
<td>219.9692</td>
</tr>
<tr>
<td>gallons(Imp)</td>
<td>liters(dm³)</td>
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<td>liters</td>
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<td>0.21997</td>
</tr>
<tr>
<td>gallons(US)</td>
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<td>m³</td>
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<tr>
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<td>liters</td>
<td>gallons(US)</td>
<td>0.26417</td>
</tr>
<tr>
<td>barrels(bbl)oil</td>
<td>gallons(Imp)</td>
<td>34.9723</td>
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<td>42</td>
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<tr>
<td>barrels(bbl)oil</td>
<td>m³</td>
<td>0.1590</td>
<td>m³</td>
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<td>6.2898</td>
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<td>158.9873</td>
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<td>0.006290</td>
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</table>
### USEFUL CONVERSIONS

#### VOLUME FLOW RATE

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Multiply by</th>
<th>From</th>
<th>To</th>
<th>Multiply by</th>
</tr>
</thead>
<tbody>
<tr>
<td>gals(Imp)/min</td>
<td>liters/min</td>
<td>4.5461</td>
<td>liters/min</td>
<td>gals(Imp)/min</td>
<td>0.21997</td>
</tr>
<tr>
<td>gals(US)/min</td>
<td>liters/min</td>
<td>3.7854</td>
<td>liters/min</td>
<td>gals(US)/min</td>
<td>0.26417</td>
</tr>
<tr>
<td>ft³/min</td>
<td>liters/min</td>
<td>28.3168</td>
<td>liters/min</td>
<td>ft³/min</td>
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<tr>
<td>m³/hour</td>
<td>liters/min</td>
<td>16.6667</td>
<td>liters/min</td>
<td>m³/hour</td>
<td>0.06</td>
</tr>
<tr>
<td>barrels oil/day</td>
<td>liters/min</td>
<td>0.1104</td>
<td>liters/min</td>
<td>barrels oil/day</td>
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<tr>
<td>ft³/sec</td>
<td>liters/min</td>
<td>1699.01</td>
<td>liters/min</td>
<td>ft³/sec</td>
<td>5.886x10⁻⁴</td>
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</table>

#### WEIGHT/FORCE

<table>
<thead>
<tr>
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<th>To</th>
<th>Multiply by</th>
<th>From</th>
<th>To</th>
<th>Multiply by</th>
</tr>
</thead>
<tbody>
<tr>
<td>lbs</td>
<td>kg</td>
<td>0.4536</td>
<td>kg</td>
<td>lbs</td>
<td>2.2046</td>
</tr>
<tr>
<td>tons(long)</td>
<td>kg</td>
<td>1016.05</td>
<td>kg</td>
<td>tons(long)</td>
<td>9.842x10⁻⁴</td>
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<tr>
<td>tons(short)</td>
<td>kg</td>
<td>907.19</td>
<td>kg</td>
<td>tons(short)</td>
<td>1.102x10⁻³</td>
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<tr>
<td>tons(long)</td>
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<td>1.016047</td>
<td>tonne</td>
<td>tons(long)</td>
<td>0.9842</td>
</tr>
<tr>
<td>tons(short)</td>
<td>tonne</td>
<td>0.9072</td>
<td>tonne</td>
<td>tons(short)</td>
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<tr>
<td>lbf</td>
<td>N</td>
<td>4.4482</td>
<td>N</td>
<td>lbf</td>
<td>0.2248</td>
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<tr>
<td>kgf</td>
<td>N</td>
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<td>kgf</td>
<td>0.10197</td>
</tr>
<tr>
<td>kiloponds</td>
<td>N</td>
<td>9.8067</td>
<td>N</td>
<td>kiloponds</td>
<td>0.10197</td>
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<tr>
<td>tonf(long)</td>
<td>kN</td>
<td>9.96402</td>
<td>kN</td>
<td>tonf(long)</td>
<td>0.10036</td>
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</table>
# USEFUL CONVERSIONS

## POWER

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Multiply by</th>
<th>From</th>
<th>To</th>
<th>Multiply by</th>
</tr>
</thead>
<tbody>
<tr>
<td>hp</td>
<td>kW</td>
<td>0.7457</td>
<td>kW</td>
<td>hp</td>
<td>1.34102</td>
</tr>
<tr>
<td>kW</td>
<td>hp</td>
<td>1.34102</td>
<td>kW</td>
<td>hp</td>
<td>1.34102</td>
</tr>
<tr>
<td>kW</td>
<td>hp(metric)</td>
<td>1.35962</td>
<td>kW</td>
<td>hp(metric)</td>
<td>1.35962</td>
</tr>
<tr>
<td>Btu/hr</td>
<td>kW</td>
<td>2.9307x10^-4</td>
<td>kW</td>
<td>Btu/hr</td>
<td>3412.1416</td>
</tr>
<tr>
<td>ft.lbf/sec</td>
<td>kW</td>
<td>0.001356</td>
<td>kW</td>
<td>ft.lbf/sec</td>
<td>737.5622</td>
</tr>
</tbody>
</table>

## TORQUE

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Multiply by</th>
<th>From</th>
<th>To</th>
<th>Multiply by</th>
</tr>
</thead>
<tbody>
<tr>
<td>lbf.ft</td>
<td>N.m</td>
<td>1.3558</td>
<td>N.m</td>
<td>lbf.ft</td>
<td>0.73756</td>
</tr>
<tr>
<td>lbf.in</td>
<td>N.m</td>
<td>0.112985</td>
<td>N.m</td>
<td>lbf.in</td>
<td>8.85075</td>
</tr>
<tr>
<td>ozf.in</td>
<td>N.m</td>
<td>0.007062</td>
<td>N.m</td>
<td>ozf.in</td>
<td>141.6119</td>
</tr>
<tr>
<td>kgf.m</td>
<td>N.m</td>
<td>9.80665</td>
<td>N.m</td>
<td>kgf.m</td>
<td>0.10197</td>
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</tbody>
</table>
### USEFUL CONVERSIONS

#### DENSITY/SPECIFIC GRAVITY (SG)

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Multiply by</th>
<th>From</th>
<th>To</th>
<th>Multiply by</th>
</tr>
</thead>
<tbody>
<tr>
<td>lbs/ft³</td>
<td>kg/m³</td>
<td>16.01846</td>
<td>kg/m³</td>
<td>lbs/ft³</td>
<td>0.06243</td>
</tr>
<tr>
<td>grms/cm²</td>
<td>kg/m³</td>
<td>1000</td>
<td>kg/m³</td>
<td>grms/cm²</td>
<td>0.001</td>
</tr>
<tr>
<td>lbs/gal(US)</td>
<td>kg/m³</td>
<td>119.8264</td>
<td>kg/m³</td>
<td>lbs/gal(US)</td>
<td>0.008345</td>
</tr>
</tbody>
</table>

#### API GRAVITY - °API

\[
°\text{API} = \frac{141.5}{\text{SG}} - 131.5
\]

\[
\text{SG} = \frac{141.5}{°\text{API} + 131.5}
\]

#### Degrees Baumé

\[
°\text{Bé} = 145 - \frac{145}{\text{SG}}
\]

\[
\text{SG} = \frac{145}{45 - °\text{Bé}}
\]

The above °Bé formulae apply to solutions denser than water.
## USEFUL CONVERSIONS

### VISCOSITY - DYNAMIC & KINEMATIC

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Multiply by</th>
<th>From</th>
<th>To</th>
<th>Multiply by</th>
</tr>
</thead>
<tbody>
<tr>
<td>cPs</td>
<td>N.sec/m²</td>
<td>0.001</td>
<td>N.sec/m²</td>
<td>cPs</td>
<td>1000</td>
</tr>
<tr>
<td>cPs</td>
<td>Pa.sec</td>
<td>0.001</td>
<td>Pa.sec</td>
<td>cPs</td>
<td>1000</td>
</tr>
<tr>
<td>lbf.sec/ft²</td>
<td>N.sec/m²</td>
<td>47.8803</td>
<td>lbf.sec/ft²</td>
<td>N.sec/m²</td>
<td>0.02089</td>
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<tr>
<td>lbf.sec/ft²</td>
<td>cPs</td>
<td>47880.259</td>
<td>cPs</td>
<td>lbf.sec/ft²</td>
<td>2.0885x10⁻⁵</td>
</tr>
<tr>
<td>cSt</td>
<td>m²/sec</td>
<td>1.0 x 10⁻⁶</td>
<td>m²/sec</td>
<td>cSt</td>
<td>1.0 x 10⁶</td>
</tr>
<tr>
<td>ft²/sec</td>
<td>cSt</td>
<td>9.2903 x 10⁴</td>
<td>cSt</td>
<td>ft²/sec</td>
<td>1.0764 x 10⁻⁵</td>
</tr>
</tbody>
</table>

approximately:  
\[
cSt = 0.226 \times \text{SSU} - \frac{195}{\text{SSU}} \quad \text{for} \quad 32 < \text{SSU} < 100
\]
\[
cSt = 0.22 \times \text{SSU} - \frac{135}{\text{SSU}} \quad \text{for} \quad \text{SSU} \geq 100
\]
USEFUL INFORMATION

SPECIFIC GRAVITY VS TEMPERATURE - PETROLEUM FRACTIONS

![Graph showing specific gravity vs temperature for petroleum fractions.](image-url)
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API-Mechanical Seal-Piping Plan Booklet