Pumps—Shaft Sealing Systems for Centrifugal and Rotary Pumps

API STANDARD 682
SECOND EDITION, JULY 2002

This Standard is Technically Equivalent to the
ISO Draft International Standard 21049

Approved American National Standard
ANSI

American
Petroleum
Institute

Helping You
Get The Job
Done Right.SM

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Downstream Segment

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Foreward

This standard is equivalent to the ISO Draft International Standard 21049.

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Suggested revisions are invited and should be submitted to the standardization manager, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

Introduction

This Standard is based on the accumulated knowledge and experience of manufacturers and users of equipment in the petroleum, natural gas and chemical industries but its use is not restricted to these industries.

Users of this Standard should be aware that further or differing requirements may be needed for individual applications. This Standard is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This may be particularly appropriate where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this Standard and provide details.

The purpose of this Standard is to assist purchasers with the selection and operation of mechanical seals.

This Standard is a stand-alone seal standard, which can be referenced by the current edition of API 610 (ISO 13709), ANSI/ASME B73.1, ANSI/ASME B73.2, and API 676 for new pumps and can also be used to retrofit existing pumps. The seals in this Standard may also be used in non-API 610 (ISO 13709) pumps.

In this Standard, where practical, US Customary units are included in brackets for information.

A bullet (●) at the beginning of a sub-clause or paragraph indicates that either a decision is required or further information is to be provided by the purchaser. This information or decision should be indicated on suitable data sheets: otherwise it should be stated in the quotation request (enquiry) or in the order.

1 Scope

1.1 General

This Standard specifies requirements and gives recommendations for sealing systems for centrifugal and rotary pumps used in petroleum, natural gas, and chemical industries. It has been written mainly for hazardous, flammable and/or toxic services where a greater degree of reliability is required for the improvement of equipment availability, the reduction of both emissions to the atmosphere and life cycle sealing costs. It covers seals for shaft diameters from 20 mm (0,75 in.) to 110 mm (4,3 in.). This Standard also applies to seal spare parts and can be referred to for the upgrading of existing equipment. The seal configurations covered by this Standard can be classified into three categories (1, 2 and 3), three types (A, B and C) and three arrangements (1, 2 and 3). Further, Arrangement 2 and 3 seals can be in three orientations: "face-to-back", "back-to-back" and "face-to-face". These categories, types, arrangements and orientations are defined in 1.2 and illustrated in Figures 2 through 6.

NOTE Figure 1 places all these concepts in one diagram. It is a comprehensive way to look at the relationships of these concepts.

1.2 Seal categories, types and arrangements

There are three seal **categories**, as follows:

1) Category 1 seals are intended for use in non-ISO 13709 seal chambers, preferably meeting the dimensional requirements of ANSI/ASME B73.1, ANSI/ASME B73.2 and ISO 3069 Type C seal chamber dimensions and their application is limited to seal chamber temperatures from – 40°C (– 40°F) to 260°C (500°F) and absolute pressures up to 22 bar (315 psi).
2) Category 2 seals are intended for use in seal chambers meeting the chamber envelope dimensional requirements of ISO 13709. Their application is limited to seal chamber temperatures from – 40°C (– 40°F) to 400°C (750°F) and absolute pressures up to 42 bar (615 psi).
3) Category 3 provides the most rigorously tested and documented seal design. It is required that the entire seal cartridge is qualification tested as an assembly in the required fluid in accordance with clause 10 and are provided with all the data requirements specified in clause 11. They meet the seal chamber envelope requirements of ISO 13709 (or equal). Their application is limited to seal chamber temperatures from – 40°C (– 40°F) to 400°C (750°F) and absolute pressures up to 42 bar (615 psi).

A summary of the main seal category differences is given in clause 11 and annex A.

Temperatures and pressures outside the ranges, or which involve fluids not included in annex A, may require engineering and seal selection guidance other than provided in this Standard.

There are three seal **types**, as follows:

1) Type A seal is a balanced, inside-mounted, cartridge design, pusher seal with multiple springs and in which the flexible element rotates. Secondary sealing elements are elastomeric O-rings;
2) Type B seal is a balanced, inside-mounted, cartridge design, non-pusher (bellows) seal in which the flexible element rotates. Secondary sealing elements are elastomeric O-rings; and
3) Type C seal is a balanced, inside-mounted, cartridge design, non-pusher (metal bellows) seal in which the flexible element is stationary. Secondary sealing elements are flexible graphite.

Type A and Type B are for temperatures up to 176ºC (350ºF); and a stationary flexible element is a data sheet selection. Type C seals are for high temperatures up to 400ºC (750ºF); a rotating flexible element is a data sheet selection.

There are three seal **arrangements**, as follows:

1) Arrangement 1: Seal configurations having one seal per cartridge assembly;
2) Arrangement 2: Seal configuration having two seals per cartridge assembly, with the space between the seals at a pressure less than the seal chamber pressure.
3) Arrangement 3: Seal configurations having two seals per cartridge assembly, utilizing an externally supplied barrier fluid at a pressure greater than the seal chamber pressure.

New technology designs and sealing methods are also considered, as follows:

1) Contacting wet seals "CW": Seal design where the mating faces are not designed to intentionally create aerodynamic or hydrodynamic forces to sustain a specific separation gap (refer to definitions);
2) Non-contacting seals (whether wet or dry) "NC": Seal design where the mating faces are designed to intentionally create aerodynamic or hydrodynamic separating forces to sustain a specific separation gap; (refer to definitions) and
3) Containment seals (whether contacting or non-contacting) "CS": Seal design with one flexible element, seal ring and mating ring mounted in the containment seal chamber.

Figure 1 places all these concepts in one diagram. It is a comprehensive way to look at the relationships of all these concepts.

Finally, Arrangement 2 and Arrangement 3 seals can be in the following three orientations:

1) Face-to-back (old tandem terminology): a dual seal in which one mating ring is mounted between the two flexible elements and one flexible element is mounted between the two mating seal rings;
2) Back-to-back: a dual seal in which both of the flexible elements are mounted between the mating seal rings; and
3) Face-to-face: a dual seal in which both of the mating seal rings are mounted between the flexible elements.

1.3 Objectives

Shaft sealing systems conforming to this Standard are intended to meet the following objectives:

1) All seals should operate continuously for 25,000 h without replacement;
2) Containment seals should run for at least 25 000 h (wet or dry seals) at any containment seal chamber pressure equal to or less than the seal leakage pressure switch setting [not to exceed a gauge pressure of 0,7 bar (10 psi)] and for at least 8 h at the full seal chamber conditions;
3) All seals should operate for 25,000 h while complying with local emissions regulations, or 1 000 ml/m^3 (1 000 ppm vol) as measured by the EPA Method 21, whichever is more stringent.

1.4 Specifying and/or purchasing a sealing system

The data sheet (annex F) shall be used to convey purchasing requirements. Default requirements are identified therein that allow the purchaser to specify a seal with minimum information. The minimum data required on the data sheet to obtain budgetary pricing on a sealing system is expressed in the seal code (annex J). This assumes all standard defaults (construction features and materials). The minimum information required on the data sheet to purchase a seal with assurance that the selection will satisfy the objectives of 1.3 is the pump data, fluid data and seal specification.

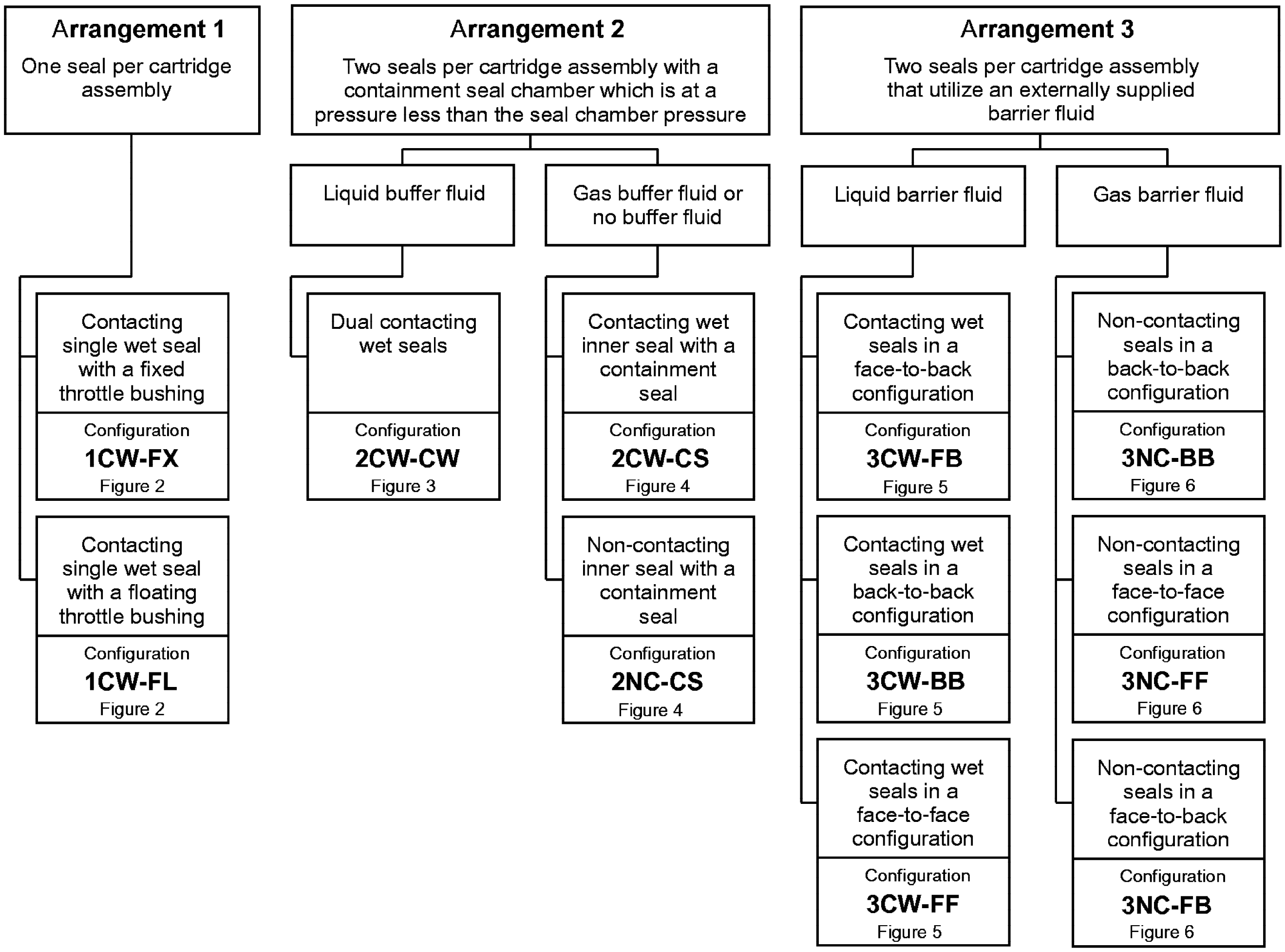
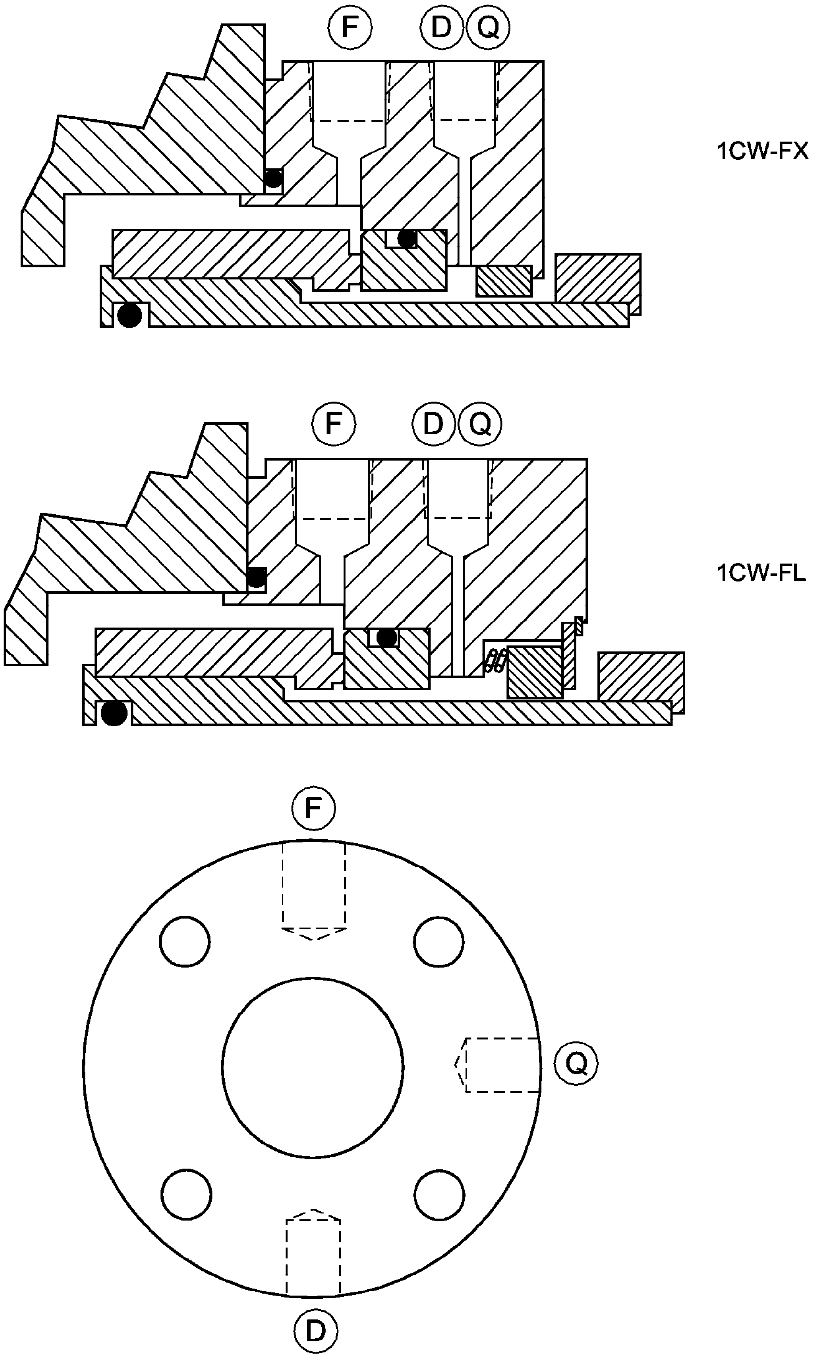


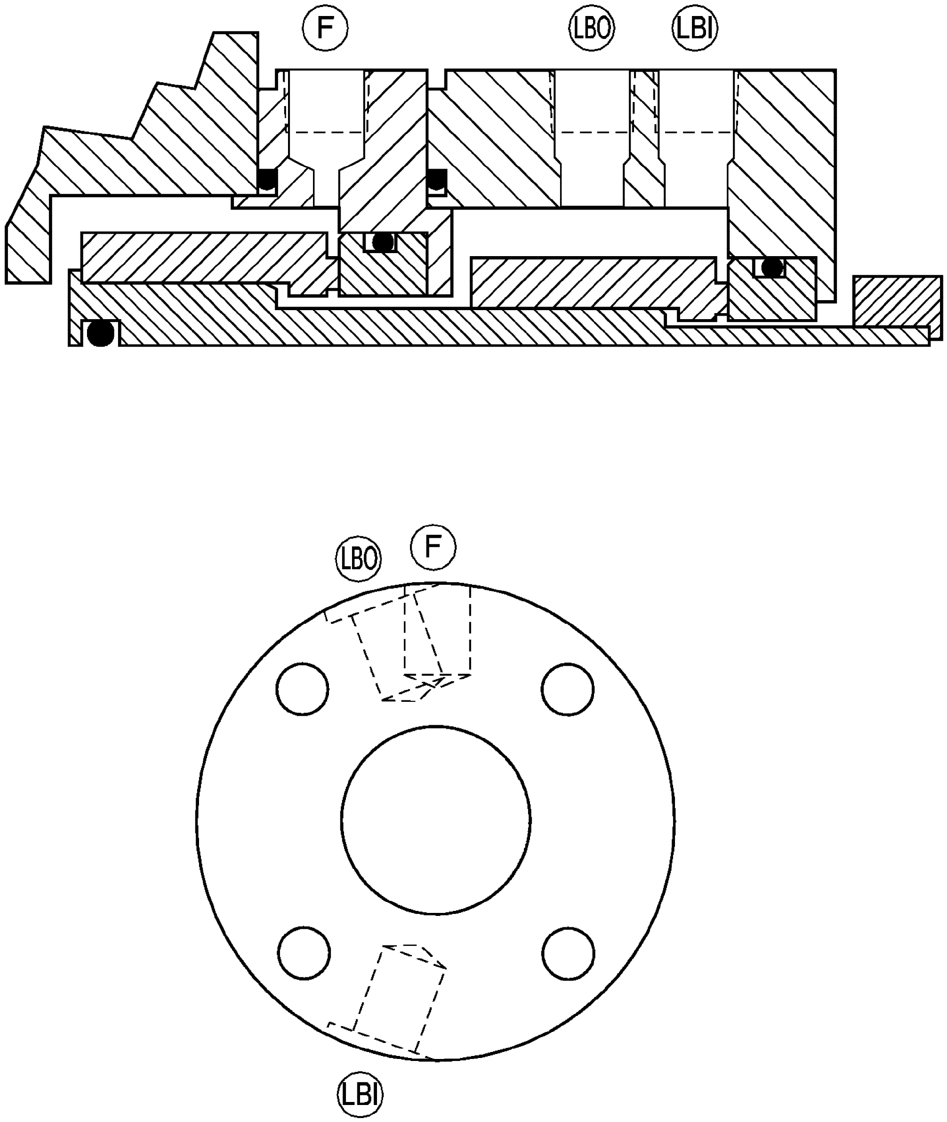
Figure 1 — Seal configurations



Key

1CW-FX contacting single wet seal with a fixed throttle bushing
1CW-FL contacting single wet seal with a floating throttle bushing
NOTE For connection designations, see Table 1.

Figure 2 — Arrangement 1: One seal per cartridge assembly



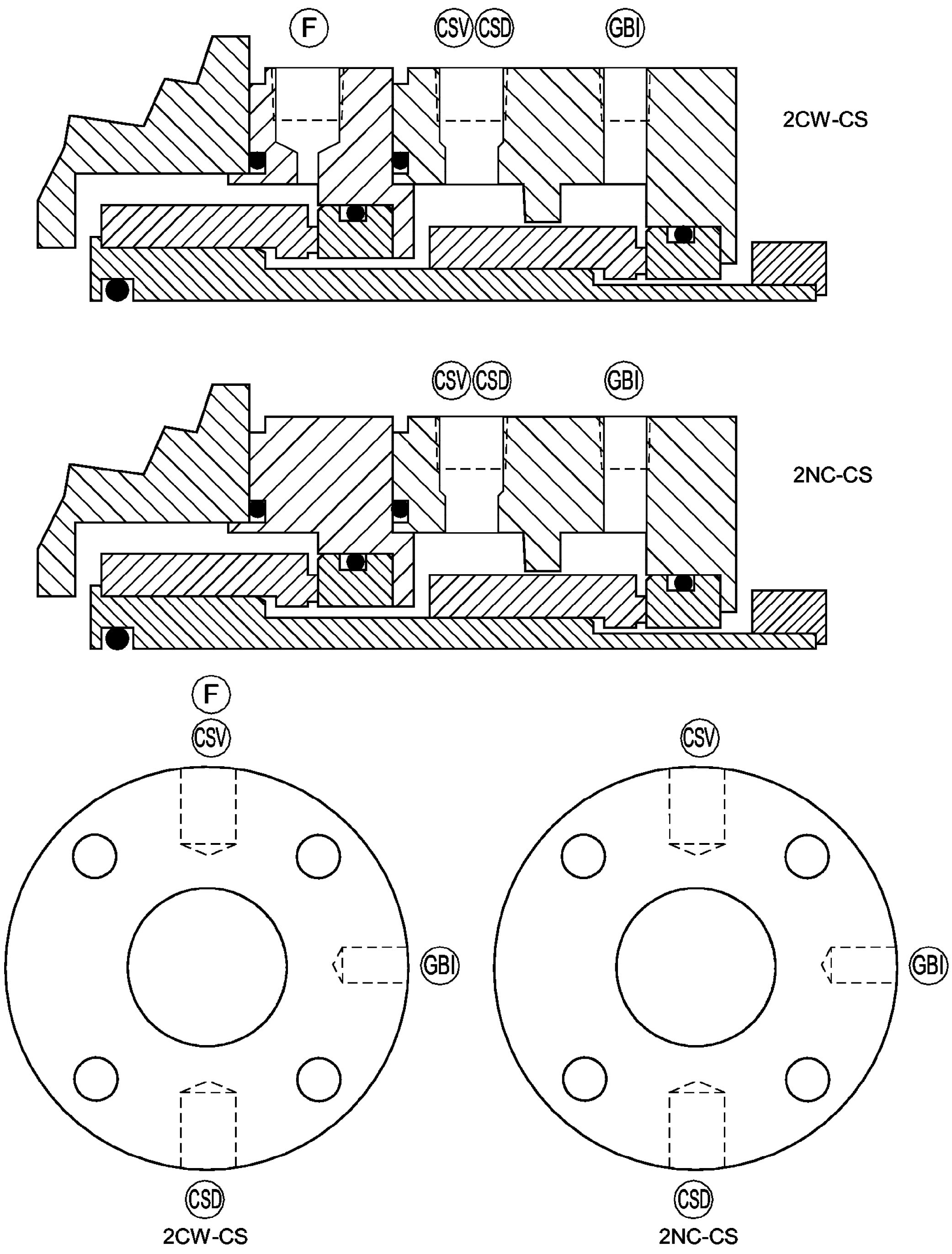
2CW-CW

Key

2CW-CW dual contacting wet seal

NOTE For connection designations, see Table 1.

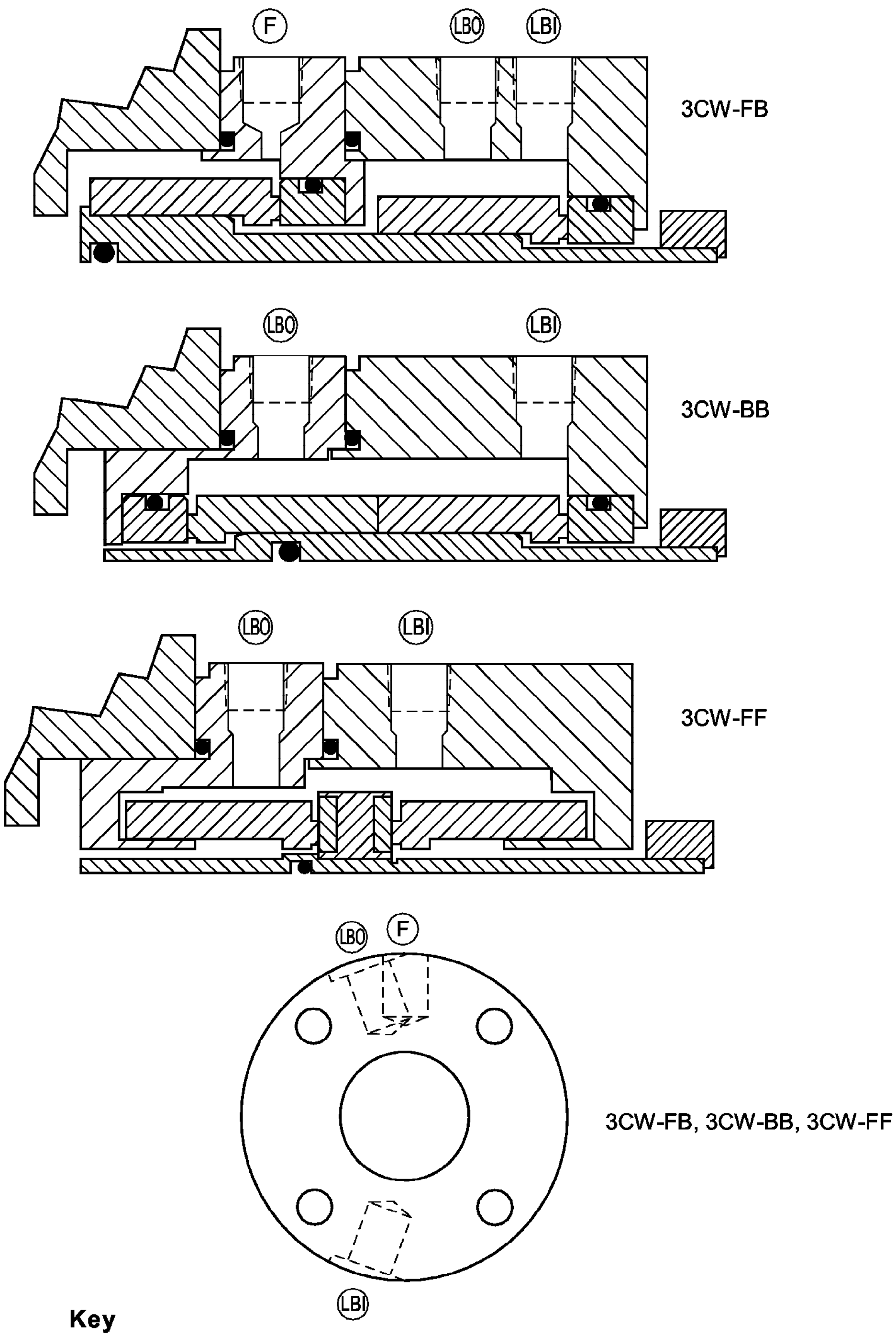
Figure 3 — Arrangement 2: Two seals per cartridge asembly with a liquid buffer fluid



Key

2 CW-CS	contacting wet inner seal with a containment seal
2 NC-CS	non-contacting inner seal with a containment seal
NOTE	For connection designations, see Table 1.

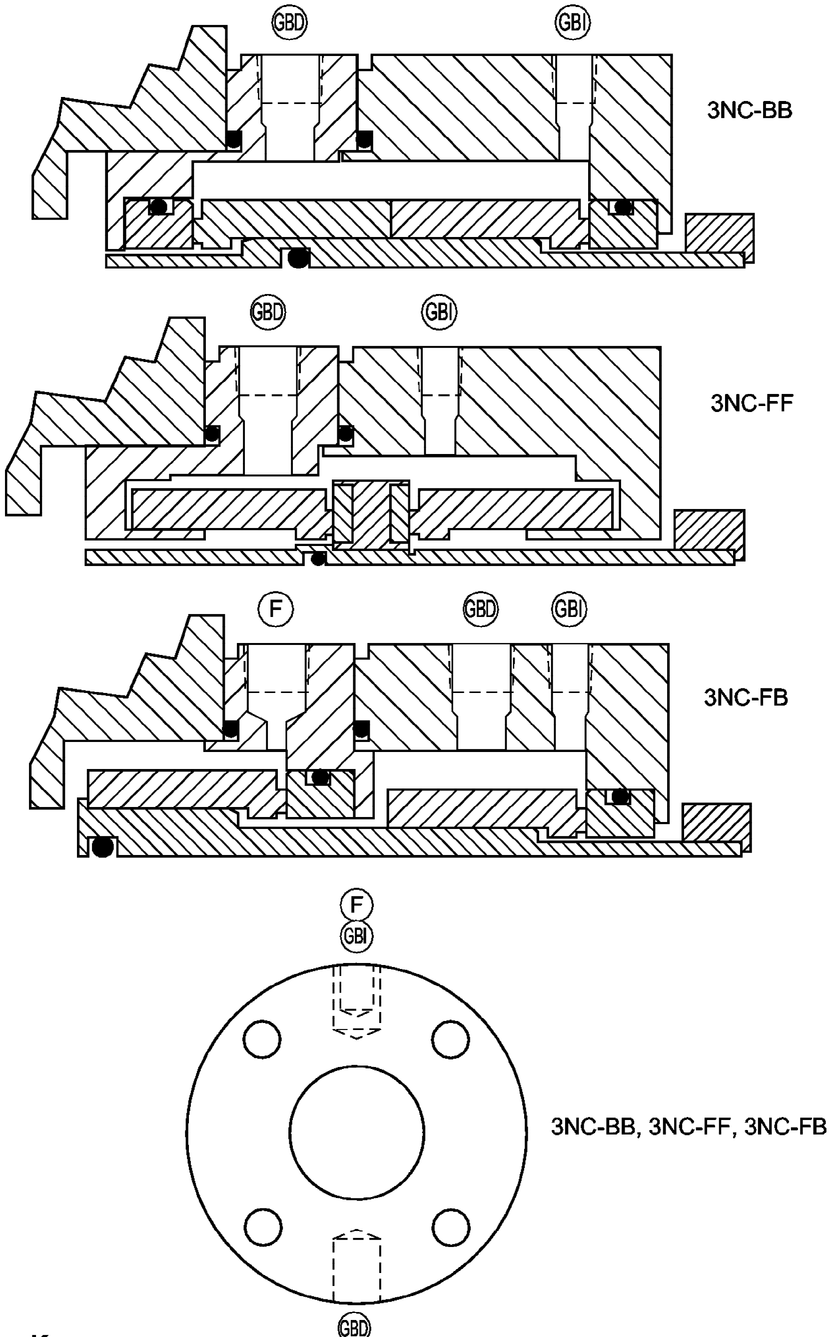
Figure 4 — Arrangement 2: Two seals per cartridge assembly with or without a gas buffer fluid



Key

3CW-FB contacting wet seals in a face-to-back configuration
3CW-BB contacting wet seals in a back-to-back configuration
3CW-FF contacting wet seals in a face-to-face configuration
NOTE For connection designations, see Table 1.

Figure 5 — Arrangement 3: Two seals per cartridge assembly with a liquid barrier fluid



Key

3NC-BB non-contacting seals in a back-to-back configuration
3NC-FF non-contacting seal in a face-to-face configuration
3NC-FB non-contacting seal in a face-to-back configuration
NOTE For connection designations, see Table 1.

Figure 6 — Arrangement 3: Two seals per cartridge assembly with a gas barrier fluid

2 Normative references

The following normative documents contain provisions which, through references in this text, constitute provisions of this Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply, however. Parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid Standards.

ISO 228-1, *Pipe threads where pressure-tight joints are not made on the threads — Part 1: Dimensions, tolerances and designation.*

ISO 261, *ISO general-purpose metric screw threads — General plan.*

ISO 286-2, *ISO system of limits and fits — Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts.*

ISO 3069, *End-suction centrifugal pumps — Dimensions of cavities for mechanical seals and for soft packings.*

ISO 7005-1, *Metallic flanges — Part 1: Steel flanges.*

ISO 13709[1)], *Petroleum and natural gas industries — Centrifugal pumps.*

IEC 60079, *Electrical apparatus for explosive gas atmospheres.*

IEC 60529, *Degrees of protection provided by enclosures (IP code).*

AISI[2)], *Standards, codes and specifications of the American Iron and Steel Institute.*

ANSI/ASME B73.1[3)], *Vertical Inline Centrifugal Pumps.*

ANSI/ASME B73.2, *Horizontal Inline Centrifugal Pumps.*

API RP 520[4)], *Sizing, selection, and installation of pressure-relieving devices in refineries.*

API Std 526, *Flanged steel pressure relief valves.*

ASME V, *ASME Boiler and pressure vessel code, Section V, Non-destructive examination.*

ASME VIII, *ASME Boiler and pressure vessel code, Section VIII, Rules for the construction of pressure vessels.*

ASME IX, *ASME Boiler and pressure vessel code, Section IX, Welding and brazing qualifications.*

ASME B1.1, *Unified inch screw threads (UN and UNR thread form).*

ASME B1.20.1, *Pipe threads, general purpose, inch.*

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1) To be published

2) Available from the American Iron and Steel Institute: 1101 17th Street NW, Suite 1300, Washington, D.C. 20036, USA

3) Available from the American Society of Mechanical Engineers: Three Park Avenue, New York, NY, 10016-5990, USA

4) Available from the American Petroleum Institute, 1220 L Street, NW, Washington, D.C., USA 20005-4070

ASME B16.5, *Pipe flanges and flanged fittings, steel, nickel alloy and other special alloys.*

ASME B16.11, *Forged steel fittings, socket-welding and threaded.*

ASME B16.20, *Metallic gaskets for pipe flanges — Ring joint, spiral-wound, and jacketed.*

ASME B31.3, *Process piping.*

ASME B40.100, *Pressure gages.*

ASME PTC 8.2, *Centrifugal pumps, performance test codes.*

ASTM A 53[5)], *Zinc-Coated Welded and Seamless Black and Hot-Dipped Steel Pipe.*

ASTM A 105, *Carbon Steel Forgings for Piping Components.*

ASTM A 106, *Seamless Carbon Steel Pipe for High Temperature Service.*

ASTM A 120, *Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses.*

ASTM A 153, *Zinc Coating (Hot-Dip) on Iron and Steel Hardware.*

ASTM A 181, *Carbon Steel Forgings for General Purpose Piping.*

ASTM A 182, *Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.*

ASTM A 193, *Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.*

ASTM A 194, *Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service.*

ASTM A 197, *Cupola Malleable Iron.*

ASTM A 269, *Seamless and Welded Austenitic Stainless Steel Tubing for General Service.*

ASTM A 276, *Stainless and Heat-Resisting Steel Bars and Shapes.*

ASTM A 312, *Seamless and Welded Austenitic Stainless Steel Pipe.*

ASTM A 338, *Malleable Iron Flanges, Pipe Fittings, and Valve Parts for Railroad, Marine, and Other Heavy Duty Service at Temperatures up to 650ºF (345ºC).*

ASTM A 524, *Seamless Carbon Steel Pipe for Atmospheric and Lower Temperatures.*

ASTM E 94, *Guide* for *radiographic testing.*

ASTM E 125, *Reference photographs for magnetic particle indications on ferrous castings.*

ASTM E 142, *Controlling quality of radiographic testing.*

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5) Available from ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, Pennsylvania, 19428-2959, USA

ASTM E 709, *Practice for magnetic particle examination.*

AWS D1.1, *Structural welding code — Steel.*

EPA Method 21[6], Appendix A of Title 40, Part 60 of the U.S. Code of Federal Regulations, *Environmental Protection Agency, United States.*

NEMA 250[7], *Enclosures for electrical equipment (1000 volts maximum).*

NFPA 70[8], *National Electrical Code.*

Volatile Hazardous Air Pollutant, National Emission Standards for Hazardous Air Pollutants.

3 Terms and definitions

For the purpose of this Standard, the following terms and definitions apply.

3.1
anti-rotation device
device such as a key or pin, used to prevent rotation of one component relative to an adjacent component in a seal assembly

3.2
Arrangement 1 seal
seal configuration having one seal per cartridge assembly

NOTE The gland plate can be supplied with a fixed bushing or with an optional close clearance floating bushing.

3.3
Arrangement 2 seal
seal configuration having two seals per cartridge assembly with a containment seal chamber which is at a pressure less than the seal chamber pressure

NOTE The containment seal (3.13) can be a conventional wet seal or a dry-running seal. The inner seal utilizes a flush plan typical of Arrangement 1 seals. If the containment seal is a conventional wet seal design, an unpressurized liquid buffer fluid is supplied to the containment seal chamber (3.14). If the containment seal is a dry-running seal, a gas buffer may be used.

3.4
Arrangement 3 seal
seal configuration having two seals per cartridge assembly that utilize an externally supplied barrier fluid

3.5
back-to-back configuration
dual seal in which both of the flexible elements are mounted between the mating seal rings

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6) Available from the National Archives and Records Administration, 700 Pennsylvania Avenue, N.W., Washington, D.C. 20408, USA

7) Available from the National Electrical Manufacturers Association, 1300 North 17th Street, Rosslyn, VA 22209, USA

8) Available from the National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, Massachusetts 02269-9101, USA

3.6
balanced seal
mechanical seal in which the seal balance ratio is less than 1

3.7
barrier fluid
externally supplied fluid at a pressure above the pump seal chamber pressure, introduced into an Arrangement 3 seal to completely isolate the process liquid from the environment

3.8
bellows seal
type of mechanical seal which uses a flexible metal bellows to provide secondary sealing and spring-type loading

3.9
buffer fluid
externally supplied fluid, at a pressure lower than the pump seal chamber pressure, used as a lubricant and/or to provide a diluent in an Arrangement 2 seal

3.10
cartridge seal
completely self-contained unit (including seal faces, flexible elements, seal gland plate, sleeve, and mating ring) which is pre-assembled and preset before installation

3.11
connection
threaded or flanged joint that mates a port to a pipe or to a piece of tubing

3.12
contacting seal
seal design where the mating faces are not designed to intentionally create aerodynamic or hydrodynamic forces to sustain a specific separation gap

NOTE Contacting seals may actually develop a full fluid film but this is not typical. Contacting seals do not incorporate geometry e.g. grooves, pads, face waviness, to ensure that the faces do not touch. The amount of contact is generally very low and permits reliable operation with low leakage.

3.13
containment seal
seal design with one flexible element, seal ring and mating ring mounted in the containment seal chamber; it is the outer seal for all Arrangement 2 configurations

3.14
containment seal chamber
component forming the cavity into which the containment seal is installed

3.15
crystallizing fluid
fluid which is in the process of forming solids or which may form solids due to dehydration or chemical reaction

3.16
drill through
passageway from the gland plate connection to the seal chamber and containment seal chamber

3.17
drive collar
external part of the seal cartridge that transmits torque to the seal sleeve and prevents axial movement of the seal sleeve relative to the shaft

3.18
dual mechanical seal
Arrangement 2 or Arrangement 3 seal of any kind

3.19
dynamic sealing pressure rating
highest pressure differential that the seal or seal assembly can continuously withstand at the maximum allowable temperature while the shaft is rotating; thereafter, the seal retains its static sealing pressure rating

3.20
face-to-back configuration
dual seal in which one mating face is mounted between the two flexible elements and one flexible element is mounted between the two mating seal rings (old tandem terminology)

3.21
face-to-face configuration
dual seal in which both of the mating seal rings are mounted between the flexible elements

3.22
flashing
rapidly changing fluid state, from liquid to gas

NOTE In a dynamic seal, this can occur when frictional energy is added to the fluid as it passes between the primary sealing faces, or when fluid pressure is reduced below the fluid's vapor pressure because of a pressure drop across the sealing faces.

3.23
flashing liquid
liquid with an absolute vapor pressure greater than 1 bar (14,5 psi) at the pumping temperature

3.24
flexible element
combination of components which move axially relative to the shaft/sleeve or seal chamber

3.25
flexible graphite
pure carbon graphite material used for static (secondary seal) gaskets in mechanical seal design, from cryogenic to hot service

3.26
floating bushing
bushing that fits around the shaft or sleeve and has sufficient clearance around the outside diameter so it can move or "float" radially

NOTE A spring pushes the bushing axially against a sealing surface of the housing, seal chamber, or gland plate to force the fluid to pass through the small clearance between the shaft and bushing instead of going in between the circumference of the bushing and the housing. A floating design can be used for the throat or throttle bushings. The radial float allows the diametrical clearance between the bushing ID and the shaft or sleeve OD to be very tight.

3.27
fluoroelastomer (FKM)
type of O-ring material commonly used in mechanical seals

3.28
flush
fluid which is introduced into the seal chamber on the process fluid side in close proximity to the sealing faces and typically used for cooling and lubricating the seal faces

3.29
flush distribution system
any arrangement of holes, passages, baffles, etc. that is designed to promote an even distribution of flush fluid around the circumference of the seal faces and has been qualified by testing in accordance with this Standard

3.30
general purpose application
application that is usually spared or is in non-critical service

3.31
gland plate
end plate which connects the stationary assembly of a mechanical seal to the seal chamber or containment seal chamber

3.32
hook sleeve
sleeve with a step or hook at the product end placed over the shaft to protect it from wear and corrosion; this step is usually abutted against the impeller to hold it in place with a gasket between the shaft and the step (hook)

3.32
inner seal
in Arrangement 2 and Arrangement 3, the seal that is located closest to the pump impeller in the seal chamber

3.33
inside mounted seal
seal configuration in which the seal is mounted within the boundaries of the seal chamber and gland plate

3.34
internal circulating device
device located in the seal chamber to circulate seal chamber fluid through a cooler or barrier/buffer fluid reservoir

NOTE This is usually referred to as a pumping ring.

3.35
leakage concentration
measure of the concentration of a volatile organic compound (VOC) or other regulated emission in the environment immediately surrounding the seal

3.36
leakage rate
volume or mass of fluid passing between the seal faces through a seal in a given length of time

3.37
light hydrocarbon
hydrocarbon liquid that will readily boil at ambient conditions; typically this includes pure and mixed streams of C5 and lighter

3.38
mating ring
disk- or ring-shaped member, mounted either on a sleeve or in a housing, such that it does not move axially relative to the sleeve or the housing and which provides the mating seal face for the seal ring

3.39
maximum allowable temperature
maximum continuous temperature for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified maximum operating pressure

NOTE 1 This information is supplied by the seal manufacturer.

NOTE 2 The maximum allowable temperature is usually set by material considerations. This may be the material of the casing or a temperature limit imposed by a gasket or O-ring. The yield strength and ultimate strength are temperature dependent. A component's stress level can depend on operating pressure. Thus, the margin between the strength limit of the material and the operating stress depends on both the material's operating temperature and the component's stress level. If the temperature is lowered, the material's strength increases and the stress level of the component may increase. This is the reason for associating the maximum allowable temperature to the maximum specified operating pressure.

3.40
maximum allowable working pressure (MAWP)
maximum continuous pressure for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified maximum operating temperature

NOTE See also static sealing pressure rating and dynamic sealing pressure rating.

3.41
maximum dynamic sealing pressure (MDSP)
highest pressure expected at the seal (or seals) during any specified operating condition and during start-up and shutdown

NOTE In determining this pressure, consideration should be given to the maximum suction pressure, the flush pressure, and the effect of clearance changes within the pump. This is the process condition and is specified by the purchaser.

3.42
maximum operating temperature
maximum temperature to which the seal (or seals) can be subjected

NOTE This is the process condition and is specified by the purchaser.

3.43
maximum static sealing pressure (MSSP)
highest pressure, excluding pressures encountered during hydrostatic testing, to which the seal (or seals) can be subjected while the pump is shut down

NOTE This is the process condition and is specified by the purchaser.

3.44
non-contacting seal
seal design where the mating faces are designed to intentionally create aerodynamic or hydrodynamic separating forces to sustain a specific separation gap

NOTE Non-contacting seals are specifically designed so that there is always an operating gap between the stationary and rotating face.

3.45
non-flashing liquid
liquid whose vapor pressure at any specified operating temperature is less than an absolute pressure of 1 bar (14.5 psi)

3.46
non-hydrocarbon service
all services that are not predominantly hydrocarbons

NOTE Some fluids included are fluids in which hydrocarbons may be entrained; inorganic fluids, such as boiler feedwater (and other water services), sour water, caustics, acids, amines, and other various chemicals commonly used in refinery services.

3.47
non-pusher type seal
seal design (usually metal bellows) in which the secondary seal is not required to slide axially to compensate for wear and misalignment

3.48
observed test
product test which will be observed at the purchaser's discretion, having been given notice of the test by the manufacturer

NOTE An observed test does not constitute a manufacturing hold point.

3.49
orifice nipple
pipe nipple made of solid bar stock with an orifice hole drilled through it to regulate the flush flow commonly found on Plan 11 systems; the nipple should be welded to the discharge casing

3.50
O-ring
elastomeric sealing ring with an O-shaped (circular) cross-section, which may be used as a secondary seal or as a gasket

3.51
outer seal
in Arrangement 2 and Arrangement 3, the seal that is located farthest from the pump impeller

3.52
perfluoroelastomer (FFKM)
chemical-resistant O-ring material suitable for high temperatures

3.53
polymerizing fluids
fluids which are in the process of changing, or are capable of changing, from one chemical composition to another with different properties, usually becoming significantly more viscous and/or tacky

3.54
port
fluid passageway, typically located in the gland plate

3.55
pressure casing
composite of all the stationary pressure containing parts of the seal, including seal chamber, seal gland plate, and barrier/buffer fluid reservoir and other attached parts, but excluding the seal ring and the mating ring

3.56
product temperature margin (PTM)
difference between the vaporization temperature of the fluid at the seal chamber pressure and the actual temperature of the fluid, expressed as a temperature in degrees

NOTE For pure fluids, the vaporization temperature is the saturation temperature at seal chamber pressure; for mixed fluids, the vaporization temperature is the bubble point temperature at the seal chamber pressure.

3.57
pump manufacturer
agency that designs, manufactures, tests, and provides service support for the equipment; the pump manufacturer may purchase the sealing system and perform the installation

3.58
purchaser
agency that issues the order and specifications to the vendor

3.59
pusher type seal
seal design in which the secondary seal is mounted between the seal ring on the flexible element and the sleeve or seal gland plate in which this secondary seal slides axially to compensate for wear and misalignment

3.60
quench
neutral fluid, usually water or steam, introduced on the atmospheric side of the seal to retard formation of solids that may interfere with seal movement

3.61
seal
combination of a mating ring, seal ring, secondary seal(s), axially flexible elements(s), and supporting hardware that allows a rotating shaft to penetrate a stationary housing without incurring uncontrolled leakage

3.62
seal balance ratio
ratio, sometimes expressed as a percentage, of seal face area exposed to closing force by hydraulic pressure in the seal chamber, to the total sealing face area (see Figure 10)

3.63
seal chamber
component, either integral with or separate from the pump case (housing), that forms the region between the shaft and casing into which the shaft seal is installed

3.64
seal face
side or end of a mating ring or seal ring which provides the sealing surface on the ring

3.65
seal face width
radial dimension of the sealing face measured from the inside edge to the outside edge

3.66
seal manufacturer
agency that designs, manufactures, tests, and provides service support for seals and associated support sealing systems

3.67
seal ring
seal face that contacts the mating ring; it is flexibly mounted using springs or bellows

3.68
secondary seal
device, such as an O-ring or a flexible graphite gasket, or bellows, that prevents leakage around other seal components

3.69
service condition
maximum/minimum temperature and pressure under static or dynamic conditions

3.70
sleeve
hollow cylindrical component used for spacing, protection, or mounting of other components

EXAMPLES: Shaft sleeves and seal sleeves.

3.71
slotted seal gland plate
gland plate with slots instead of holes for the mounting studs

3.72
slurry
mixture of liquid and solids

3.73
special purpose application
application for which the equipment is designed for uninterrupted, continuous operation in critical service, and for which there is usually no spare equipment

NOTE It is left up to the user to determine what critical service is.

3.74
static sealing pressure rating
highest pressure that the seal can continuously withstand at the maximum allowable temperature while the shaft is not rotating; thereafter, the seal maintains its dynamic sealing pressure rating

3.75
throat bushing
device that forms a restrictive close clearance around the sleeve (or shaft) between the inner seal and the impeller

3.76
throttle bushing
device that forms a restrictive close clearance around the sleeve (or shaft) at the outboard end of a mechanical seal gland plate

NOTE A throttle bushing is standard for Arrangement 1 seals — a fixed bushing for Category 1 and Category 2 seals and a floating bushing for Category 3 seals. Throttle bushings are optional for Arrangement 2 or Arrangement 3 seals (see Figure 1).

3.77
total indicator reading (TIR)
total indicated runout (TIR)
difference between the maximum and minimum readings of a dial indicator or similar device; monitoring a face or cylindrical surface during one complete revolution of the monitored surface

NOTE For a perfectly cylindrical surface, the indicator reading implies an eccentricity equal to half the reading. For a perfectly flat face, the indicator reading gives an out-of-squareness equal to the reading. If the diameter in question is not perfectly cylindrical or flat, interpretation of the meaning of TIR is more complex, and may represent ovality or lobing.

3.78
Type A seal
standard Type A seal is a balanced, inside mounted, cartridge design, pusher seal with multiple springs and in which the flexible element rotates

NOTE 1 Alternatives, such as using a stationary flexible element, or using a single spring, are data sheet selections. Secondary sealing elements are elastomeric O-rings. Materials are specified in clause 6 and annex C. Figure 7 depicts a Type A seal.

3.79
Type B seal
standard Type B seal is a balanced, inside mounted, cartridge design, non-pusher (bellows) seal in which the flexible element rotates

NOTE 1 A stationary flexible element is a data sheet selection. Secondary sealing elements are elastomeric O-rings. Materials are specified in clause 6 and annex C. Figure 8 depicts a Type B seal.

NOTE 2 A metal bellows seal offers the advantage of having only static secondary seals. It is also a cost effective alternative for services where chemical resistance or cost of O-ring materials is an issue. It may be specified instead of the standard Type A seal for low temperature service.

3.80
Type C seal
standard Type C seal is a balanced, inside mounted, cartridge design, non-pusher (metal bellows) seal in which the flexible element is stationary

NOTE 1 A rotating flexible element is a data sheet selection. Secondary sealing elements are flexible graphite. Materials are specified in clause 6 and annex C. Figure 9 depicts a Type C seal.

NOTE 2 Bellows seals are inherently balanced. Stationary metal bellows seals are the primary selections for high temperature services. The stationary bellows configuration, Type C, is chosen as standard because of its advantage if the gland plate and shaft lose their perpendicular alignment. In this arrangement, the bellows can deflect to a fixed position to match the rotating face. In a rotating arrangement, Type B, the bellows would have to flex and change positions once per shaft revolution to accommodate the runout of the stationary face; however, rotating metal bellows tend to throw out particulate from between the bellows in coking or other particulate bearing services.

NOTE 3 The user should note that rotating bellows seals often have a tendency to vibrate and are, therefore, equipped with dampening tabs or other devices to control vibration. Stationary bellows seals largely avoid this issue.

NOTE 4 Metal bellows seals offer the advantage of having only static secondary seals. This allows their application in high-temperature services where suitable O-ring elastomers are not available. Metal bellows seals are also a cost-effective alternative for services where chemical resistance or cost of O-ring materials is an issue.

3.81
unbalanced seal
mechanical seal in which the balance ratio is equal to or greater than 1

3.82
vendor
supplier
agency that supplies the equipment

NOTE 1 The vendor may be the manufacturer of the equipment or the manufacturer's agent and normally is responsible for service support.

NOTE 2 This document addresses the responsibilities between the two parties. These parties are defined as the purchaser and the vendor or the supplier. There are many parties that are involved in the purchase and manufacture of the equipment. These parties are given different titles depending on their chain in the order. They may be called buyer, contractor, manufacturer, and subvendor. For example, the party supplying a lube oil console may be the console vendor to the compressor manufacturer, the subvendor to the purchaser, and the purchaser to components within the console. All of these terms, however, can be reduced to the purchaser and vendor or supplier. It is for this reason that only these two terms are defined. Attempts to define these other terms would only cause added confusion.

3.83
vent
eliminate gas or vapor from the seal chamber

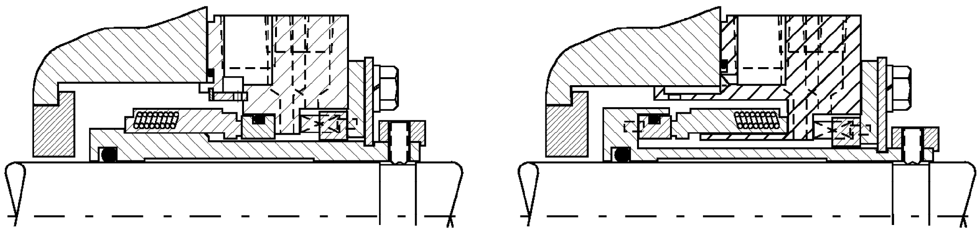
NOTE This is normally accomplished through a gland connection, such as the flush connection.

3.84
volatile hazardous air pollutants (VHAP)
any compound as defined by Title 1, Part A, Section 112 of the U.S. National Emission Standards for Hazardous Air Pollutants (NESHAPs) (Clean Air Act Amendment)

3.85
volatile organic compound (VOC)
term used by various environmental agencies to designate regulated compounds

NOTE Emissions are measured with a calibrated analyzer.

3.86
witnessed inspection
witnessed test
inspection or test where the purchaser is notified of the timing of the inspection or test and a hold is placed on the inspection or test until the purchaser or his representative is in attendance

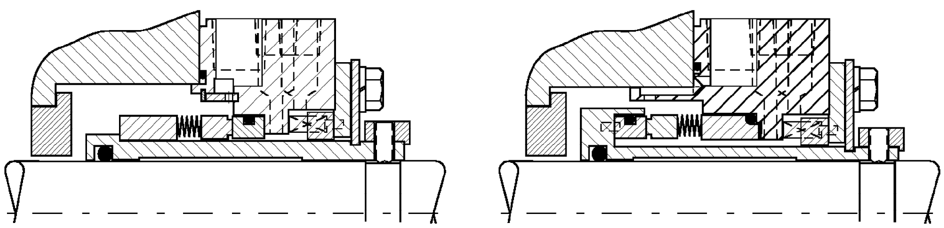


1 **2**

Key

1 standard (rotating flexible element)
2 alternative (stationary flexible element)

Figure 7 — Arrangement 1 Type A seals

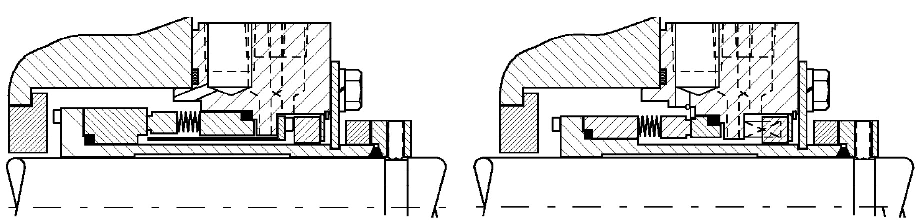


1 **2**

Key

1 standard (rotating bellows assembly)
2 alternative (stationary bellows assembly)

Figure 8 — Arrangement 1 Type B seals



1 2

Key

1 standard (stationary bellows assembly)
2 alternative (rotating bellows assembly)

Figure 9 — Arrangement 1 Type C seals

4 Unit responsibility

Unless otherwise specified, the pump vendor shall have unit responsibility for the seal system if the seal system is purchased as part of a pump system. If not purchased as part of a pump system, the seal vendor shall have unit responsibility for the seal system. The vendor who has unit responsibility shall ensure that all sub-vendors comply with the requirements of this Standard. For information, annex H summarizes the seal and pump vendor interfaces.

5 Dimensions

● **5.1** The purchaser shall specify whether data, drawings, hardware (including fasteners), and equipment supplied to this Standard shall use SI units or US Customary units.

● **5.2** Where dual references are cited, the purchaser shall specify whether the primary (first reference cited) or the secondary reference shall apply.

6 Design requirements

6.1 Common design requirements (all categories)

6.1.1 General information

6.1.1.1 All mechanical seals, regardless of type or arrangement, shall be of the cartridge design. Assembled cartridges that include hook sleeves are excluded from this Standard.

NOTE ISO 13709 already requires that pumps be designed to enable seal removal without disturbing the driver. If retrofitting pumps that are not back-pullout design, it should be verified that adequate shaft end spacing exists.

● **6.1.1.2** If specified, a stationary flexible element can be supplied for Type A or Type B seals.

NOTE The rotating flexible element was selected as the standard for pusher seals because it allows application of a smaller seal.

● **6.1.1.3** If specified, a rotating flexible element can be supplied for Type C seals.

6.1.1.4 The cartridge seal shall incorporate a setting device (such as setting plates) that is sufficiently robust to enable the assembly to be pushed or pulled during installation, rotor adjustment, or disassembly without transferring radial or axial load to the seal faces.

6.1.1.5 A stationary flexible element seal shall be provided if seal face surface speed at the mean diameter of the seal face exceeds 23 m/s (4,500 ft/min).

NOTE 1 As speed increases, the flexible element of a rotating seal will flex at a correspondingly faster rate to keep the seal faces closed. At very high speeds (and for large seal sizes), the forces required to keep the faces closed become so large that they negatively affect the seal life.

NOTE 2 Consideration should be given for requiring a stationary flexible element if:

— balance diameter exceeds 115 mm (4,5 in.) (see 6.1.1.7);

— pump case or gland plate distortion and misalignment exist due to pipe loads, thermal distortion, pressure distortion, etc.;

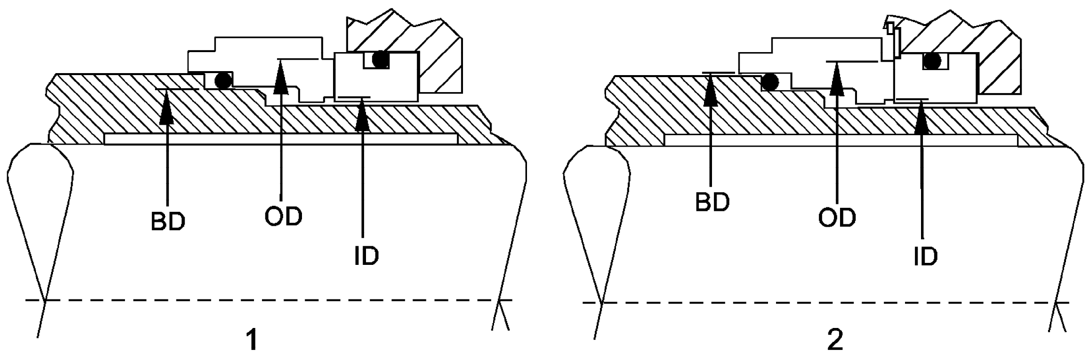
— seal chamber mounting surface's perpendicularity to the shaft is a problem, aggravated by high rotational speed; or

— the seal chamber face runout requirements described in 6.1.2.13 cannot be met (this is a condition with some slender-shaft, multi-stage pump designs).

6.1.1.6 This Standard does not cover the design of the component parts of mechanical seals; however, the design and materials of the component parts shall be suitable for the specified service conditions. The maximum allowable working pressure shall apply to all parts referred to in the definition of pressure casing.

NOTE It is not normal practice for seals to be rated for the maximum allowable working pressure for the pump in which they are installed.

6.1.1.7 The seal manufacturer shall design the seal faces and seal balance ratio to minimize seal face-generated heat consistent with optimum life expectations in 1.3 and emissions limit requirements. The seal balance ratio measurement points shall be as shown in Figure 10.



Key
1 seal with higher pressure at outer diameter
2 seal with higher pressure at inner diameter

Figure 10 — Balance ratio measurement points

For seals pressurized at the outside diameter, the seal balance ratio is defined by the simplified equation:

$$\frac{(OD^2 - BD^2)}{(OD^2 - ID^2)}$$

where

OD is the seal face outside diameter;

ID is the seal face inner diameter; and

BD is the balance diameter of the seal.

For seals pressurized at the inner diameter, the seal balance ratio is defined by the equation:

$$\frac{(BD^2 - ID^2)}{(OD^2 - ID^2)}$$

where

OD is the seal face outside diameter;

ID is the seal face inner diameter; and

BD is the balance diameter of the seal.

Balance diameter varies with seal design, but for spring pusher seals under outer diameter pressure, it is normally the diameter of the sliding contact surface of the inner diameter of the dynamic O-ring; for spring pusher seals under inner diameter pressure, it is normally the diameter of the sliding contact surface of the outer diameter of the dynamic O-ring; for welded metal bellows type seals, the balance diameter is normally the mean diameter of the bellows, but this can vary with pressure.

NOTE 1 Temperature control plays an important role in the success of a mechanical seal. Every seal generates heat at the seal faces. In some cases, heat soak from the fluid pumped should also be controlled. Heat soak is the heat transferred from the pump and pumped fluid to fluid in the seal chamber. For example, if a particular fluid must be maintained at 60ºC (140ºF) to maintain a satisfactory vapor pressure margin and the pump operating temperature is 146ºC (295ºF), heat would be transferred through the pump case into the seal chamber. The combined heat load (soak- and face-generated) should be carried away by the flush. Annex B provides guidance on the calculation of heat soak and seal generated heat.

NOTE 2 The calculated heat load allows sizing of the cooling system, determination of start-up and running torques, determination of flush rates, and boiling point margins. Normally, seal flush rates are based upon a maximum allowable 5ºC (10ºF) temperature rise, considering all heat inputs. Certain seal chamber arrangements such as dead-ended and taper bore boxes have other considerations.

NOTE 3 Starting torque, seal power, and seal generated heat can be a significant issue for small pump drivers, seals at or above the balance diameter and pressure boundaries of this Standard, and for Arrangement 3 seals.

6.1.1.8 The seal supplied shall be capable of handling normal and transient differential axial movement between the rotor and stator.

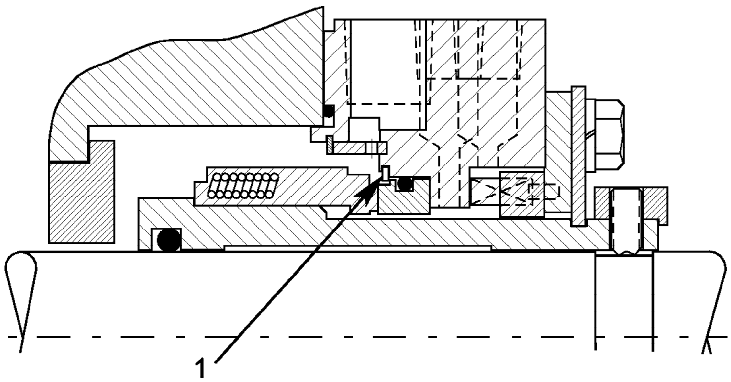
NOTE Maximum axial movement is of particular concern in hot multi-stage pumps. During start-up conditions, it is not unusual for a large amount of differential thermal growth to occur between the shaft and casing. This differential can exceed the capabilities of some seals. Axial movement is also a concern in some vertical pump designs that rely on the motor bearing for thrust positioning (i.e., in-line pumps without pump bearing housings and vertical can pumps). In certain conditions, process pressure may result in an upward thrust. Shaft axial movement is only limited by motor bearing axial float in these cases.

6.1.1.9 O-ring sealing surfaces, including all grooves and bores, shall have a maximum surface roughness of 1,6 μm Ra (63 μin. Ra) for static O-rings and 0,8 μm Ra (32 μin. Ra) for the surface against which dynamic O-rings slide. Bores shall have a minimum 3 mm (0,12 in.) radius or a minimum 1,5 mm (0,06 in.) chamfered lead-in for static O-rings and a minimum 2 mm (0,08 in.) chamfered lead-in for dynamic O-rings. Chamfers shall have a maximum angle of 30º.

6.1.1.10 O-ring grooves shall be sized to accommodate perfluoroelastomer O-rings.

NOTE Some perfluoroelastomers have a greater thermal expansion than most other O-ring materials, such as fluoroelastomer. Installing a perfluoroelastomer in a groove designed for fluoroelastomer will lead to damage to the O-ring. On the other hand, fluoroelastomer O-rings function properly in the larger grooves. Choosing the wider groove as a standard eliminates this potential cause of O-ring failure and reduces the number of necessary spares. Note that thermal expansion damage in perfluoroelastomer O-rings is often confused with damage due to chemical induced swelling of the O-rings, and vice versa.

6.1.1.11 For vacuum services, all seal components shall be designed with a positive means of retaining the sealing components to prevent them from being dislodged (see Figure 11). The seal design shall be adequate to seal under vacuum conditions when the pump is not operating (refer to 6.1.2.14).



Key

1 feature required in 6.1.1.11

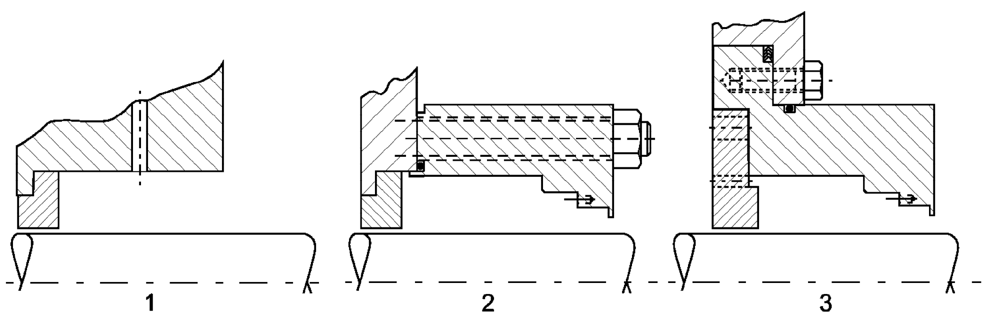
Figure 11 — Positive retention of seal components in vacuum services

6.1.2 Seal chamber and gland plate

6.1.2.1 Gland plates shall be provided by the seal manufacturer.

6.1.2.2 Unless otherwise specified, seal chambers shall be provided by the pump manufacturer.

6.1.2.3 Seal chambers are one of three types: traditional, externally mounted, or internally mounted. Seal chambers are not required to accommodate packing. Figure 12 shows the three types.



Key

1 traditional

2 externally mounted

3 internally mounted

Figure 12 — Seal chamber types

6.1.2.4 The standard seal chamber is the traditional type (cylindrical chamber; integral to the head of the pump) supplied by the pump manufacturer.

Category 1 seals shall be designed to fit into the dimensional envelope defined by ANSI/ASME B73.1 and ANSI/ASME B.73.2, or ISO 3069 Type C.

Category 2 and Category 3 seals shall be designed to fit into the dimensional envelope of ISO 13709.

NOTE 1 Seal chamber designs that utilize all the design features of this Standard should result in improved reliability and general standardization of components. Reduced seal radial clearance requires the user to address flush plans and construction requirements for non-compliant seals.

NOTE 2 Mechanical seal reliability is affected by the radial clearance between its rotating parts and the seal chamber bore. Meeting the minimum radial clearance requirements of this Standard is particularly important when sealing difficult services such as those with significant solids content or those that can result in excessive seal face temperature. Alternative seal chamber designs, such as large-bore or tapered seal chambers with flow modifiers, may eliminate the need for a flush or enhance performance based on design of the chamber.

NOTE 3 It is expected that the majority of Category 1 seals will be applied to ANSI/ASME B73.1, ANSI/ASME B73.2 and ISO 2858 pumps, and the majority of Category 2 and Category 3 seals will be installed in ISO 13709 applications. However, there is a recognized possibility that Category 1 seals may be installed in ISO 13709 applications, and Category 2 and Category 3 seals, in certain configurations, may be installed in ANSI/ASME B73.1, ANSI/ASME B73.2, and ISO 2858 pumps. Careful consideration should be given to correctly applying seal categories into pump types or services for which they are not intended.

● **6.1.2.5** If specified, a bolt-on seal chamber provided by the seal manufacturer shall be supplied.

6.1.2.6 The minimum radial clearance between the rotating components of the seal and the stationary surfaces of the seal chamber and gland plate shall be 3 mm ($^1/_8$ in.) except as noted in 8.6.2.3 (circulation devices), 7.2.5.1.1, and 7.2.6.1.1 (Arrangement 2 containment seal chamber bushings).

NOTE The $^1/_8$ in. radial clearance might not be possible in small pump sizes and ISO 3069 Type C seal chambers. Refer to Notes 1 and 2, 6.1.2.4.

6.1.2.7 All bolt and stud stresses shall be in accordance with the pressure design Code at maximum allowable working pressure. Four studs shall be used. The diameter of the studs shall be in accordance with the seal chamber dimensional references in 6.1.2.4. Larger studs shall be furnished only if required to meet the stress requirements of ASME VIII or to sufficiently compress spiral wound gaskets in accordance with ASME B16.20.

6.1.2.8 The maximum allowable working pressure of the pressure casing shall be equal to or greater than that of the pump pressure casing on which it is installed. The seal pressure casing shall have a corrosion allowance of 3 mm ($^1/_8$ in.), and shall have sufficient rigidity to avoid any distortion that would impair seal operation, including distortion that may occur during tightening of the bolts to set gasketing. Lower corrosion allowance may be acceptable for some higher alloy materials, although purchaser approval is required.

6.1.2.8.1 Unless otherwise specified, gland plates shall be provided with holes (not slots) for attachment studs.

6.1.2.8.2 Provisions shall be made for centering the seal gland plates and/or chamber with either an inside- or an outside-diameter register fit. The register fit surface shall be concentric to the shaft and shall have a total indicated runout of not more than 0,125 mm (0,005 in.), see Figure 13.

6.1.2.8.3 A shoulder at least 3 mm ($^1/_8$ in.) thick shall be provided in the seal gland plate to prevent the stationary element of the mechanical seal from dislodging as a result of chamber pressure see Figure 14.

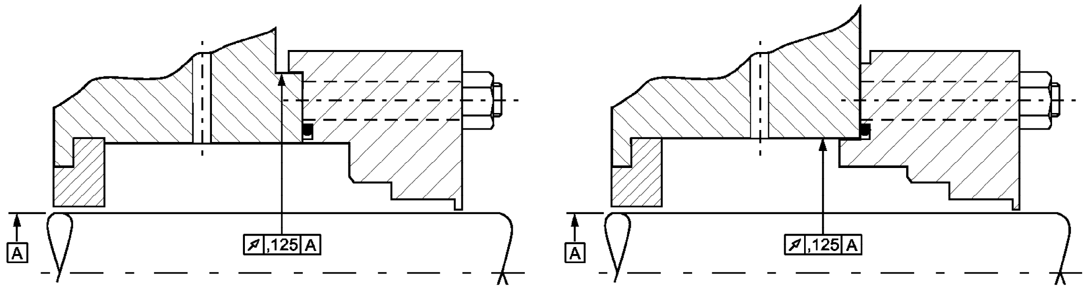


Figure 13 — Seal chamber register concentricity

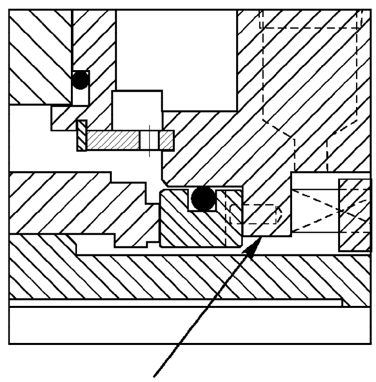


Figure 14 — Seal gland plate shoulder

6.1.2.9 Stress values used in the design of the pressure casing for any material shall not exceed the values used in the design of the pump casing on which it is installed. Where the original pump design values are not available the stress values shall be in accordance with ISO 13709.

6.1.2.10 Manufacturing data report forms, third party inspections, and stamping as specified in ASME VIII are not required.

6.1.2.11 The use of threaded holes in pressurized parts shall be minimized. To prevent leakage in pressure sections of casing, metal equal in thickness to at least half the nominal bolt diameter, in addition to the allowance for corrosion, shall be left around and below the bottom of drilled and tapped holes.

6.1.2.12 Bolting for pressure casings shall meet the requirements of 6.1.2.12.1 through 6.1.2.12.4.

6.1.2.12.1 The details of threading shall conform to ASME B1.1 or ISO 261. Metric fine and UNF threads shall not be used.

6.1.2.12.2 Unless otherwise specified, studs shall be used in lieu of other fasteners such as cap screws for connection of seal chamber to pump and seal gland plate to pump or seal chamber.

6.1.2.12.3 Adequate clearance shall be provided at bolting locations to permit the use of socket or box wrenches.

NOTE Adequate clearance to use socket or box wrenches at gland plate bolting locations may not be feasible on small pumps.

6.1.2.12.4 Stud markings, if provided, shall be located on the nut end of the exposed stud.

6.1.2.13 Seal manufacturer shall design for seal chamber face runout up to 0,5 μm/mm (0,000 5 in./in. of seal chamber bore, (TIR) (see Figure 15).

NOTE 1 Mechanical seal performance depends on the runout conditions at the mechanical seal chamber. Seal chamber face runout or seal chamber interface runout is a measure of the squareness of the pump shaft with respect to the face of the seal chamber mounting face.

NOTE 2 Some multistage slender-shaft designs may not be able to meet the requirements of this paragraph (refer to 6.1.1.5).

6.1.2.14 Seal chamber pressure and support systems for Arrangement 1 and Arrangement 2 shall be designed in accordance with 6.1.2.14.1 and 6.1.2.14.2.

6.1.2.14.1 Seal chamber pressure for contacting wet seals (excluding containment seals) shall be designed for not less than a 30% margin between seal chamber pressure and maximum fluid vapor pressure or a 20°C (36°F) product temperature margin based on the maximum process fluid temperature.

Pumps that develop low differential pressure and pumps that handle high vapor pressure fluids may not achieve the required margins. Where seal chamber conditions do not meet the specified margins, the seal manufacturer shall:

— confirm the adequacy of the seal selection and flush plan based on the specified fluid;

— advise the seal chamber operating conditions (minimum pressure and maximum temperature) that will result in a seal installation that has a high probability of achieving 3 years of uninterrupted service;

— furnish the seal gland plate or seal chamber with a second flush connection to permit measurement of seal chamber pressure directly; and

— furnish a distributed flush system unless space limitations prohibit its use.

NOTE 1 For contacting wet seal designs, maintaining an adequate vapor pressure margin helps protect the seal faces against localized boiling of the process fluid at the seal faces. Boiling of the process fluid at the seal faces can cause loss of seal-face lubrication and subsequent seal failure. Low-density fluids are some of the most troublesome fluids to seal and account for a high percentage of seal repairs.

NOTE 2 These margins can be achieved in many ways. For example, using one or a combination of the following options may provide a vapor pressure and product temperature margin for reliable seal performance. The application of these solutions is usually the result of mutual agreement between the purchaser, seal, and pump manufacturers:

— lowering the seal chamber fluid temperature by cooling the flush fluid;

— raising the seal chamber pressure by removing the back wear ring and plugging impeller balance holes;

— utilizing an external flush fluid; and/or

— raising the seal chamber pressure through the use of a close clearance (floating) throat bushing.

NOTE 3 Lowering the flush fluid temperature (seal chamber fluid temperature) is always preferable to pressurizing the seal chamber by using a close clearance throat bushing. Bushing wear will inevitably result in a decreased seal chamber pressure and margin over vapor pressure.

NOTE 4 Some applications may not need complicated seal flush systems. A generic example of this is cooling water service. Assuming the water is at 38°C (100°F) and an atmospheric pump suction and seal chamber pressure exists, the absolute vapor pressure would be 0,065 bar (0,94 psi). The absolute vapor pressure at 58°C (136°F) would be about 0,186 bar (2,7 psi). Ample product temperature margin would be present in the seal chamber to provide good seal life without seal flush fluid cooling or pressurizing the seal chamber.

NOTE 5 The user should be aware that there may be other criteria that should be used to establish seal chamber conditions to achieve target reliability. An example is hot water at a temperature above 82°C (180°F), which requires cooling to maintain adequate fluid lubricity (see annex A).

6.1.2.14.2 During operation, the seal chamber pressure shall be at least 0,35 bar (5 psi) above atmospheric pressure.

NOTE This is particularly important if the inlet pressure to the pump is below atmospheric.

6.1.2.15 If supplied, throat bushings shall be renewable and designed so that they cannot be forced out by hydraulic pressure.

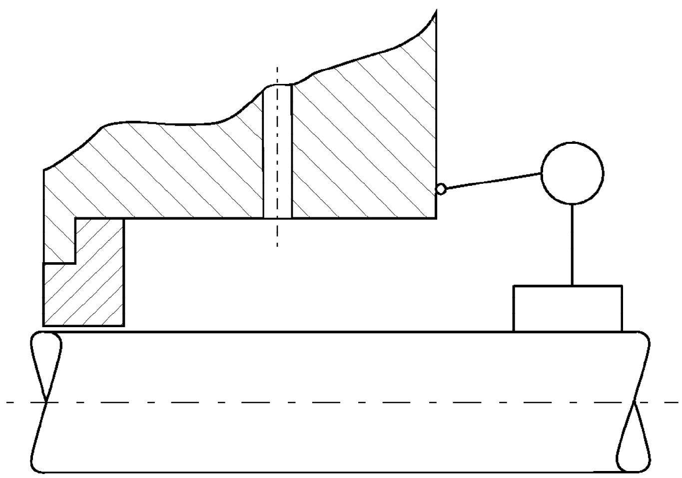


Figure 15 — Seal chamber face runout

NOTE 1 Throat bushings can be used for any or all of the following purposes along with the appropriate flush plans:

— to increase or decrease seal chamber pressure;

— to isolate the seal chamber fluid; and/or

— to control the flow into or out of the seal chamber.

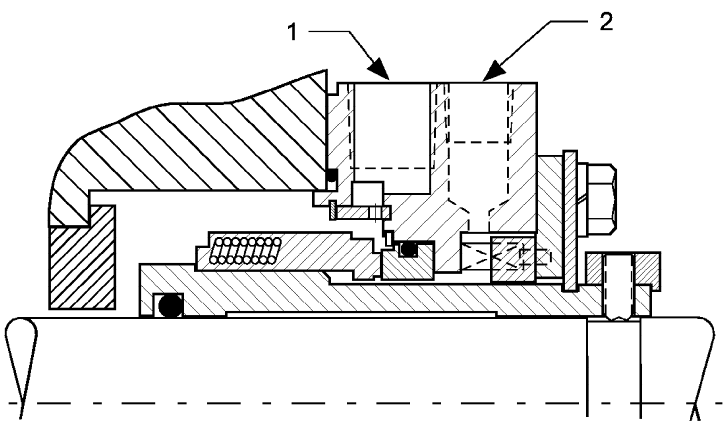
NOTE 2 Also refer to annex A for additional guidance concerning the use of throat bushings.

● **6.1.2.16** If specified, or if recommended by the seal manufacturer, close clearance, floating throat bushings shall be furnished. Materials and clearances shall be suitable for the service and approved by the purchaser.

6.1.2.17 Data sheet specified gland plate and seal chamber connections shall be identified by symbols permanently marked (e.g. stamped or cast) on the component. The code size and location in Table 1 shall be used (also see Figure 16 for the relative axial position of the process and atmospheric connections). Where appropriate, the letters I and O (In and Out) shall be used in conjunction with these markings. For horizontal pumps, 0° is vertical on top. For vertical pumps, the location of the flush (F) connection defines 0° (see Figure 2 to Figure 6). Where the size of the pump or seal gland precludes the inclusion of the required connection on the seal gland, the seal vendor shall advise the pump vendor to include the necessary connection on the pump or seal chamber. If tangential porting is used, the location of the drilled port into the seal chamber shall comply with Table 1. However, the associated locations for the gland plate tapped connections may differ from those specified in Table 1.

NOTE 1 The lack of space for tap and port connections in the seal chamber area may require that these be included within the pump manufacturer's scope of supply refer to annex H for pump and seal vendor interface issues.

NOTE 2 Differential sizing minimizes the possibility of improper assembly, particularly during maintenance in the field. The user should be aware that the specified connection size and location in Table 1 might not be practical on smaller pumps.



Key

1 process side connection

2 atmospheric side connection

Figure 16 — Mechanical seal piping connections

Table 1 — Symbols and size for seal chamber and gland plate connections

Seal Configuration	Symbol	Connection	Location	Type	Size		Connection Required (Note 7)
					Category I (Note 1)	Category II and III (Note 1)	
1CW-FX 1CW-FL	F	Flush	0	Process	1/2 (Note 3)	1/2	Required
	FI	Flush In (Plan 23 only)	180	Process	1/2 (Note 3)	1/2	WS
	FO	Flush Out (Plan 23 only)	0	Process	1/2 (Notes 3 & 6)	1/2	WS
	D	Drain	180	Atmospheric	3/8 (Note 5)	3/8	Required
	Q	Quench	90	Atmospheric	3/8 (Note 5)	3/8	Required
	H	Heating	---	Utility	1/2 (Note 3)	1/2	WS
	C	Cooling	---	Utility	1/2 (Note 3)	1/2	WS
2CW-CW	F	Flush (Inner Seal)	0	Process	1/2 (Note 3)	1/2	Required
	LBI	Liquid Buffer Fluid In	180	Process	1/2 (Note 4)	1/2 (Note 4)	Required
	LBO	Liquid Buffer Fluid Out	0	Process	1/2 (Note 4)	1/2 (Note 4)	Required
	D	Drain (Outer Seal)	180	Atmospheric (Note 2)	3/8 (Note 5)	3/8	WS
	Q	Quench (Outer Seal)	90	Atmospheric (Note 2)	3/8 (Note 5)	3/8	WS
2CW-CS	F	Flush (Inner Seal)	0	Process	1/2	1/2	Required
	FI	Flush In (Plan 23 only)	180	Process	1/2 (Note 3)	1/2	WS
	FO	Flush Out (Plan 23 only)	0	Process	1/2 (Notes 3 & 6)	1/2	WS
	GBI	Gas Buffer Fluid In	90	Process	1/4	1/4	WS
	CSV	Containment Seal Vent	0	Process	1/2	1/2	Required
	CSD	Containment Seal Drain	180	Process	1/2	1/2	Required
	D	Drain (Outer Seal)	180	Atmospheric (Note 2)	3/8 (Note 5)	3/8	WS
	Q	Quench (Outer Seal)	90	Atmospheric (Note 2)	3/8 (Note 5)	3/8	WS
2NC-CS	GBI	Gas Buffer Fluid In	90	Process	1/4	1/4	WS
	CSV	Containment Seal Vent	0	Process	1/2	1/2	Required
	CSD	Containment Seal Drain	180	Process	1/2	1/2	Required
	D	Drain (Outer Seal)	180	Atmospheric (Note 2)	3/8 (Note 5)	3/8	WS
	Q	Quench (Outer Seal)	90	Atmospheric (Note 2)	3/8 (Note 5)	3/8	WS
3CW-FB 3CW-FF 3CW-BB	F	Flush (Seal Chamber)	0	Process	1/2	1/2	WS
	LBI	Liquid Barrier Fluid In	180	Barrier	1/2 (Note 4)	1/2 (Note 4)	Required
	LBO	Liquid Barrier Fluid Out	0	Barrier	1/2 (Note 4)	1/2 (Note 4)	Required
	D	Drain (Outer Seal)	180	Atmospheric (Note 2)	3/8 (Note 5)	3/8	WS
	Q	Quench (Outer Seal)	90	Atmospheric (Note 2)	3/8 (Note 5)	3/8	WS
3NC-FF 3NC-BB 3NC-FB	F	Flush (Seal Chamber)	0	Process	1/2	1/2	WS
	GBI	Gas Barrier Fluid In	0	Barrier	1/4	1/4	Required
	GBO	Gas Barrier Fluid Out	180	Barrier	1/2	1/2	Required
	D	Drain (Outer Seal)	180	Atmospheric (Note 2)	3/8 (Note 5)	3/8	WS
	Q	Quench (Outer Seal)	90	Atmospheric (Note 2)	3/8 (Note 5)	3/8	WS

NOTE 1 All sizes are NPT tapered thread connections.

NOTE 2 These connections are rarely provided because they are only required when a throttle bushing is provided. A throttle bushing is not provided with standard Arrangement 2 and 3 configurations.

NOTE 3 A 3/8 NPT connection may be used if 1/2 NPT is not possible due to space constraints.

NOTE 4 A 1/2 NPT required for shaft diameters 63.5 mm (2.5 inch) or smaller, 3/4 NPT for larger shaft sizes.

NOTE 5 A 1/4 NPT connection may be used if 3/8 NPT is not possible due to space constraints.

NOTE 6 A tangential connection is preferred for the outlet.

NOTE 7 WS = Connection is provided *only when* the appropriate flush plan is *specified*.

6.1.2.18 Threaded connection points shall be plugged with solid round or solid hexagonal head plugs furnished in accordance with the dimensional requirements of ASME B16.11. Square head plugs shall not be used due to the tendency to be damaged during installation and removal. All plugs shall be of the same material as the gland plate. An anaerobic lubricant/sealant shall be used on the threads to ensure the threads are vapor-tight. PTFE tape, anti-seize, or anti-galling compounds shall not be used on gland plate connections because of the possibility of fouling the seal.

Category 1 seal gland plates and seal chambers may not be able to meet this standard plug requirement due to space constraints. In such cases, flush-mount socket head plugs are acceptable.

NOTE 1 ASME B16.11 is referenced to prevent the supply of hollow or cored plugs; failures of such plugs have occurred within the industry.

NOTE 2 The head on a pipe plug will interfere with the installation and actual ability to fit on many smaller Category 1 pumps if the bearing bracket inner diameter is close to the gland plate outer diameter in size. Also, a head on the plug utilized on the seal chamber port may interfere with the back side of the gland plate due to the limited axial space.

6.1.2.19 All piping or tubing connections shall be suitable for the hydrostatic test pressure of seal chamber or gland plate to which they are attached.

6.1.2.20 Gland plates and/or seal chambers for contacting wet seals shall be designed such that the seal chamber and piping system is self-venting during start-up and operation through the piping system. Designs, other than Plan 23, requiring manual seal chamber venting shall be approved by the purchaser.

NOTE On small horizontal pumps where the elevation of the discharge nozzle is not high enough to achieve a continuously rising Plan 11 flush line, then the concentration for the Plan 11 can be located in the process piping upstream of the check valve.

The seal chamber or gland plate shall have a port no less than 3 mm ($^1/_8$ in.) above the seal faces to allow the removal of trapped gas if contacting wet seal arrangements are vertically oriented. This port shall be uppermost in the chamber (see Figure 17). This applies to ports for both sets of faces in Arrangement 2 (2CW-CW configuration) and the outer seal face of Arrangement 3 contacting wet seals.

Horizontal or vertical pumps having a flush Plan 23 or vertical pumps having flush Plans 11, 21, 31 and 41 shall be provided with a separate vent connection in the piping. Vertical pumps having flush Plan 2 shall have a vent connection in the gland plate. Designs, other than these, requiring manual seal chamber venting require purchaser's approval.

NOTE 1 Low-volume seal flush systems that have positive flow due to differential pressures within the pump may not require manual venting (i.e., a short Plan 11 or Plan 13 on a small pump). Entrained gas will quickly purge from the piping and seal chamber upon start-up of the pump.

NOTE 2 Venting of the seal chamber for Arrangement 3 non-contacting seals prior to start-up and during operation may be necessary to avoid the collection of gas in the pump.

6.1.2.21 Drill throughs shall be sized for the application and shall be a minimum of 5 mm ($^3/_{16}$ in.) diameter.

6.1.2.22 The diametrical clearance at a fixed throttle bushing bore shall not be more than 0,635 mm (0,025 in.) for sleeve diameters up to 50 mm (2 in.). For larger diameters, the maximum diametrical clearance shall be 0,635 mm (0,025 in.) plus 0,127 mm (0,005 in.) for each additional 25 mm (1 in.) of diameter or fraction thereof.

6.1.2.23 Floating carbon throttle bushings shall have a sleeve clearance as shown in Table 2.

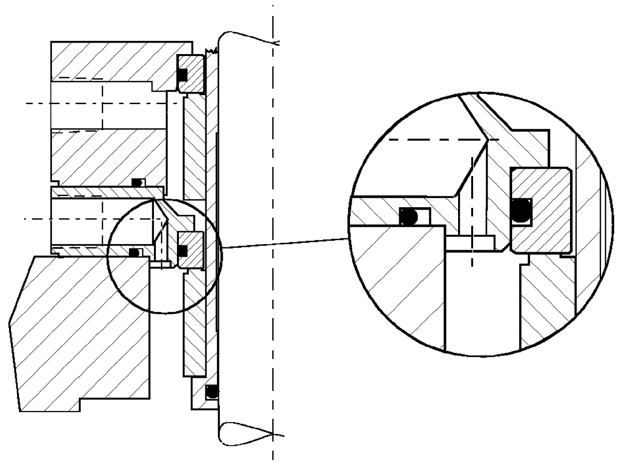


Figure 17 — Seal chamber/gland plate for vertical pumps

Table 2 — Floating carbon throttle bushing diametrical clearances

Sleeve diameter		Maximum diametrical clearance at pumping temperature	
mm	(in.)	mm	(in.)
0 to 50	(0 to 2,00)	0,18	(0,007)
51 to 80	(2,01 to 3,00)	0,225	(0,009)
81 to 120	(3,01 to 4,75)	0,28	(0,011)

● **6.1.2.24** If specified, heating jackets or inserts shall be provided on seal chambers. Heating requirements shall be agreed between the purchaser, vendor and seal manufacturer.

6.1.2.25 The supply of flush tap and port connections shall satisfy clause 4.

NOTE The lack of space for tap and port connections off the gland plate may require that these be included within the pump manufacturer's scope of supply.

6.1.3 Cartridge seal sleeves

6.1.3.1 Seal sleeves shall be furnished by the seal manufacturer. The sleeve shall be sealed at one end. The seal sleeve assembly shall extend beyond the outer face of the seal gland plate.

NOTE Leakage between the shaft and the sleeve thus may not be confused with leakage through the mechanical seal.

6.1.3.2 Shaft-to-sleeve diametrical clearance shall be F7/h6 according to ISO 286-2.

NOTE The F7/h6 correlates to 0,020 mm (0,000 8 in.) to 0,093 mm (0,003 7 in.) clearance for the range of seal sizes covered by this specification, and varies as a function of diameter. The intent is to minimize sleeve runout (see Figure 18), while allowing for ease of assembly/disassembly. Shrink discs typically require tighter clearances, and should follow the shrink disc manufacturer's design criteria.

6.1.3.3 Sleeves shall have a shoulder (or shoulders) for positively locating the rotating element (or elements).

6.1.3.4 Unless otherwise specified, shaft-to-sleeve sealing devices shall be elastomeric O-rings or flexible graphite rings.

NOTE Metallic sealing devices are often unreliable, damage the shaft, and make disassembly difficult. Sealing devices should be softer than the shaft.

6.1.3.5 Shaft-to-sleeve O-ring seals shall be located at the impeller end of the sleeve. For shafts that require the O-ring to pass over the threads, at least 1,6 mm ($^1/_{16}$ in.) radial clearance shall be provided between the threads and the internal diameter of the gasket, and the diameter transition shall be radiused or chamfered (see 6.1.1.9) to avoid damage to the O-ring.

NOTE This location prevents pumpage from accumulating under the sleeve and making disassembly difficult.

6.1.3.6 Shaft-to-sleeve sealing devices located at the outboard end of the sleeve shall be captured between the sleeve and the shaft.

NOTE Flexible graphite is commonly used on metal bellows seals located on the outboard end of the sleeve.

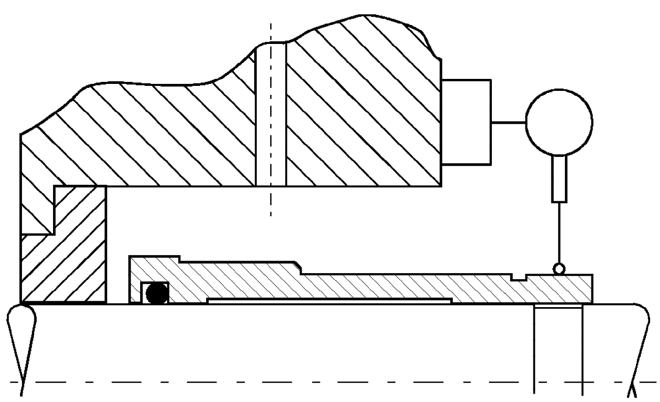


Figure 18 — Seal sleeve runout

6.1.3.7 Sleeves shall have a minimum radial thickness of 2,5 mm (0,100 in.). Sleeve thickness in the area of component drive set screws shall be in accordance with Table 3.

NOTE 1 The sleeve thickness in the proximity of set screw locations will prevent sleeve distortion due to tightening of the set screws.

NOTE 2 Excessively thin sleeves distort easily. The minimum thickness is for the sleeve in its thinnest section, such as under seal-setting plate grooves.

Table 3 — Minimum sleeve thickness in the area of component drive set screws

Shaft diameter		Minimum sleeve radial thickness	
mm	(in.)	mm	(in.)
< 57	(< 2,250)	2,5	(0,100)
57 to 80	(2,250 to 3,250)	3,8	(0,150)
> 80	(> 3,250)	5,1	(0,200)

6.1.3.8 The sleeve shall be machined and finished throughout its length such that the bore and outside diameter are concentric within 25 µm (0,001 in.) TIR.

6.1.3.9 Sleeves shall be relieved along their bore leaving a locating fit at or near each end.

NOTE Relieving the bore makes assembly and disassembly easier with the required close fits.

6.1.3.10 Drive collar set screws shall not pass through clearance holes unless the sleeve bore is relieved.

NOTE If set screws are tightened against the shaft, the holes upset the metal on the shaft surface. If this damage is under the sleeve, it cannot be corrected prior to sleeve removal. For between-bearing pumps, the full length of the sleeve must be pulled over the damaged area. This can cause the sleeve to gall to the shaft or otherwise be damaged. The problem is less severe with overhung pumps where only a small length of the sleeve needs to be pulled over the damaged area. For between-bearing pumps, drive collar set screws should not pass through clearance holes in the sleeve to engage the shaft unless they bear on a relieved area of this shaft.

6.1.3.11 Drive collar set screws shall be of sufficient hardness to securely embed in the shaft.

6.1.3.12 Designs using nine or more set screws to drive and/or axially position the sleeve require purchaser approval.

NOTE 1 As shaft size and sealing pressure increase, the axial force on the sleeve (pressure times area) increases. As the number of set screws increases, the drive collar is weakened and the amount of additional force each set screw will resist decreases.

NOTE 2 Dimples drilled in the pump shaft to accommodate set screws will result in a protruding lip around the drilled hole unless it is chamfered or otherwise eliminated. This lip will damage flexible graphite secondary seals and could damage O-rings.

NOTE 3 The use of spot drilling on shafts for overhung pumps is not recommended as this creates a stress riser which may reduce the fatigue life of the shaft.

NOTE 4 Spot drilling should be done only after the axial position of the shaft is set. Ensure holes are drilled in line with the set screw holes on the drive collar so that no distortion of the collar or sleeve occurs when the set screws are tightened.

NOTE 5 It may not be possible to use pre-existing spot drilling for replacement seals.

● **6.1.3.13** If specified, or if recommended by the seal or pump manufacturer and approved by the purchaser, devices other than set screws may be used for axially positioning and driving the sleeve. Examples include a split ring engaging a groove in the shaft (see Figure 19), or a shrink disc (see Figure 20).

NOTE These designs are expensive and are usually used only on unspared pumps. Use of these designs avoid shaft damage by dimpling the shaft for dog point set screws when high thrust loads exist on the sleeve.

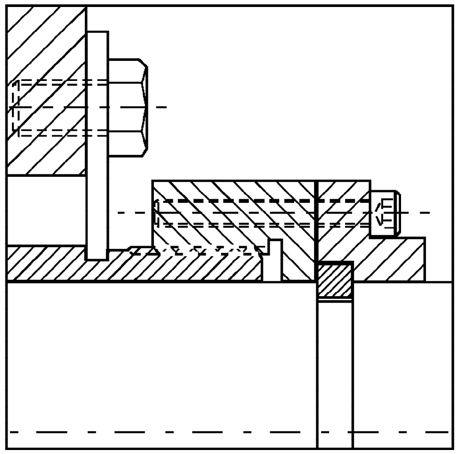


Figure 19 — Seal sleeve attachment by split ring

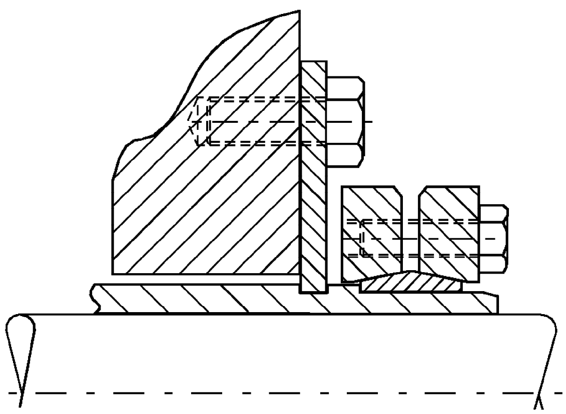


Figure 20 — Seal sleeve attachment by shrink disk

6.1.4 Mating rings

6.1.4.1 Anti-rotation devices shall be designed to minimize the distortion of the seal faces. Clamped faces shall not be used unless specifically approved by the purchaser (see Figure 21).

NOTE Flat seal faces are essential for achieving low emissions and good seal performance. Clamped rings are easily distorted.

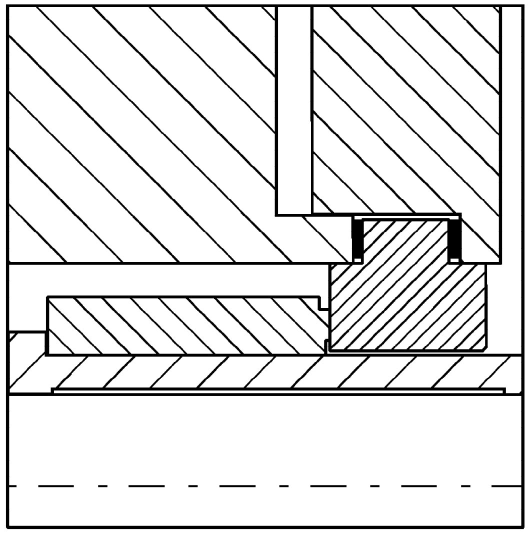


Figure 21 — Clamped faces

6.1.4.2 The arrangement of the mating ring and its mounting into the seal gland plate shall be designed to facilitate cooling of the ring and to avoid thermal distortion.

NOTE Mating rings that are mounted deep in the gland plate and have minimal contact with the process fluid tend to not transfer heat away effectively. The resulting temperature gradients can cause distortion of the faces.

6.1.5 Flexible elements

● **6.1.5.1** If specified, a single spring Type A seal shall be furnished.

NOTE 1 Multiple coil-spring seals tend to be more axially compact than single coil-spring seals. This gives wider applicability when dual seals are considered. Multiple springs also tend to provide a more even loading.

NOTE 2 Single spring seals generally add 6 mm (0,25 in.) to 13 mm (0,5 in.) to the axial space requirement of a sealing application. For single seal applications, the single spring has advantages and disadvantages. The single spring allows a lower spring rate to achieve the same face loading. This makes the single spring more tolerant of axial misalignment (errors in axial setting of the seal). This advantage is largely eliminated by use of cartridge seals. For corrosive services, the wire in single springs is significantly greater in cross-section providing a greater corrosion allowance.

6.1.5.2 Flexible elements shall not rely on static lapped joints for sealing.

NOTE Designs such as lapped joint rotating seal rings are prohibited by this paragraph as they employ an unretained slip fit into a flexible element unit. Designs retaining the seal ring with an interference fit and/or gasket are acceptable.

6.1.6 Materials

6.1.6.1 General

6.1.6.1.1 Unless otherwise specified on the data sheets, shaft seal components shall be furnished with the materials referenced in 6.1.6.2 through 6.1.6.9.

NOTE Proper material selection is critical to the reliable operation of a mechanical seal. Selection depends on the characteristics of the contacting fluid. Variables such as operating temperature, pressure, speed, lubricity, and chemical compatibility are key parameters. The purchaser should solicit seal manufacturer input when in doubt about the compatibility of these materials with the intended service.

6.1.6.1.2 Superior or alternative materials recommended for the service by the seal manufacturer shall be stated in the proposal.

6.1.6.1.3 Materials identified in the proposal other than those specified in this Standard, or materials for an engineered seal, or exceptions to materials in this Standard shall be identified with their applicable specification numbers (e.g. ASTM, EN etc) and the material grade. If no such designation exists, the manufacturer's material specification, giving physical properties, chemical composition, and test requirements, shall be made available upon request.

6.1.6.2 Seal faces

6.1.6.2.1 Each seal shall be comprised of a seal ring and a mating ring.

6.1.6.2.2 One of the rings shall be premium grade, blister-resistant carbon graphite with manufacturing treatment to reduce wear, provide chemical resistance, and minimize porosity consistent with the intended service.

● **6.1.6.2.3** For Category 2 and Category 3 seals, one of the rings shall be reaction-bonded silicon carbide (RBSiC). If specified, self-sintered silicon carbide (SSSic) shall be furnished. Several grades of these materials are available; therefore, the manufacturer shall state the type of silicon carbide offered for each service.

For Category 1 seals, one of the rings shall be self-sintered silicon carbide (SSSiC). If specified, reaction-bonded silicon carbide (RBSiC) shall be furnished. Several grades of these materials are available; therefore, the manufacturer shall state the type of silicon carbide offered for each service.

NOTE See annex C.2.1 for guidance related to manufacture and use of RBSiC versus SSSiC.

6.1.6.2.4 Abrasive, viscous and high-pressure services may require two hard materials. Unless otherwise specified for this service, both the seal ring and the mating rings shall be silicon carbide. Other hard face combinations of SSSiC, RBSic and Tungsten Carbide are widely used, and are acceptable with purchaser approval (see annex C.2.2 for further guidance).

The seal manufacturer shall advise if the specified face material combination may present problems during testing of the pump on water. If so, the seal manufacturer shall recommend alternative materials for use during pump performance testing.

NOTE See annex C.2.2 for guidance regarding the selection of optimum hard face material combinations. The user should be aware of the potential inappropriateness of some seal face material combinations for use during pump shop testing because of the test fluid, water.

6.1.6.2.5 Seal and mating rings shall be of one homogeneous material. Overlays or coatings shall not be used as the sole means of providing wear-resistance.

NOTE The overlays or coatings discussed in this clause refer to designs such as sprayed-on tungsten carbide. Materials such as silicon carbide or tungsten carbide may be enhanced by applying a coating. Temperature limitations for seal face materials are listed in annex C.2.

6.1.6.3 Seal sleeves

Unless otherwise specified, seal sleeves shall be AISI Type 316 stainless steel, or EN 10088 Grade 1.4571, or equivalent (see annex C.1).

6.1.6.4 Springs

Unless otherwise specified, seals with multiple coil-springs shall be Alloy C-276 of Alloy C-4 spring material. Single coil-springs shall be AISI Type 316 stainless steel spring material.

NOTE Cross-section thickness of the spring should be taken into consideration when selecting spring materials. Heavier cross-section springs, such as those found in single spring seals, are not as prone to stress corrosion cracking as the thinner cross-section type found in multiple spring seals. For example, Alloy C-276 is the material most suited to multiple spring seals, whereas AIS I Type 316 stainless steel may be just as suitable in the same service using a single spring.

6.1.6.5 Secondary sealing components

6.1.6.5.1 Unless otherwise specified, O-rings shall be fluoroelastomer (FKM). Temperature limitations for elastomers are listed in annex C.3.

6.1.6.5.2 Unless otherwise specified, if operating temperatures or chemical compatibility preclude the use of fluoroelastomers (FKM), O-rings shall be perfluoroelastomers (FFKM). See annex C.4 for additional details.

NOTE Users may wish to consider alternatives in cases where the perfluoroelastomer cost is high and/or perfluoroelastomer performance may be questionable. These alternatives include use of alternative secondary element materials and designs such as TFE coated O-rings, solid TFE sealing elements (usually spring energized), Nitrile (NBR), Ethylene Propylene (EPM/EPDM), perfluoroelastomer alternatives/substitutes/approximations, and flexible graphite. The primary factors in selecting an appropriate alternative should be proven experience and lower cost than perfluoroelastomer use.

6.1.6.5.3 Unless otherwise specified, if the temperature or chemical limitations of elastomers have been exceeded, secondary seals shall be flexible graphite.

6.1.6.6 Metal bellows

Unless otherwise specified, metal bellows for the Type B seal shall be Alloy C-276; for the Type C seal, Alloy 718.

6.1.6.7 Gland plates

6.1.6.7.1 Unless otherwise specified, gland plate material shall be AISI Type 316 stainless steel or EN 10088 Grade 1.4571, or equivalent (see annex C.1). Gland plates for alloy pumps shall be of the same alloy as the casing, or one with superior corrosion resistance and mechanical properties than the pump casing material for the intended service.

● **6.1.6.7.2** Unless otherwise specified, dynamic and static secondary sealing elements shall be the same material required by 6.1.6.5.1 and 6.1.6.5.2. Gland plate to seal chamber gasket shall be an O-ring for services below 175°C (350°F). For temperatures over 175°C (350°F), or if specified, graphite-filled type 304 or 316 stainless steel spiral wound gaskets shall be used.

NOTE Spiral wound gaskets have bolt torque requirements for full compression. Refer to 6.1.2.7 for bolting requirements for spiral wound gaskets.

6.1.6.8 Bolt-on seal chambers

6.1.6.8.1 Bolt-on seal chambers shall be AISI Type 316 stainless steel or EN 10088 Grade 1.4571, or equivalent (see annex C.1). Chambers for alloy pumps shall be the same alloy as the casing, or one with superior corrosion resistance and mechanical properties than the pump casing material for the intended service.

NOTE The user should consider thermal expansion properties of the materials to avoid stress or gasket-related problems if bolt-on chambers are supplied for high temperature services in material dissimilar to that of the pump or attachment stud.

6.1.6.8.2 Chamber to casing gasket material requirements shall conform to 6.1.6.7.2.

6.1.6.9 Miscellaneous parts

6.1.6.9.1 Unless otherwise specified, spring retaining components, drive pins, anti-rotation pins, and internal set screws shall have strength and corrosion resistance of AISI Type 316 stainless steel (see annex C.1) or better.

6.1.6.9.2 Outside drive components shall have suitable corrosion resistance for the service. Set screws shall have sufficient hardness and design to carry the load or alternative methods can be used, (e.g., spot drilling, split rings or shrink discs) (refer to 6.1.3.12 and 6.1.3.13 and accompanying notes).

NOTE If hardened carbon steel set screws are not suitable for the service, then a hardened stainless steel set screw should be provided (such as 17-4 precipitation hardened stainless steel).

6.1.6.10 Welding

6.1.6.10.1 Welding of piping, pressure-containing parts, rotating parts and other highly stressed parts, weld repairs and any dissimilar metal welds shall be performed and inspected by operators and procedures qualified in accordance with standards such as ASME IX.

NOTE Metal bellows used in non-pusher seal construction are manufactured by a welding process that is proprietary to the seal manufacturer. This welding process is not covered by general welding codes or industry standards and is not within the scope of this Standard.

6.1.6.10.2 The manufacturer shall be responsible for the review of all repairs and repair welds to ensure that they are properly heat treated and non-destructively examined for soundness and compliance with the applicable qualified procedures. Repair welds shall be non-destructively tested by the same method used to detect the original flaw. As a minimum, the inspection shall be by liquid penetrant testing for stainless steel components.

NOTE The magnetic particle method is the default for ferrous materials, in accordance with 10.2.8 and 10.2.9.

6.1.6.10.3 Unless otherwise specified, all welding other than that covered by ASME VIII, Division 1 and ASME B31.3, such as welding on baseplates, non-pressure ducting, lagging, and control panels, shall be performed in accordance with AWS D1.1.

6.1.6.10.4 Pressure casings made of wrought materials or combinations of wrought and cast materials shall conform to the conditions specified in 6.1.6.10.4.1 through 6.1.6.10.4.4.

NOTE Bolt-on seal chambers may be of welded construction.

6.1.6.10.4.1 Plate edges shall be inspected by magnetic particle or liquid penetrant examination as required by ASME VIII, Division 1, UG-93(d)(3).

6.1.6.10.4.2 Accessible surfaces of welds shall be inspected by magnetic particle or liquid penetrant examination after back chipping or gouging and again after post-weld heat treatment.

6.1.6.10.4.3 Pressure-containing welds, including welds of the case to horizontal and vertical joint flanges, shall be full penetration welds.

6.1.6.10.4.4 Fabricated pressure retaining parts (regardless of thickness) shall be post-weld heat treated.

6.1.6.10.5 Connections welded to the pressure retaining parts shall be installed as specified in 6.1.6.10.5.1 through 6.1.6.10.5.5.

● **6.1.6.10.5.1** In addition to 6.1.6.10.1, if specified 100% radiography, magnetic particle examination, ultrasonic examination, or liquid penetrant examination of welds shall be performed.

6.1.6.10.5.2 Auxiliary piping welded to alloy steel pressure retaining parts shall be of a material with the same nominal properties as the casing material or shall be of low carbon austenitic stainless steel. Other materials compatible with the casing material and intended service may be used with the purchaser's approval.

6.1.6.10.5.3 If heat treatment is required, piping welds shall be made before the component is heat treated.

● **6.1.6.10.5.4** If specified, proposed connection designs shall be submitted to the purchaser for approval before fabrication. The drawings shall show weld designs, size, materials, and pre- and post-weld heat treatments.

6.1.6.10.5.5 All welds shall be heat treated in accordance with the methods described in ASME VIII, Division 1, UW-40.

6.1.6.11 Low temperature

● **6.1.6.11.1** For operating temperatures below – 30°C (– 20°F) or, if specified, for other low-ambient temperatures, steels shall have properties as described in 6.1.6.11.2 through 6.1.6.11.6.

NOTE Also see annex C.3 which covers temperature limits for elastomers.

6.1.6.11.2 To avoid brittle failures, materials of construction for low temperature service shall be suitable for the minimum design metal temperature in accordance with the codes and other requirements specified. The purchaser and the vendor shall agree on any special precautions necessary with regard to conditions that may occur during operation, maintenance, transportation, erection, commissioning, and testing.

NOTE Good design practice should be followed in the selection of fabrication methods, welding procedures, and materials for vendor furnished steel pressure retaining parts that may be subject to temperatures below the ductile-brittle transition temperature. The published design-allowable stresses for metallic materials in standards such as the ASME Boiler and Pressure Vessel code are based on minimum tensile properties. Some standards do not differentiate between rimmed, semi-killed, fully-killed hot-rolled, and normalized material, nor do they take into account whether materials were produced under fine- or course-grain practices. The vendor should exercise caution in the selection of materials intended for services between – 30°C (– 20°F) and 40°C (100°F).

6.1.6.11.3 All pressure retaining steels applied at a specified minimum design metal temperature below – 29°C (– 20°F) require a Charpy V-notch impact test of the base metal and the weld joint unless they are exempt in accordance with ASME VIII, Division 1, UHA-51. Impact test results shall meet the requirements of ASME VIII, Division 1, UG-84.

6.1.6.11.4 Carbon and low alloy steel pressure retaining parts applied at a specified minimum design metal temperature between – 30°C (– 20°F) and 40°C (100°F) shall require impact testing, as follows:

a) Impact testing is not required for parts with a governing thickness (see 6.1.6.11.5) of 25 mm (1 in.) or less.

b) Impact testing exemptions for parts with a governing thickness (see 6.1.6.11.5) greater than 25 mm (1 in.) shall be established in accordance with ASME VIII, Division 1, UCS-66. The minimum design metal temperature without impact testing may be reduced as shown in ASME VIII, Division 1, Figure UCS-66.1. If the material is not exempt, Charpy V-notch impact test results shall meet the minimum impact energy requirements of ASME VIII, Division 1, UG-84.

6.1.6.11.5 Governing thickness used to determine impact testing requirements shall be the greater of the following:

a) the nominal thickness of the largest butt welded joint;

b) the largest nominal section for pressure containment, excluding:

structural support sections such as feet or lugs; and

structural sections required for attachment or inclusion of mechanical features such as jackets or seal chambers; or

c) one fourth of the nominal flange thickness, including gland plate and seal chamber flanges.

● **6.1.6.11.6** The purchaser shall specify the minimum design metal temperature to be used to establish impact test requirements.

NOTE Normally, this will be the lower of the minimum surrounding ambient temperature or minimum liquid pumping temperature. However, the purchaser may specify a minimum design metal temperature based on pumpage properties, such as autorefrigeration at reduced pressures.

6.2 Design requirements (category specific)

6.2.1 Category 1 seals

6.2.1.1 General information (Category 1)

This clause provides design details for Category 1 seals, as defined in clause 1 and clause 3. Specific information provided here is in addition to the common seal design features listed in 6.1.

6.2.1.2 Seal chamber and gland plate (Category 1)

● **6.2.1.2.1** If specified, or if required by 6.1.2.14, a distributed seal flush system such as a circumferential or multi-port arrangement shall be provided for Arrangement 1 and Arrangement 2 seals with rotating flexible elements. The seal flush arrangement shall be located to maximize the uniformity and degree of cooling of the seal faces. For multi-port systems, a minimum of 3 mm ($^{1}/_{8}$ in.) diameter ports shall be used. The seal flush passages shall be designed so that they can be cleaned (see Figure 22).

NOTE Distributed flush systems are not specified for stationary single seals or for stationary dual seals because this becomes complex and expensive. Furthermore, stationary single seal faces are in a position in the seal chamber where effective mixing takes place and the need for distribution of the flush is diminished.

6.2.1.2.2 All mating joints between the seal gland plate, the seal chamber, the containment seal chamber and the pump case shall incorporate a confined gasket to prevent blowout. Controlled compression of the gasket (for example, an O-ring or a spiral- wound gasket) shall be accomplished with metal-to-metal contact between the gland plate and the seal chamber face. The design of the joint shall prevent extrusion of the gasket to the interior of the seal chamber where it might interfere with seal cooling. Where space or design limitations make this requirement impractical, an alternative seal gland plate design shall be submitted to the purchaser for approval (see Figure 23).

NOTE To minimize runout, metal-to-metal contact is needed to keep seal faces and the shaft perpendicular.

6.2.2 Category 2 seals

6.2.2.1 General information (Category 2)

6.2.2.1.1 This clause provides design details for Category 2 seals, as defined in clause 1 and clause 3. Specific information provided here is in addition to the common seal design features listed in 6.1.

6.2.2.2 Seal chamber and gland plate (Category 2)

● **6.2.2.2.1** If specified, or if required by 6.1.2.14, a distributed seal flush system such as a circumferential or multi-port arrangement shall be provided for Arrangement 1 and Arrangement 2 seals with rotating flexible elements. The seal flush arrangement shall be located to maximize the uniformity and degree of cooling of the seal faces. For multi-port systems, a minimum of 3 mm ($^1/_8$ in.) diameter ports shall be used. The seal flush passages shall be designed so that they can be cleaned (see Figure 22).

NOTE Distributed flush systems are not specified for stationary single seals or for stationary dual seals because this becomes complex and expensive. Furthermore, stationary single seal faces are in a position in the seal chamber where effective mixing takes place and the need for distribution of the flush is diminished.

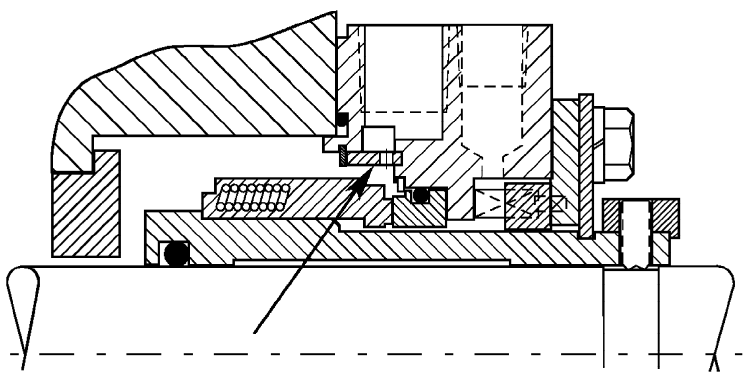


Figure 22 — Distributed seal flush system

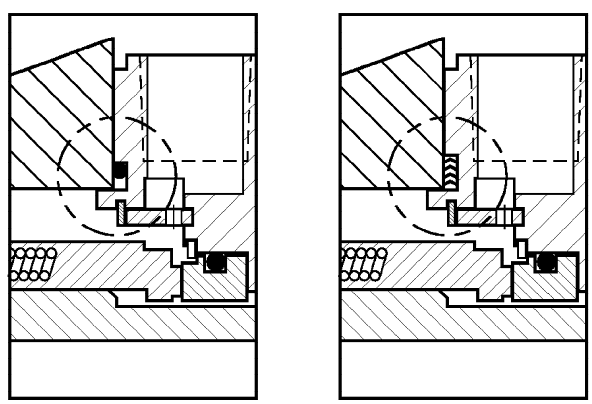


Figure 23 — Mating joint gasket (O-ring or spiral wound)

6.2.2.2.2 All mating joints between the seal gland plate, the seal chamber, the containment seal chamber and the pump case shall incorporate a confined gasket to prevent blowout. Controlled compression of the gasket (for example, an O-ring or a spiral- wound gasket) shall be accomplished with metal-to-metal joint contact both inside and outside the stud circle to prevent buckling of the gland plate. The design of the joint shall prevent extrusion of the gasket to the interior of the seal chamber where it might interfere with seal cooling. Where space or design limitations make this requirement impractical, an alternative seal gland plate design shall be submitted to the purchaser for approval (see Figure 23).

NOTE To minimize runout, metal-to-metal contact is required to keep seal faces and the shaft perpendicular.

6.2.2.3 Cartridge seal sleeves (Category 2)

6.2.2.3.1 Standard seal sizes shall fit shafts in even 10 mm increments.

6.2.2.3.2 Where key drives are supplied, keys shall be positively secured to the shaft (see Figure 24).

NOTE Keys located on the shaft deep in traditional stuffing boxes cannot be easily reached for seal assembly.

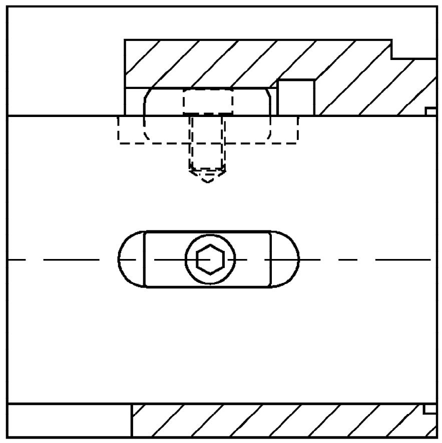


Figure 24 — Key drives attachment to shaft

6.2.3 Category 3 seals

6.2.3.1 General information (Category 3)

6.2.3.1.1 This clause provides design details for Category 3 seals, as defined in clause 1 and clause 3. Specific information provided here is in addition to the common seal design features listed in 6.1. Category 2 information from 6.2.2 applies to Category 3 seals, except as amended in this clause.

6.2.3.2 Seal chamber and gland plate (Category 3)

6.2.3.2.1 A distributed seal flush system such as a circumferential or multi-port arrangement shall be provided for all Category 3, single Arrangement 1 seals with rotating flexible elements. The seal flush arrangement shall be located to maximize the uniformity and degree of cooling of the seal faces. For multi-port systems, a minimum of 3 mm ($^1/_8$ in.) diameter ports shall be used. The seal flush passages shall be cleanable (see Figure 22).

NOTE In many cases, effective seal operation is dependent on distributed flush systems which maximize heat removal from the seal faces to ensure effective film formation and prevent asymmetrical thermal distortions in sealing components. Distributed flush systems are not mandated for stationary single seals or for dual seals because this becomes complex and expensive. Furthermore, stationary single seal faces are in a position in the seal chamber where effective mixing takes place and the need for distribution of the flush is diminished.

7 Specific seal configurations

7.1 Arrangement 1 seals

7.1.1 Seal sleeves

Seal sleeves shall be designed of one piece.

7.1.2 Seal chamber and gland plate

7.1.2.1 Unless otherwise specified:

a) a fixed carbon throttle bushing shall be installed in the gland plate for Category 1 seals;

b) a fixed non-sparking metal bushing shall be installed in the gland plate for Category 2 seals; and

c) a close-clearance (floating) carbon throttle bushing shall be installed in the gland plate for Category 3 seals.

Throttle bushings shall be positively retained against pressure blowout to minimize leakage if the seal fails. Alternative leakage control devices may be provided as specified.

NOTE Bushings may be sized to allow for thermal growth of the shaft. Carbon bushing material is suitable for chemical plant and refining services, but is more sensitive to impact damage than a non-sparking metal bushing. Category 2 seals are designed to fit into ISO 13709 seal chambers and will be used in most refinery services. PTFE (and PTFE-graphite composites) is a less desirable bushing material due to its thermal expansion properties and lack of memory.

● **7.1.2.2** If specified, a close-clearance (floating) carbon throttle bushing shall be furnished for Category 1 or Category 2 seals.

7.1.2.3 Unless otherwise specified, flush, vent, and drain connections shall be provided and plugged. Plugs for threaded connections shall comply with 6.1.2.18.

7.2 Arrangement 2 seals

7.2.1 General

7.2.1.1 Unless otherwise specified, the inner seal shall be a contacting wet seal (2CW-CW or 2CW-CS). The inner seal shall have an internal (reverse) balance feature designed and constructed to withstand reverse pressure differentials up to 2,75 bar (40 psi) without opening or dislodging components.

NOTE The containment seal chamber pressure is normally less than the inner seal chamber pressure. The containment seal chamber is usually connected through an orifice to a vapor recovery system, in which case it will operate at the pressure of the system to which it is connected. It is unusual for a vapor recovery system to reach a gauge pressure of 2,75 bar (40 psi) even under upset conditions.

● **7.2.1.2** If specified, a non-contacting inner seal (2NC-CS) shall be provided.

NOTE Non-contacting inner seal designs utilize a lift-off face pattern, such as grooves or waves, which can provide reliable operation in liquid or gas service. Often it is difficult to provide adequate vapor suppression margin when sealing clean high vapor pressure or mixed vapor pressure fluids with contacting wet face designs. A non-contacting inner seal can give the option of sealing a liquid/gas mixture by allowing the product to flash into a gas across the seal faces, effectively using the non-contacting design inner seal as a gas seal. The leakage rate from a non-contacting design will normally be higher than a contacting wet design.

7.2.1.3 Unless otherwise specified, a contacting containment seal shall be used with liquid buffer systems and a non-contacting containment seal shall be used if a liquid buffer system is not provided.

If recommended by the seal manufacturer and agreed by the purchaser, a contacting containment seal face design may be provided for services with a gas buffer system.

NOTE 1 Inner and outer seal faces are a contacting design if a liquid buffer system is provided.

NOTE 2 For gas buffer systems, contacting or non-contacting containment seal face designs may be used. Non-contacting containment seals utilize a face pattern (grooves, waves, etc.) to provide lift-off of the seal faces. Relative to contacting "dry running" containment seals, non-contacting face designs:

a) have a lower wear rate in operation;

b) are more tolerant to a "bone dry" buffer gas environment; and

c) are designed for higher surface speeds and pressure differentials.

Contacting containment seal designs normally provide the lowest leakage of vapors and liquids. Manufacturer's standard dry contacting seal designs are pressure limited for continuous service, usually below a gauge pressure of 0,7 bar (10 psi). However, designs are suitable in a gas environment of product vapors for continuous operation with excursions in gauge pressure to 2,75 bar (40 psi) to allow for variation in the vapor recovery system pressure. Friction and rubbing wear is dependent on the shaft speed, containment seal chamber pressure, and properties of the vapor being sealed. Use of "bone dry" nitrogen as a buffer gas may result in rapid carbon face wear.

● **7.2.1.4** The buffer fluid shall be specified on the data sheet.

NOTE Many existing 2CW-CS installations do not use an external buffer gas. If a buffer gas is not used, the containment seal chamber will be filled with vaporized process fluid.

7.2.2 Seal sleeves

7.2.2.1 Where possible, seal sleeves shall be designed as one piece. Cartridge designs that incorporate an auxiliary sleeve at the inboard end of the seal sleeve to facilitate the assembly of the inner seal components are acceptable. The auxiliary sleeve shall be axially located on the seal sleeve by a shoulder and driven by dog point set screws (see Figure 25).

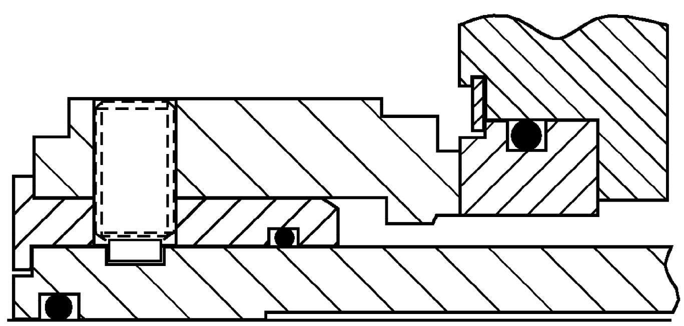


Figure 25 — Auxiliary sleeve arrangement

7.2.2.2 If recommended by the vendor and agreed by the purchaser, alternative auxiliary sleeve designs may be provided.

NOTE Having an auxiliary sleeve at the inboard end of a dual seal cartridge will permit the inner seal to be installed from the inboard end. It reduces the time and complexity involved in cartridge assembly. It also makes it possible for the inner and outer pusher seal to be the same size. To ensure reliable seal performance, the fit of the auxiliary sleeve and the seal sleeve should meet the requirements of clause 6.

7.2.3 Seal chamber and gland plates

● **7.2.3.1** If specified as a result of the process conditions and if additional length for the seal arrangement is available, a fixed carbon throttle bushing shall be installed in the gland plate and positively retained against pressure blowout.

NOTE A throttle bushing with a dual seal is rarely required, but may be used in cold services where a quench is used to avoid icing. Limited axial space between the seal chamber face and the bearing housing often makes the use of a throttle bushing with an Arrangement 2 seal impractical.

7.2.4 Contacting wet seals with a liquid buffer fluid (2CW-CW)

7.2.4.1 General

7.2.4.1.1 Liquid buffer systems shall be designed such that the maximum temperature differential between the buffer fluid inlet and outlet immediately adjacent to the seal chamber is:

— 8°C (15°F) for glycol/water or diesel buffer fluids; and

— 16°C (30°F) for mineral oil buffer fluids.

NOTE The allowable temperature differential will include the effects of both "heat soak" and seal face generated heat. The allowable temperature differential across the seal should not be confused with the bulk temperature rise of the buffer fluid during steady-state operation or the differential temperature between the process fluid and steady-state buffer fluid temperature.

7.2.4.2 Seal chamber and gland plates

● **7.2.4.2.1** If specified, or if recommended by the seal manufacturer, a tangential buffer fluid outlet shall be provided for Category 1 and Category 2 seal assemblies. A tangential buffer fluid outlet shall be provided for Category 3 seals.

NOTE Using a tangential buffer fluid outlet connection will increase buffer fluid flow if an internal pumping ring is used. However, a tangential outlet is best applied if a radial-pumping ring is used and installed in the same plane as the outlet connection.

7.2.5 Contacting wet inner seal with a dry running containment seal (2CW-CS)

7.2.5.1 Seal chamber and gland plates

7.2.5.1.1 A fixed non-sparking bushing, or equivalent device approved by the purchaser, shall be installed inside the containment seal chamber downstream of the containment seal vent and drain connection ports and upstream of the containment seal faces. The bushing shall be positively retained to prevent axial movement and damage to seal components. The minimum radial clearance between the bushing and rotating parts in the seal chamber shall be 1,5 mm (0,060 in.) (see Figure 26).

Purchaser's approval is required for any alternative seal chamber layout that deviates from the standard layout described above.

NOTE The bushing will help isolate the containment seal faces from normal inner seal leakage by directing it toward the containment seal vent or drain connection. Space limitations may require the seal supplier to propose an alternative containment seal chamber layout.

7.2.5.1.2 The use of the containment seal vent or drain connections for buffer gas injection is permitted only with the purchaser's approval.

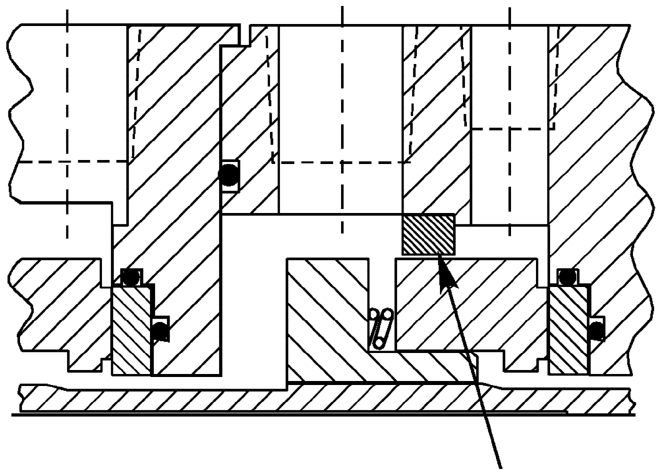


Figure 26 — Containment seal chamber bushing for 2CW-CS and 2NC-CS configurations

7.2.6 Non-contacting inner seal with a dry running containment seal (2NC-CS)

7.2.6.1 Seal chamber and gland plates

7.2.6.1.1 A fixed non-sparking bushing, or equivalent device approved by the purchaser, shall be installed inside the containment seal chamber downstream of the containment seal vent and drain connection ports and upstream of the containment seal faces. The bushing shall be positively retained to prevent axial movement and damage to seal components. The minimum radial clearance between the bushing and rotating parts in the seal chamber shall be 1,5 mm (0,060 in.) (see Figure 26).

Purchaser's approval is required for any alternative seal chamber layout that deviates from the standard layout described above.

NOTE The bushing will help isolate the containment seal faces from normal inner seal leakage by directing it toward the containment seal vent or drain connection. Space limitations may require the seal supplier to propose an alternative containment seal chamber layout minimum.

7.2.6.1.2 The use of the containment seal vent or drain connections for buffer gas injection is permitted only with the purchaser's written approval.

7.3 Arrangement 3 seals

7.3.1 General

● **7.3.1.1** The barrier fluid shall be a liquid or gas as specified.

NOTE 1 Gas barrier seal designs may not be appropriate for services where dissolved or suspended solids in the pumped fluid tend to adhere to the seal faces or cause hang-up. This is especially true if the process fluid is on the ID of the inner gas lubricated seal. Liquid barrier seal designs arranged such that the process fluid is on the OD of the seal faces will help to minimize solids accumulation on the faces and minimize hang-up.

NOTE 2 While stationary, capillary action of sticky or polymerizing fluids between gas barrier lubricated faces may cause torque failure upon startup even if the gas barrier pressure is maintained while the pump is idle.

7.3.1.2 The inner seal shall have an internal (reverse) balance feature designed and constructed to withstand reverse pressure differentials without opening.

NOTE Internal or reverse balance feature requires that the mating ring and the secondary seal be designed to stay in place in the event that barrier fluid pressure is lost. Barrier fluid pressure is usually regulated between a gauge pressure of 1,4 bar (20 psi) and 4,1 bar (60 psi) over the pressure in the seal chamber.

7.3.1.3 Standard Arrangement 3 configurations shall utilize two seal rings and two mating seal rings. If recommended by the vendor and approved by the purchaser, a common mating ring (mono-block design) may be provided.

7.3.2 Seal sleeves

7.3.2.1 Where possible, seal sleeves shall be designed as one piece. Cartridge designs that incorporate an auxiliary sleeve at the inboard end of the seal sleeve to facilitate the assembly of the inner seal components are acceptable. The auxiliary sleeve shall be axially located on the seal sleeve by a shoulder and driven by dog point set screws (see Figure 25).

NOTE Having an auxiliary sleeve at the inboard end of a dual seal cartridge will permit the inner seal to be installed from the inboard end. It reduces the time and complexity involved in cartridge assembly. It also makes it possible for the inner and outer pusher seal to be the same size. To ensure reliable seal performance, the fit of the auxiliary sleeve and the seal sleeve should meet the requirements of clause 6.

7.3.3 Seal chamber and gland plates

● **7.3.3.1** If specified as a result of the process conditions and if additional length for the seal arrangement is available, a fixed carbon throttle bushing shall be installed in the gland plate and positively retained against pressure blowout.

NOTE The specification of a throttle bushing for a dual seal is rarely required, but may be used in services where a quench is used to avoid icing. Limited axial space between the seal chamber face and the bearing housing often makes the use of a throttle bushing with an Arrangement 3 seal impractical.

● **7.3.3.2** If specified, a flush connection to the process side of the seal chamber shall be provided with Arrangement 3 configurations.

NOTE Some Arrangement 3 configurations may require a flush on the process fluid side of the seal chamber to isolate the process fluid from the seal parts or to assist in heat removal from the inner seal. Toxic and/or difficult-to-seal applications may utilize a flush in the seal chamber in addition to an Arrangement 3 seal.

7.3.4 Contacting wet seal configurations with a liquid barrier fluid (3CW-FB, 3CW-FF, 3CW-BB)

7.3.4.1 General

7.3.4.1.1 Liquid barrier systems shall be designed such that that maximum temperature differential between the barrier fluid inlet and outlet immediately adjacent to the seal chamber is:

— 8°C (15°F) for glycol/water or diesel barrier fluids; and

— 16°C (30°F) for mineral oil barrier fluids.

NOTE The allowable temperature differential will include the effects of both "heat soak" and seal face generated heat. The allowable temperature differential across the seal should not be confused with the bulk temperature rise of the barrier fluid during steady-state operation or the differential temperature between the pump fluid and steady-state barrier fluid temperature.

7.3.4.2 Standard seal types and arrangements

7.3.4.2.1 The standard seal configuration shall have the inner and outer seals arranged in series (3CW-FB) (Figure 5).

NOTE Since the first edition of API 682 was issued, seal manufacturers have developed standard design liquid barrier dual seals arranged in series (3CW-FB). The advantages of the series configuration are that abrasive contamination is centrifuged and has less effect on the inner seal, and that in the event of a loss of barrier fluid pressure, the seal will behave like an Arrangement 2 seal. Restricted seal chamber dimensions and the resulting cartridge hardware construction can affect the ability of the barrier fluid flush to adequately cool the inner seal of a 3CW-FB installation. Inadequate cooling of the inner seal can result in reduced seal reliability. Selection of a 3CW-BB or FF configuration or use of a process fluid side seal chamber cooling flush may resolve an inner seal cooling problem.

● **7.3.4.2.2** If specified, a face-to-face (3CW-FF) or a back-to-back (3CW-BB) configuration may be provided (Figure 5).

NOTE The installed population of Arrangement 3 seals arranged in series (3CW-FB) is relatively small compared to the other configurations (3CW-FF and 3CW-BB). Both back-to-back and face-to-face configurations (3CW-BB and 3CW-FF) have the potential of more compact designs and can provide higher levels of performance. Therefore, a purchaser's option for alternative Arrangement 3 configurations (3CW-FF and 3CW-BB) is provided.

7.3.4.3 Seal chambers and gland plates

● **7.3.4.3.1** If specified, or if recommended by the seal manufacturer, a tangential barrier fluid outlet shall be provided for Category 1 and Category 2 seal assemblies. A tangential barrier fluid outlet is required for Category 3 seals.

NOTE Using a tangential barrier fluid outlet connection will increase barrier fluid flow if an internal pumping ring is used. However, a tangential outlet is best applied if a radial-pumping ring is used and installed in the same plane as the outlet connection.

7.3.5 Non-contacting seal configurations with a gas barrier fluid (3NC-FB, 3NC-FF, 3NC-BB)

7.3.5.1 Standard seal types and arrangements

7.3.5.1.1 The standard seal shall be a back to-back (3NC-BB) configuration (Figure 6).

● **7.3.5.1.2** If specified, a face-to-face (3NC-FF) or a face-to-back (3NC-FB) configuration may be provided (Figure 6).

NOTE 1 The majority of installations for pressurized gas lubricated non-contacting seals are used by the chemical industry. Seal manufacturers have standard designs that can be assembled in either a face-to-face or a back-to-back arrangement.

NOTE 2 The installed population of series configuration pressurized gas lubricated non-contacting seals (3NC-FB) is small relative to the other configurations (3NC-FF and 3NC-BB).

8 Accessories

8.1 Auxiliary piping systems

8.1.1 Auxiliary systems are defined as piping systems that are in the following services:

a) Group I (mechanical seal flush/cooling systems):

   1) process flush;
   2) dual seal barrier/buffer fluid;
   3) drains and vents; or
   4) barrier/buffer gas.

b) Group II (quench systems):

   1) steam injection or quench;
   2) water injection or quench;
   3) drains and vents; or
   4) inert gas quench.

c) Group III (cooling-water systems):

   1) cooling water; or
   2) drains and vents.

Auxiliary systems shall comply with the requirements of Table 4.

Table 4 — Minimum requirements for auxiliary piping materials

System	Group I		Group II		Group III	
	Nonflammable/ Nonhazardous	Flammable/ Hazardous	≤ 500 kPa (≤ 75 psig)	> 500 kPa (> 75 psig)	Standard (≤1 NPS)	Optional (≥ 1-1/2 NPS)
Pipe	Seamless[a]	Seamless[a]	Seamless[a]	Seamless[a]	—	ASTM A120 Schedule 40 galvanized to ASTM A 153
Tubing[c]	Seamless ASTM A 269 Type 316 stainless steel	Seamless ASTM A 269 Type 316 stainless steel	Seamless ASTM A 269 Type 316 stainless steel	Seamless ASTM A 269 Type 316 stainless steel	Seamless ASTM A 269 Type 316 stainless steel	— stainless steel
All valves	Class 800	Class 800	Class 800	Class 800	Class 200, bronze	Class 200, bronze
Gate and globe valves	Bolted bonnet and gland	Bolted bonnet and gland	Bolted bonnet and gland	Bolted bonnet and gland	—	—
Pipe fittings and unions	Forged, Class 3000	Forged, Class 3000	Forged, Class 3000	Forged, Class 3000	—	ASTM A 338 and A 197, Class 150 malleable iron, galvanized to ASTM A 153
Tube fittings	Manufacturer's standard	Manufacturer's standard	Manufacturer's standard	Manufacturer's standard	Manufacturer's standard	—
Fabricated joints ≤1 NPS	Threaded	Socket Welded	Threaded	Socket Welded	Threaded	Threaded
Fabricated joints ≥ 1-1/2 NPS	—	—	—	—	—	Purchaser to specify
Gaskets	Type 304 or 316 stainless steel, spiral wound	Type 304 or 316 stainless steel, spiral wound	Type 304 or 316 stainless steel, spiral wound	Type 304 or 316 stainless steel, spiral wound	—	—
Flange bolting	ASTM A 193, Grade B7 ASTM A 194, Grade 2H	ASTM A 193, Grade B7 ASTM A 194, Grade 2H	ASTM A 193, Grade B7 ASTM A 194, Grade 2H	ASTM A 193, Grade B7 ASTM A 194, Grade 2H	—	—

NOTES
1. Carbon steel piping shall conform to ASTM A 53, Grade B; ASTM A 106, Grade B; ASTM A 524; or API Specification 5L, Grade A or B. Carbon steel fittings, valves and flanged components shall conform to ASTM A 105 and A 181.
2. Stainless steel piping shall be seamless in accordance with ASTM A 312, Type 316L. Stainless steel fittings, valves and flanged components shall conform to ASTM A 182, Type 316L.

[a] Schedule 80 for diameters from 1/2 NPS to 1-1/2 NPS; Schedule 40 for diameters 2 NPS and larger.

[b] Acceptable tubing sizes are (ref ISO 4200), 12.7 mm dia X1.66 mm wall (1/2-inch dia x 0.065-inch wall), 19 mm dia x 2.6 mm wall (3/4-inch dia x 0.095-inch wall), 25 mm dia x 2.9 mm wall (1-inch dia x 0.109-inch wall), 25 mm dia x 2.9 mm wall (1-inch dia x 0.109-inch wall).

8.1.2 Auxiliary piping systems shall include tubing, piping, isolating valves, control valves, relief valves, temperature gauges and thermowells, pressure gauges, sight flow indicators, orifices, barrier/buffer fluid reservoirs, and all related vents and drains.

8.1.3 The supplier specified on the data sheet shall furnish all auxiliary piping systems, including mounted appurtenances, located within the confines of the associated pump's base area, any barrier/buffer fluid reservoir base area, or any auxiliary base area. If piping is furnished, it shall terminate with flanged connections at the edge of the base. The purchaser shall furnish only interconnecting piping or tubing between equipment groupings and off-base facilities.

● **8.1.4** If specified, the arrangement of the equipment, including piping and auxiliaries, shall be developed jointly by the purchaser and the vendor. The arrangement shall provide adequate clearance areas and safe access for operation and maintenance.

8.1.5 Unless otherwise specified, seamless tubing shall be furnished in accordance with Table 4 for all auxiliary systems.

8.1.6 Piping design and joint fabrication, examination, and inspection shall comply with ASME B31.3. Welding shall be performed by operators and procedures qualified in accordance with ASME IX.

8.1.7 The mechanical design of auxiliary tubing or piping systems shall achieve the following:

a) proper support and protection to prevent damage from vibration or from shipment, operation, and maintenance;

b) proper flexibility and normal accessibility for operation, maintenance, and thorough cleaning;

c) installation in a neat and orderly arrangement adapted to the contour of the machine without obstructing access openings;

d) elimination of air pockets by the use of valved vents or non-accumulating piping arrangements.

e) complete drainage through low points without disassembly of piping, seal, or gland plate components.

f) reduction of the number of potential emission sources and pressure drop by minimizing the use of threaded connections, flanges, fittings, and valves; and

g) the system should be suitable for any special cleaning/decontamination procedures identified by the purchaser (i.e., steam cleaning, solvent wash, etc.).

8.1.8 Piping shall be fabricated by bending and welding to minimize the use of flanges and fittings where practical. Welded flanges are permitted only at equipment connections, at the edge of any base, and for ease of maintenance. The use of flanges at other points is permitted only with the purchaser's specific approval. Other than tees and reducers, welded fittings are permitted only to facilitate pipe layout in congested areas. Threaded connections shall be held to a minimum. Pipe bushings shall not be used.

8.1.9 Pipe shall have tapered threads in accordance with ASME B1.20.1 or ISO 228-1. Flanges shall be in accordance with ASME B16.5 or ISO 7005-1 . Slip-on flanges may be used only with the purchaser's specific approval. For socket-welded construction, a 1,5 mm ($^1/_{16}$ in.) gap shall be left between the pipe end and the bottom of the socket.

8.1.10 Connections, piping, valves, and fittings that are 30 mm (1 $^1/_4$ in.), 65 mm (2 $^1/_2$ in.), 90 mm (3 $^1/_2$ in.), 125 mm (5 in.), 175 mm (7 in.), or 225 mm (9 in.) in size shall not be used.

8.1.11 Piping, components, and appurtenances in Group I service shall have a pressure-temperature rating at least equal to the maximum allowable working pressure and temperature of the pump casing to which the system will be attached, but in no case shall they be suitable for absolute pressures less than:

a) Category 1: 22 bar (315 psia) at ambient temperature ;

b) Category 2 and Category 3: 42 bar (615 psia) at ambient temperature.

8.1.12 All components in contact with the process fluid during normal operating conditions shall be of a material having a corrosion/erosion resistance equal or better than the pump casing for the specified process fluid.

8.1.13 Special requirements for piping, flanges, gaskets and O-rings, valves, and other appurtenances in special and/or hazardous service will be specified by the purchaser.

8.1.14 The purchaser shall specify if chlorides are present in a concentration above 10 mg/kg (ppm wt). Caution should then be used in applying stainless steel due to the potential for chloride stress corrosion cracking.

8.1.15 The minimum size of any connection or piping shall be 13 mm ($^1/_2$ in.) nominal pipe size. Gland plate connections shall be in accordance with 6.1.2.17.

8.1.16 Piping systems furnished by the vendor shall be fabricated, installed in the shop, and properly supported. Bolt holes for flanged connections shall straddle lines parallel to the main horizontal or vertical centerline of the equipment.

8.1.17 Tapped openings not connected to piping shall be plugged in accordance with 6.1.2.18.

8.1.18 For pressure ratings above ASME Class 900, block valves shall be of welded-bonnet or no-bonnet construction with bolted gland; these valves shall be capable of being repacked under pressure.

8.1.19 Pressure gauges shall have block-bleed valves.

8.2 Mechanical seal flush/cooling systems (Group I)

8.2.1 The purchaser and the mechanical seal manufacturer shall mutually agree as to which auxiliary seal flush plan or plans (refer to Figure D.1 through Figure D.25) shall be furnished to meet the seal chamber pressure and temperature requirements of 6.1.2.14.

8.2.2 Only mechanically-forced seal flush and barrier/buffer fluid systems shall be provided. Systems that rely only on a thermo-syphon to maintain circulation during normal operation shall not be used (see 8.6).

8.2.3 Seal systems that utilize internal circulating devices, such as a pumping ring, and rely on the rotation of the mechanical seal to maintain circulation shall be designed with the inlet at the bottom of the seal and the outlet at the top of the seal as space allows.

NOTE This requirement enhances venting, and thermo-syphoning when the pump shaft is not rotating.

8.2.3.1 To allow removal of all trapped gas, these systems shall be provided with a vent at their highest point.

8.2.3.2 An austenitic stainless steel tag shall be securely fastened to all coolers provided with seal flush Plan 23. In letters a minimum of 6 mm ($^1/_4$ in.) high, this tag shall read: "IMPORTANT: ALL TRAPPED GAS MUST BE VENTED FROM THIS SYSTEM PRIOR TO OPERATION TO PREVENT DAMAGE TO THE MECHANICAL SEAL."

8.3 Quench systems (Group II)

● If specified, or if required by the seal manufacturer, an external quench (see Figure D.19 and Figure D.20) shall be provided to the seal gland plate in accordance with the following:

a) the design shall direct the quench to the seal face and secondary seals;

b) seals equipped with a water quench shall be designed to allow quench water to exit via the drain connection; and

NOTE 1 Quenching is the introduction of a medium, usually water, nitrogen, or steam, on the atmospheric side of a mechanical seal assembly. Quenching is normally applied where the material being sealed is noxious, flammable, oxidizes, polymerizes, or will crystallize when dried. A quench may also be used for heating or cooling. The gland plate is equipped with a throttle bushing to prevent moisture or steam leakage from a quenched seal from entering the bearing housing and contaminating the lubricating oil, and to maximize containment of the quench fluid.

c) if a steam quench is specified and if space allows, the seal gland plate shall be equipped with an anti-coking baffle.

NOTE 2 This baffle directs the steam to the area where coke would tend to collect and routes the steam to carry material away from the seal and seal faces. By cooling the leakage on the atmospheric side of the seal faces a steam quench prevents coke formation and subsequent seal hang-up in hot [above 150°C (300°F)] services. It also keeps viscous stocks thin when the pump is not running. If stocks thicken at the faces, seals may be damaged at start-up. Condensation collecting at the seal faces may vaporize and damage the seal faces.

8.4 Cooling-water systems (Group III)

8.4.1 The cooling-water system shall be designed for the conditions specified in Table 5. Provisions shall be made for complete venting and draining of the system.

Table 5 — Conditions affecting cooling water system design

Condition	Value
Velocity over heat exchange surfaces	1,5 – 2,5 m/s (5 – 8 ft/s)
Maximum allowable working pressure, gauge	5,2 bar (75 psi)
Test pressure, gauge	8 bar (115 psi)
Maximum pressure drop	1 bar (15 psi)
Maximum inlet temperature	32°C (90°F)
Maximum outlet temperature	49°C (120°F)
Maximum temperature rise	17°C (30°F)
Fouling factor on water side	0,35 m^2.K/kw (0,002 hr-ft^2-°F/Btu)
Shell corrosion allowance[1)]	3 mm (0,125 in.)
1) Not applicable for piping	

● **8.4.2** If specified, galvanized pipe shall be used.

● **8.4.3** If specified, sight flow indicators (open or closed as specified) shall be furnished in each outlet line.

● **8.4.4** If specified, each utility such as air and inert gas supply, cooling water supply and return lines, and others as specified shall be manifolded to a common connection. The manifold shall be sized to handle the maximum flow through all components which may require simultaneous use of the specified utility.

8.5 Accessories and auxiliary system components

8.5.1 Cyclone separator

8.5.1.1 Unless otherwise specified, the seal flush system shall be designed so that the cyclone separator is the flow limiting device.

8.5.1.2 Cyclone separators shall be selected to optimize removal of solids for a specific pump stage differential. If the pressure differential exceeds the cyclone separator design differential, a flow orifice may be used. Cyclone separators shall not be used with a pressure differential less than 1,7 bar (25 psi).

NOTE 1 In order to effectively remove solids from the flush stream, the solids should have a density of at least twice that of the fluid. Some common materials frequently found in refinery process streams and their following approximate densities are listed in Table 6. Therefore, for most hydrocarbon services where, except for initial start-up, the most likely solid contaminate is coke, a cyclone separator would most likely be ineffective. However, for inlet water pumps, taking suction from a river, bay, or well, a cyclone separator may work if properly installed. Many users, however, specify cyclones for all pumps based on the assumption that during construction and major unit overhauls, debris, such as weld beads, sand, and stones, may get into the piping that would cause a seal failure during start-up.

NOTE 2 The efficiency of separation (percentage of solids carried over) of a cyclone also depends on differential pressure and particle size. As the differential pressure across the cyclone varies (increases or decreases) from the design differential, the separation efficiency usually is reduced. As the size decreases, separation efficiency also decreases.

Table 6 — Approximate densities of materials found in process streams

Substance	Density kg/m^3 (lb/ft^3)
Cement, sand, stone	2307 (144)
Clay	1762 (110)
Coke	513 (32)
Earth (mud)	1538 (96)
Gasoline (Sp. Gr. = 0.7)	721 (45)
Glass	2595 (162)
Kerosene	801 (50)
Limestone	2355 (147)
Paraffin	897 (56)
Sand	2018 (126)
Steel	7801 (487)
Sulphur	2002 (125)
Tar	1201 (75)
Water	993 (62)
Wood (pine)	432 (27)

8.5.1.3 For between bearing pumps, a separate cyclone separator shall be provided for each mechanical seal.

8.5.1.4 Unless otherwise specified or required by 8.1.12, cyclone separators shall be austenitic stainless steel.

8.5.2 Flow control orifice

8.5.2.1 The number and location of flow control orifices needed shall be determined by the vendor specified to furnish the auxiliary piping system, as specified in 8.1.3.

NOTE An orifice may be required in the seal flush system solely, or in conjunction with a throat bushing and/or cyclone separator to : a) Limit the seal flush circulation rate to the seal, b) control the seal chamber pressure.

● **8.5.2.2** Unless otherwise specified, if tubing is supplied, a blind/orifice tubing connector or connectors shall be supplied. If piping is specified, a plate orifice or orifices shall be furnished and mounted in the auxiliary piping between a pair of flanges. Orifice unions shall not be used.

8.5.2.2.1 All orifices shall have a minimum bore of 3 mm ($^1/_8$ in.).

NOTE Orifice bores of a diameter of less than 3 mm ($^1/_8$ in.) become blocked more easily and may cause a seal failure.

8.5.2.2.2 Unless otherwise specified, or required by 8.1.12, orifice plates shall be fabricated from austenitic stainless steel having a tang that extends beyond the outside diameter of the flange. The tang shall be stamped with the bore diameter, line size, and plate material.

8.5.2.3 If multiple orifices are required, they shall be mounted in series, at least 150 mm (6 in.) apart.

NOTE Multiple orifices, installed in series, can be used if more pressure drop is required than can be taken in a single 3 mm ($^1/_8$ in.) orifice.

● **8.5.2.4** If specified, an orifice nipple (not an orifice union) shall be furnished at the pump discharge and/or suction nozzle to restrict leakage in the event of an auxiliary system pipe or component failure.

8.5.3 Seal flush coolers

8.5.3.1 External seal flush coolers mounted in the seal flush piping may be considered as a viable means of creating the required product temperature margin (see 6.1.2.14.1). When furnished, external seal flush coolers shall be in accordance with 8.5.3.1.1 through 8.5.3.1.7. Requirements for coolers mounted within or integral to barrier/buffer fluid reservoirs are covered in 8.5.4.5.

8.5.3.1.1 Seal flush coolers shall be sized for the seal manufacturer's recommended seal flush flow rates but shall not be sized for less than 8 l/min (2 gpm) per seal.

8.5.3.1.2 Unless otherwise specified, seal flush coolers shall be arranged with the seal flush fluid on the tube side and the cooling water on the shell side.

NOTE The user should design the cooler system to avoid shell overpressurization resulting from the water side being blocked in while high temperature process fluid is passing through the tubes. This can be accomplished through adequate pressure rating of the shell, the addition of pressure relief protection, or operating procedures.

8.5.3.1.3 Cooling water lines should be heat traced in freezing climates.

● **8.5.3.1.4** If specified or required by local code, the seal flush coolers shall be designed, fabricated, and inspected in accordance with ASME B31.3 using piping components.

8.5.3.1.5 Unless otherwise specified, for shaft sizes over 60 mm (2,5 in.), tubes shall be $^3/_4$ in. with 0,095 in. wall minimum size; For shaft sizes 60 mm (2,5 in.) and below, tubes shall be $^1/_2$ in. with 0,065 in. wall minimum size. As a minimum, for all sizes, unless otherwise required by 8.1.12, the tubes shall be austenitic stainless steel and the shell shall be carbon steel.

8.5.3.1.6 The seal flush cooler shall be arranged for complete draining and venting of both the water and process sides. A drain valve (not just a plug) shall be mounted at the lowest point on the shell side.

8.5.3.1.7 For all between bearing pumps, a separate external seal flush cooler shall be provided for each mechanical seal.

8.5.4 Barrier/buffer fluid reservoirs

8.5.4.1 If a barrier/buffer fluid reservoir is specified, the purchaser and the mechanical seal manufacturer shall mutually agree on the sizing, instrumentation requirements, fluid selection, and general arrangement.

● **8.5.4.2** Unless otherwise specified, the barrier/buffer fluid reservoir shall be arranged in accordance with 8.5.4.2.1 through 8.5.4.2.8 (see Figures D.26 and D.27).

8.5.4.2.1 A separate reservoir shall be furnished for each mechanical seal.

8.5.4.2.2 The barrier/buffer fluid reservoir shall be mounted on a substantial support furnished by the manufacturer specified on the data sheet and should not be affected by pump vibration (see 8.1.3).

8.5.4.2.3 The height of the normal liquid level (NLL) in the barrier/buffer fluid reservoir above the gland plate of the associated pump shall be established by the seal manufacturer. It shall not be less than 1 m (3 ft). It shall be based on required flow rate, barrier/buffer fluid ambient conditions, reservoir location, system hydraulic resistance, and the positive circulating device's head versus flow performance characteristics and net positive suction head requirements.

8.5.4.2.4 In order to reduce the pressure drop within the system, the length of the lines and the use of fittings between the reservoir and seal gland plate shall be minimized. All lines shall slope up from the pump gland to the reservoir at a minimum of 10 mm per 240 mm ($^1/_2$ in. per ft), using smooth long radius bends.

NOTE Barrier/buffer fluid reservoirs should be located as close to the pump as possible while leaving sufficient room for operation and maintenance. Reservoirs should not be located directly above the pump and should not be affected by pump vibration. Hot lines should be insulated as necessary for safety.

8.5.4.2.5 Unless otherwise specified, the reservoir shall be provided with a valved high point vent and an independent fill connection. A method of filling the reservoir shall be considered during the engineering phase of a project to install external barrier/buffer fluid reservoirs. Provide a means to fill the seal reservoir under pressure (to prevent a pressure reversal for barrier fluid applications). A closed fill system, one which enables the operator to fill the reservoir without exposure to the barrier/buffer fluid, should be considered. Manual filling is discouraged. It should be possible to fill the reservoir from grade level for safety and operability. A system that requires the use of a ladder or step is unacceptable. Whatever system is incorporated, adequate instrumentation and pressure relief protection shall be provided to prevent the inadvertent over-pressurization of the reservoir or the system. These systems are normally in the user's scope of supply but can often be supplied by the seal or pump supplier upon request. Some examples include:

a) a centrally located tank which is hard piped to various reservoirs and/or day tanks utilizing gravity fill, a transfer pump, or inert gas pressure to transfer the barrier/buffer fluid;

b) a hand pump which can be connected to a day tank or drum with a hose or removable spool piece; or

c) a small vessel, located adjacent to the reservoir, which can be pressured with an inert gas to force the barrier/buffer fluid into the reservoir.

NOTE 1 When designing the vent piping to a vapor recovery system, the purchaser should take into account the potential for condensation of hydrocarbon vapors from other sources connected to that system. Additional condensation collection vessels and/or heat tracing of the vent lines may be required to avoid build-up of a static liquid head in the vent piping and the possible contamination of the barrier/buffer fluid.

NOTE 2 Disposal of contaminated fluid shall be considered in the design of the barrier/buffer fluid reservoir installation. Any hardware required to accomplish this should be included in the system design.

8.5.4.2.6 Unless otherwise specified flow orifices shall be provided and will be in accordance with 8.5.2.

NOTE Frequently, buffer fluid reservoirs are continuously vented to a vapor recovery system. A flow control orifice, sized specifically for the system, is normally installed in the vent line to restrict the flow from the reservoir and to provide a back pressure on it.

● **8.5.4.2.7** Unless otherwise specified, the reservoir shall be equipped with a pressure switch and a pressure gauge sensing the vapor space above the high liquid level (HLL) in the reservoir. The purchaser shall specify if the switch shall alarm on an increasing (high) pressure or a decreasing (low) pressure.

NOTE Arrangement 2 seals equipped with a buffer fluid reservoir normally utilize a high pressure alarm indicating that the primary seal has failed. Arrangement 3 seals equipped with a barrier fluid reservoir normally utilize a low pressure alarm indicating a drop or loss of barrier fluid pressure.

● **8.5.4.2.8** Unless otherwise specified, the reservoir shall be equipped with a low level alarm (LLA) switch. If specified, a high level alarm (HLA) switch shall be provided.

8.5.4.3 Unless otherwise specified, the reservoir shall be designed to meet the sizing criteria of 8.5.4.3.1 through 8.5.3.2.7 (see Figures D.26 and D.27).

8.5.4.3.1 The volume of liquid in the reservoir, at NLL, shall be a minimum of:

a) 12 l (3 gal) for shaft diameters 60mm (2,5 in.) and smaller;

b) 20 l (5 gal) for shaft diameters larger than 60 mm (2,5 in.).

8.5.4.3.2 The NLL shall be at least 150 mm (6 in.) above the LLA point.

NOTE A distance of 150 mm (6 in.) allows a convenient visual reference.

8.5.4.3.3 The volume of the vapor space in the reservoir above the NLL shall be equal to or greater than the liquid volume between the NLL and the low level alarm (LLA) point.

NOTE The requirements in 8.5.4.3.2 and 8.5.4.3.3 provide adequate volume to allow for fluctuations in level while ensuring adequate vapor space above the liquid.

8.5.4.3.4 The high liquid level (HLL) alarm point, if furnished, shall be at least 50 mm (2 in.) above the NLL.

NOTE A distance of 50 mm (2 in.) minimizes the amount of leaked product entering the reservoir while providing sufficient volume to prevent spurious alarms due to normal fluctuations in levels.

8.5.4.3.5 The low level alarm point shall be at least 50 mm (2 in.) above the top of the return connection.

NOTE The level specified in 8.5.4.3.5 allows the level to fluctuate but still cover the return nozzle.

8.5.4.3.6 The barrier/buffer return (inlet) to the reservoir shall be at least 250 mm (10 in.) above the barrier/buffer supply (outlet) connection.

8.5.4.3.7 The barrier/buffer supply (outlet) from the reservoir shall be a minimum of 50 mm (2 in.) above the bottom of the reservoir. In addition, a valved drain connection, orientated to allow complete draining, shall be provided at the bottom of the reservoir.

NOTE Having the supply line come off the reservoir above the bottom prevents any particulate that may have settled out in the reservoir from being carried into the mechanical seal. Alternative designs which exit at the bottom of the reservoir and use an internal to the reservoir stand–pipe are acceptable.

8.5.4.4 The barrier/buffer fluid reservoir shall be fabricated in accordance with 8.5.4.4.1 through 8.5.4.4.8.

● **8.5.4.4.1** The standard reservoir shall be in accordance with Figure D.26. If specified, the reservoir shall be in accordance with Figure D.27.

8.5.4.4.2 The reservoir is part of the pump piping system. Unless otherwise specified or required by local code, the reservoir shall be designed, fabricated, and inspected in accordance with ASME B31.3 using piping components.

8.5.4.4.3 Unless otherwise specified:

a) 12 l (3 gal) reservoirs shall be fabricated from DN 150 (NPS 6) schedule 40 pipe; and

b) 20 l (5 gal) reservoirs shall be fabricated from DN 200 (NPS 8) schedule 40 pipe.

NOTE If the reservoir is built entirely of piping components, ASME B31.3 can be applied and provides adequate design for the reservoir just as it does for the pump suction and discharge piping. It is the user's responsibility to ensure that local codes do not require that reservoirs be built in accordance with ASME VIII, Division 1.

8.5.4.4.4 A nameplate, stamped with the MAWP, hydrostatic test pressure, and the minimum and maximum allowable temperature, shall be permanently attached to the reservoir.

8.5.4.4.5 Unless otherwise specified, the barrier/buffer fluid reservoir level gauge shall be a reflex, weld pad with a visible range extending from below the low level alarm point to at least 75 mm (3 in.) above the NLL or, if furnished, 25 mm (1 in.) above the high level alarm point, whichever is greater. Permanent marking to indicate normal level shall be provided.

8.5.4.4.6 Unless otherwise specified, the barrier/buffer fluid reservoir and any piping or components welded directly to the reservoir shall be AISI 316 L stainless steel.

8.5.4.4.7 The seal manufacturer shall confirm that the temperature at the exit of the orifice in the vent line from the reservoir is above the nil ductility transition temperature for the materials of construction. The effects of barrier/buffer fluid temperature and autorefrigeration of leakage across the orifice shall be reviewed to determine the design temperature of the components.

8.5.4.4.8 Unless otherwise specified, lines connecting the barrier/buffer fluid reservoir to the mechanical seal shall be austenitic stainless steel tubing in accordance with Table 4 and below:

a) 12 mm ($^{1}/_{2}$ in.) minimum, for shaft diameter 60 mm (2,5 in.) and smaller; and

b) 18 mm ($^{3}/_{4}$ in.) minimum, for shaft diameter greater than 60 mm (2,5 in.), if practical.

● **8.5.4.4.9** If specified, schedule 80, austenitic stainless steel pipe in accordance with Table 4 and below shall be provided:

a) 12 mm ($^{1}/_{2}$ in.) minimum, for shaft diameter 60 mm (2,5 in.) and smaller; and

b) 18 mm ($^{3}/_{4}$ in.) minimum, for shaft diameter greater than 60 mm (2,5 in.), if practical.

8.5.4.4.10 Unless otherwise specified, all connections to the reservoir shall be threaded.

8.5.4.5 Unless otherwise specified, the barrier/buffer fluid reservoir shall be equipped with a cooling coil in accordance with 8.5.4.5.1 through 8.5.4.5.5.

8.5.4.5.1 The thermal sizing criteria for the cooling coil shall be provided by the seal manufacturer (refer to 8.4.1). The seal manufacturer shall confirm that the selected reservoir cooling coil will meet the expected thermal duty requirements at the site utility conditions specified on the data sheets.

NOTE 1 While it is expected that there will be standard size cooling coils based on the length of the reservoir, the seal manufacturer needs to take into account several factors when specifying the minimum cooling coil size needed. These include internal circulating device or external circulator flow rates, the need for thermo-syphon, cooling liquid parameters, and characteristics of the barrier/buffer fluid.

NOTE 2 Investigate the use of other cooling media if ambient conditions do not allow the use of water due to freezing potential or if the available cooling water is of very poor quality and prone to fouling.

8.5.4.5.2 The coil shall be mounted internally to the reservoir such that the top of the coil is below the bottom of the return (inlet) connection. The cooling liquid shall be on the tube side.

8.5.4.5.3 The tubes shall be austenitic stainless steel, 12 mm ($^1/_2$ in.) with minimum wall thickness of 1,6 mm (0,065 in.). No tubing connectors, fittings, or seams mounted internal to the reservoir are allowed.

8.5.4.5.4 Reservoirs equipped with cooling coils that will not be used in the field installation shall have the cooling water inlet and outlet connection plugged in accordance with 6.1.2.18.

8.5.4.5.5 The cooling coil shall be arranged so that it can be completely drained.

8.5.5 Barrier/buffer fluid selection criteria

8.5.5.1 The purchaser shall specify on the data sheets the characteristics of the barrier/buffer fluid (refer to annex A, Sheet 10 of the recommended selection procedure).

● **8.5.5.2** If specified, the seal and/or pump manufacturer shall review the purchaser's selection of a barrier/buffer fluid.

8.6 Barrier/buffer fluid and seal flush positive circulating devices

8.6.1 General

● If dual wet seals or a single seal with a Plan 23 are specified, a positive circulating arrangement, such as an internal circulating device, an external circulating pump, or a flow-through system from an external source, is required to ensure positive circulation of the barrier/buffer fluid or seal flush to the seal. The purchaser shall specify which type of circulating device is to be provided.

8.6.2 Internal circulating device

● **8.6.2.1** The internal circulating device shall provide the required flowrate using the specified barrier/buffer fluid, at all operating and start-up conditions based upon the accessory components supplied and the maximum installation criteria in Figure D.28 and Figure D.29.

NOTE This needs to be looked at very carefully for pump speeds of 1 800 r/min or less and those equipped with variable speed drivers.

● **8.6.2.2** For Category 3 or if specified, the seal manufacturer shall provide the head versus flow performance curve for the internal circulating device based on actual test results.

8.6.2.3 The radial clearance between the rotating element of a circulation device and stationary component, seal chamber bore or containment chamber bore shall not be less than 1,5 mm ($^1/_{16}$ in.).

8.6.2.4 Designs of mechanical seals utilizing internal circulating devices shall ensure that the device's inlet and outlet ports properly align with the barrier/buffer fluid or seal flush supply and return connections when installed in the seal chamber.

8.6.3 External circulating pump

● **8.6.3.1** If specified, or if an internal circulating device cannot be provided to meet desired flow, an external forced circulation pump will be required. Circulation pump selection shall be mutually agreed upon by the purchaser and the seal manufacturer.

NOTE Where a failure of the external circulating pump could potentially result in a failure of the mechanical seal in the main pump, an interlock between the circulating pump and the main pump should be considered.

8.6.3.2 Electrical equipment shall comply with NFPA 70, Articles 500-502, or IEC 60079 for the hazardous area classification specified by the purchaser.

8.6.4 External seal flush systems

● **8.6.4.1** If an external source of seal flush fluid is specified (Figure D.11 and Figure D.18) the purchaser shall specify the fluid characteristics. The seal manufacturer shall specify the volume, pressure, and temperature required, where these are factors.

● **8.6.4.2** If specified, the seal and/or pump manufacturer shall review the purchaser's selection of external flush fluid.

NOTE Inappropriate selection of flush fluid or excessive flush rates may affect pump performance.

8.6.5 Condensate collection reservoir

8.6.5.1 If a condensate collection system is provided, the system shall comply with 8.6.5.2 to 8.6.5.7 (see Figure D.24).

8.6.5.2 The condensate collection reservoir:

a) shall be at least 200 mm (8 in.) diameter carbon steel, schedule 40, and 12 l (3 gal) minimum capacity in accordance with 8.5.4.4.2, 8.5.4.4.4 and Table 4. For pumps manufactured from a material other than carbon steel, the reservoirs shall be of the same material as the pump casing, or one with superior corrosion resistance and mechanical properties to the material used for the pump casing (in the specified process fluid);

b) shall have at least one flanged end cover for internal maintenance access;

c) shall be fitted with a level gauge mounted on the flanged end cover;

d) have a $^3/_4$ NPT minimum drain connection that terminates with a fully ported globe valve; and

e) have a $^1/_2$ NPT minimum vent connection to which piping for the primary seal leakage detection pressure switch, pressure gauge and restriction orifice is installed.

● **8.6.5.3** If specified, a high level switch shall be provided.

● **8.6.5.4** If specified, a test connection shall be installed for injection of nitrogen to test containment seal and/or purge collector.

8.6.5.5 Purchaser shall provide any additional requirements for drain disposition.

8.6.5.6 All components between the containment seal chamber connection and the condensate collection reservoir drain globe valve and vent restriction orifice shall be considered pressure containing parts and hydrostatically tested according to 10.3.2.

8.6.5.7 The line from the gland plate to the collector shall slope a minimum of 42 mm/m ($^1/_2$ in./ft) towards the collector. The line shall be DN 15 (NPS $^1/_2$) minimum.

● **8.6.5.8** If leakage can solidify at ambient temperatures, the collector lines shall be heat traced and insulated. If specified, the purchaser shall identify type and specification for heat tracing.

8.6.6 Barrier/buffer gas supply systems

8.6.6.1 If a barrier/buffer gas system is specified, the purchaser and the mechanical seal manufacturer shall mutually agree on the instrumentation requirements and general arrangement.

8.6.6.2 Barrier/buffer gas supply systems shall be provided by the seal supplier and include as a minimum a pressure regulator, coalescing filter, indicating flow meter, check valve, inlet and outlet isolation valves, low pressure switch and a pressure gauge (see Figure D.30).

8.6.6.3 The pressure regulator, gauge and switch shall be selected such that the normal operating pressure is in the middle third of the range. The minimum and maximum operating pressures shall also be within the range of the instrument.

8.6.6.4 A coalescing filter with a replaceable element or cartridge design shall be supplied and include a valved drain and liquid level indicator. The coalescing filter shall have an efficiency of 98,7% on particles less than or equal to 3 microns.

NOTE It is critical that the supply of gas be effectively filtered. Seal face grooves can easily be blocked. As the grooves become blocked, seal face separation decreases and rapid face wear can occur.

● **8.6.6.5** If specified, a high flow switch shall be provided and installed between the flow meter and the check valve (see Figure D.22 and Figure D.23).

9 Instrumentation

9.1 General

9.1.1 Unless otherwise specified, instrumentation and installation shall conform to this Standard.

9.1.2 Unless otherwise specified, controls and instrumentation shall be designed for outdoor installation and shall comply with NEMA 250 enclosure Type 4 or with IEC 60529 designation IP 56.

9.1.3 Controls and instrumentation shall be made of materials compatible with the environment and fluids to which they will be exposed. Special consideration shall be given to all controls and instrumentation exposed to the pumped fluid and barrier/buffer fluid (if any) such as level gauges and switches.

● **9.1.4** Instrumentation and controls shall be designed and manufactured for use in the area classification (class, group, and division or zone) specified.

9.1.5 All controls and instruments shall be located and arranged to permit easy visibility by the operators, as well as accessibility for tests, adjustments, and maintenance.

9.2 Temperature indicating gauges

9.2.1 Dial temperature gauges shall be heavy duty and corrosion-resistant. They shall be bi-metallic or liquid filled with a rigid stem suitable for mounting as needed. Mercury filled thermometers are not acceptable. Black printing on a white background is standard for gauges.

9.2.2 Dial temperature gauges shall be installed in pipe sections or in tubing runs as specified.

NOTE Auxiliary equipment may be either piping or tubing. Therefore, the owner shall specify whether gauges shall be placed in tubing or piping.

9.2.3 The sensing elements of temperature gauges shall be in the flowing fluid to the depth specified by the gauge manufacturer.

9.2.4 Temperature gauges installed in tubing shall be a minimum of 38 mm (1,5 in.) in diameter, and the stem shall be a minimum of 50 mm (2 in.) long. All other gauges shall be a minimum of 90 mm (3,5 in.) in diameter, and the stem shall be a minimum of 75 mm (3 in.) long.

NOTE The use of 90 mm (3,5 in.), instead of standard 125 mm (5 in.) is due to the normally small size of piping used in seal systems.

9.3 Thermowells

Temperature gauges that are in contact with flammable or toxic fluids or that are located in pressurized or flooded lines shall be furnished with separable threaded solid-bar thermowells made of austenitic stainless steel or another material more compatible with the liquid as defined by the manufacturer. Thermowells installed in piping shall be DN 15 (NPS $^1/2$) minimum. Thermowells for use in tubing shall be approved by the purchaser.

NOTE Thermowell designs and installation should not restrict liquid flow.

9.4 Pressure gauges

9.4.1 Pressure gauges shall conform to ASME B40.100, accuracy grade 2 A.

9.4.2 Pressure gauges (not including built-in instrument air gauges) shall be furnished with AISI 316 stainless steel bourdon tubes or other material more compatible with the liquid, stainless steel movements, and $^1/2$ in. NPT male alloy steel connections with wrench flats. Gauges installed in tubing shall have 64 mm (2,5 in.) diameter dials. Gauges not installed in tubing shall have 114 mm (4,5 in.) diameter dials [152 mm (6 in.) dials for the range over 55 bar (800 psi)]. Black printing on a white background is standard for gauges. Gauge ranges shall be selected so that the normal operating pressure is at the middle of the gauge's range. In no case, however, shall the maximum reading on the dial be less than the applicable relief valve setting plus 10%. Each pressure gauge shall be provided with a device such as a disk insert or blowout back designed to relieve excess case pressure.

● **9.4.3** If specified, oil filled gauges shall be furnished.

9.5 Switches

9.5.1 Alarm, trip and control switches

9.5.1.1 Each alarm switch, each shut-down switch, and each control switch shall be furnished in a separate housing located to facilitate inspection and maintenance. Unless otherwise specified, double pole, double throw switches with a minimum rating of 5 amperes at 120 volt AC and $^1/2$ ampere at 120 volts DC suitable for the electrical hazard area classification shall be used as a minimum. Mercury switches shall not be used.

9.5.1.2 Unless otherwise specified, electrical switches that open (de-energize) to alarm and close (energize) to trip shall be furnished.

9.5.1.3 Alarm and trip switch settings shall not be adjustable from outside the housing. Alarm and trip switches shall be arranged to permit testing of the control circuit, including, if possible, the actuating element, without interfering with normal operation of the equipment. If trip bypass functions are furnished in a vendor-supplied panel, the vendor shall provide a clearly visible light on the panel to indicate when trip circuits are in a test bypass mode. Unless otherwise specified, shutdown systems shall be provided with key lock switches or another suitable means to permit testing without shutting down the unit.

9.5.1.4 Unless otherwise specified or required in accordance with 8.1.12, pressure sensing elements shall be of austenitic stainless steel. Low pressure alarms, which are activated by falling pressure, shall be equipped with a valved bleed or vent connection to allow controlled depressurizing so that the operator can note the alarm set pressure on the associated pressure gauge. High-pressure alarms, which are activated by rising pressure, shall be equipped with valved test connections so that a portable test pump can be used to raise the pressure.

9.5.1.5 All switches sensing the same variable shall have re-set ranges such that changing the variable to re-set one switch does not activate other switches.

NOTE Level switches may have a dead band wide enough to activate other switches during re-setting. This is especially true when dealing with the small volumes associated with dual seal reservoirs.

9.5.2 Pressure switches

9.5.2.1 Pressure switches shall have over-range protection to the maximum pressure to which the switch may be exposed. Switches exposed to vacuum shall have under-range protection to full vacuum.

9.5.2.2 The measuring element and all pressure containing parts shall be AISI 316 stainless steel unless the pumped fluid requires the use of alternative materials as determined by the seal manufacturer. Unless otherwise specified, pressure switches shall be bellows or diaphragm. Connections for pressure input shall be $^{1}/_{2}$ in. NPT. Connections for air transmission signals shall be $^{1}/_{4}$ in. NPT.

● **9.5.2.3** If specified, pressure transmitters shall be furnished.

9.5.3 Level switches

9.5.3.1 Unless otherwise specified, level switches shall be hydrostatic, capacitance, or ultrasonic as indicated on the data sheet.

● **9.5.3.2** If specified, level transmitters shall be furnished .

9.5.4 Flow switches

9.5.4.1 Flow switches provided with buffer/barrier gas systems shall be inline, mechanically actuated, that respond to gas motion within the line, independent of system pressures.

● **9.5.4.2** If specified, flow transmitters shall be furnished.

9.6 Level indicators

9.6.1 The standard level indicator shall be the weld pad reflex design.

● **9.6.2** If specified, an externally mounted, removable, reflex indicator shall be furnished instead of the standard weld pad design.

9.7 Flow indicators

9.7.1 Flow indicators shall be armoured rotameter or internal magnetic float design in accordance with the following:

a) rotameters shall be installed in the vertical position and piped in accordance with the vendor's recommendations;

b) the capacity of the rotameter selected shall be such that normal flow rate falls in the middle one-third of the scale;

c) a check valve shall be installed on the outlet of the meter to prevent back flow; and

d) glass tube meters may only be used on air or inert gas at temperatures of 60°C (140°F) or less, and gauge pressures of 7 bar (100 psi) or less.

● **9.7.2** If specified, flow transmitters shall be furnished.

9.8 Relief valves

9.8.1 Unless otherwise specified, the manufacturer shall furnish the relief valves that are to be installed on equipment or in piping and tubing that the manufacturer is supplying. Other relief valves will be furnished by the purchaser. Relief valves for all operating equipment shall meet the limiting relief valve requirements defined in API RP 520, Parts I and II, and in API Standard 526. The manufacturer shall determine the size and set pressure of all relief valves related to the equipment. The manufacturer's quotation shall list all relief valves and shall clearly indicate those to be furnished by the manufacturer. Relief valve settings, including accumulation, shall take into consideration all possible types of equipment failure and the protection of piping systems.

9.8.2 Unless otherwise specified, relief valves shall have steel bodies.

● **9.8.3** If specified, thermal relief valves shall be provided for components that may be blocked in by isolation valves.

9.9 Regulators

Regulators for gas buffer and barrier systems shall be supplied in accordance with the following:

a) regulators shall be self-contained, spring-loaded with an internal pressure sensing connection;

b) the regulators shall be designed such that the regulated pressure is applied directly to the diaphragm through the valve body;

c) an adjusting device shall be provided with a locking mechanism to ensure that the control point cannot shift or be changed inadvertently;

d) the regulator body shall be rated for the maximum upstream and downstream pressure and temperature to which it may be subjected; and

e) cast iron valve bodies are not permitted — cast aluminum if approved by the purchaser is permitted only in air or nitrogen service; spring and diaphragm housings shall be steel or stainless steel.

9.10 Pressure amplifiers

A gas pressure booster shall be provided if necessary to increase utility gas supply pressure.

10 Inspection, testing, and preparation for shipment

10.1 General

10.1.1 Unless otherwise specified, the purchaser's representative shall have entry to all vendor and sub-vendor plants where manufacturing, testing, or inspection of the equipment is in progress.

10.1.2 The vendor shall notify sub-manufacturers of the purchaser's inspection and testing requirements.

10.1.3 The vendor shall provide sufficient advance notice to the purchaser before conducting any inspection or test that the purchaser has specified should be a witnessed test or an observed test.

● **10.1.4** The purchaser shall specify the extent of his participation in the inspection and testing. Unless otherwise specified, the vendor shall give the purchaser a minimum of 5 working days notice for all observed and witnessed tests.

10.1.5 Unless otherwise specified, the purchaser's representative shall have access to the manufacturer's quality control program for review.

10.1.6 Equipment for the specified inspection and tests shall be provided by the vendor.

●**10.1.7** If specified, the purchaser, the vendor, or both, shall verify compliance with this Standard, and initial and date a completed checklist . An example of an inspector's checklist is given in annex E.

10.2 Inspection

10.2.1 Pressure-containing parts shall not be painted until the specified inspection of the parts is completed.

● **10.2.2** In addition to the requirements of 6.1.6.10, the purchaser may specify the following:

a) parts that shall be subjected to surface and subsurface examination; and

b) the type of examination required, such as magnetic particle, liquid penetrant, radiographic, and ultrasonic examination.

10.2.3 If radiographic, ultrasonic, magnetic particle, or liquid penetrant inspection of welds or materials is required or specified, the criteria in 10.2.4 through 10.2.12 shall apply unless other criteria are specified by the purchaser. Welds, cast steel, and wrought material may be inspected in accordance with 10.2.4 through 10.2.12.

10.2.4 Radiography shall be in accordance with ASTM E 94 and ASTM E 142.

10.2.5 The radiographic acceptance standard used for welded fabrications shall be ASME VIII, Division 1, UW-52. The acceptance standard used for castings shall be ASME VIII, Division 1, Appendix 7.

10.2.6 Ultrasonic inspection shall be in accordance with ASME V, Articles 5 and 23.

10.2.7 The ultrasonic acceptance standard used for welded fabrications shall be ASME VIII, Division 1, Appendix 12. The acceptance standard used for castings shall be ASME VIII, Division 1, Appendix 7.

10.2.8 Both wet and dry methods of magnetic particle inspection shall be in accordance with ASTM E 709.

10.2.9 The magnetic particle acceptance standard used for welded fabrications shall be ASME VIII, Division 1, Appendix 6 and Appendix 25. The acceptability of defects in castings shall be based on a comparison with the photographs in ASTM E 125. For each type of defect, the degree of severity shall not exceed the limits specified in Table 7.

Table 7 — Maximum severity of defects in castings

Type	Defect	Maximum security level
I	Linear discontinuities	1
II	Shrinkage	2
III	Inclusions	2
IV	Chills and caplets	1
V	Porosity	1
VI	Welds	1

10.2.10 Liquid penetrant inspection shall be in accordance with ASME V, Article 6.

10.2.11 The liquid penetrant acceptance standard used for welded fabrications shall be ASME VIII, Division 1, Appendices 8 and 24. The acceptance standard used for castings shall be ASME VIII, Division 1, Appendix 7.

10.2.12 Regardless of the generalized limits in 10.2.4 through 10.2.11, it shall be the manufacturer's responsibility to review the design limits of the equipment in the event that more stringent requirements are necessary. Defects that exceed the limits imposed in 10.2.4 through 10.2.11 shall be removed to meet the quality standards cited, as determined by the inspection method specified.

10.2.13 During assembly of the system and before testing, each component (including cast-in passages of these components) and all piping and appurtenances shall be cleaned chemically or by another appropriate method to remove foreign materials, corrosion products, and mill scale.

●**10.2.14** If specified, the hardness of parts, welds, and heat-affected zones shall be verified as being within the allowable values by testing of the parts, welds, or zones. The method, extent, documentation, and witnessing of the testing shall be mutually agreed upon by the purchaser and the manufacturer.

10.3 Testing

The seal testing sequence is shown in Figure 27.

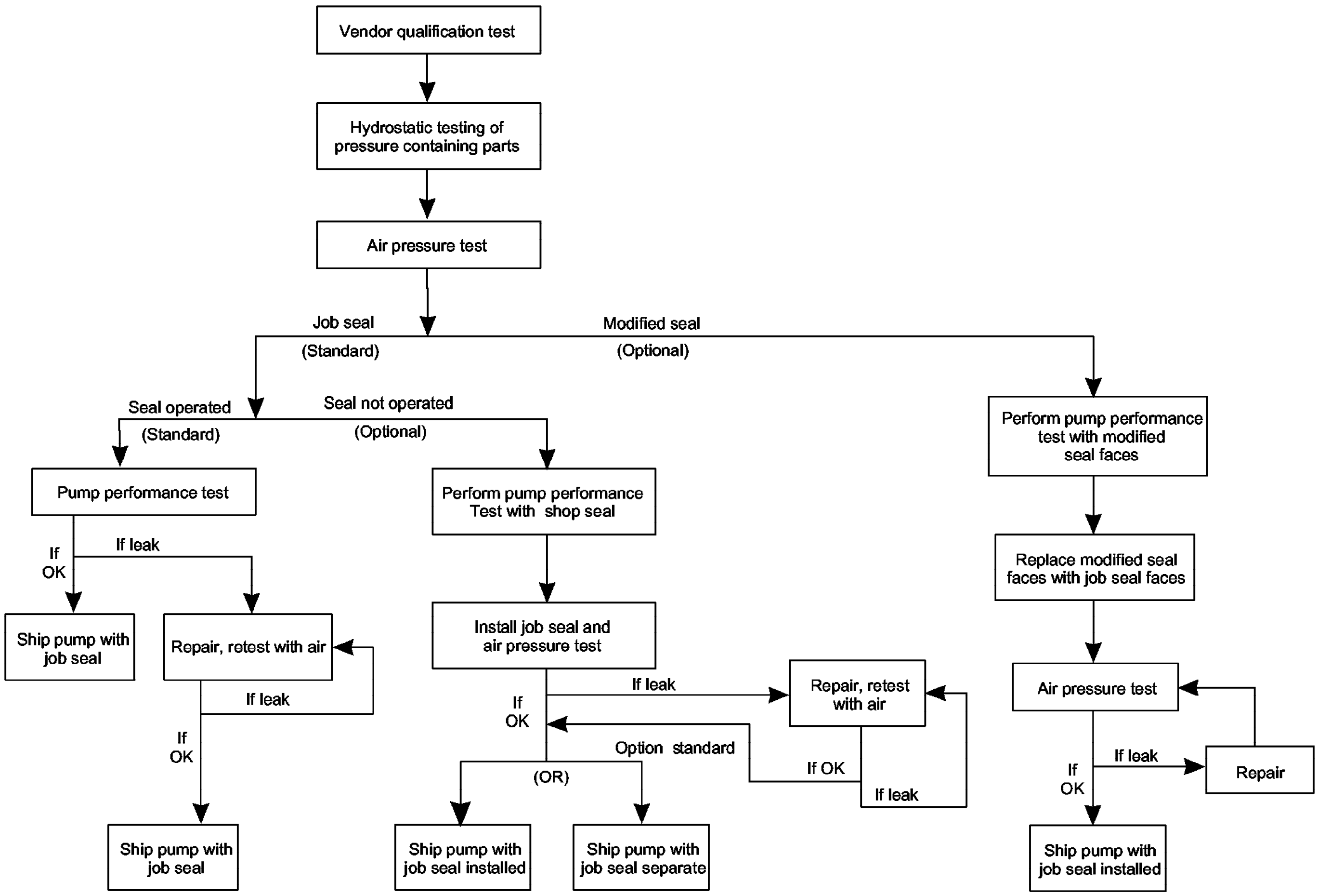


Figure 27 — Seal testing sequence

10.3.1 Seal manufacturer qualification testing

10.3.1.1 Purpose

10.3.1.1.1 In order to provide the end user with a high degree of confidence that the seal type being offered will perform as required by this Standard, each seal or system shall be suitably tested prior to its market availability. The qualification test does not constitute an acceptance test. The intent is not to test every individual seal size in all fluids, but to qualify the overall design in accordance with 10.3.1.3.

NOTE This qualification test is to provide the end user with factual proof of the seal's ability to perform reliably in various environments.

● **10.3.1.1.2** If specified, optional testing shall be performed as mutually agreed upon by the seal manufacturer and the purchaser.

NOTE The purchaser has the option to specify test conditions that may be different from the standard qualification test, as applicable.

10.3.1.2 Scope of test

10.3.1.2.1 Seals shall be tested on an appropriate test rig by the seal manufacturer in accordance with 10.3.1.2.2 to 10.3.1.2.12 and 10.3.1.3.

10.3.1.2.2 Category 3 seals shall be tested using the same configuration, type, design, and material grade proposed for the commercially available seal design.

10.3.1.2.3 Category 1 and Category 2 seals shall be tested using the same configuration, type, design, and material grade proposed for the commercially available seal design. However, if the seal ring assembly and the mating ring are interchangeable with a similarly oriented Category 3 seal that has already been tested in the same arrangement, then no additional testing is required.

NOTE This reduces the number of tests and provides incentives for sharing component parts between categories.

10.3.1.2.4 Seal face materials (type, vendor, and grade) may be qualified as mating pairs for a particular applications group by virtue of being tested in the representative test fluid for that group with either a Category 1, Category 2 or Category 3 seal.

NOTE This reduces the number of tests while assuring that all face material combinations have been tested in the representative test fluid.

10.3.1.2.5 Seals shall be tested in four different test fluids that model the fluids shown in the three application groups from the recommended seal selection procedure (annex A). The test fluids are: water, propane, 20% NaOH solution, and mineral oil. The mineral oil is a white mineral oil base formulation capable of stable operations at high temperatures up to 315°C (600°F). Table 8 identifies the test fluid for each application group.

NOTE The test fluids were selected to model the behavior of the fluids described in the recommended seal selection procedure (annex A). The properties of the test fluids are representative of the properties of the fluids shown in the application groups (for example, viscosity, corrosiveness, crystallization, vapor pressure, hydrocarbon, or non-hydrocarbon). The test fluids selected were considered to be readily available and safe for testing in a laboratory environment.

10.3.1.2.6 Each qualification test for each test fluid shall consist of three phases: (see Figures 28 through 32):

a) the dynamic phase shall be tested at constant temperature, pressure, and speed (base point);

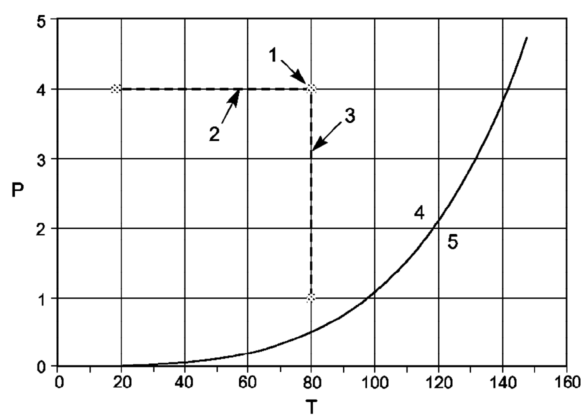
b) the static phase shall be tested at 0 r/min using the same temperature and pressure as the dynamic phase; and

c) the cyclic phase shall be tested at varying temperatures and pressures including start-ups and shutdowns. For flashing hydrocarbons, the cyclic test phase will include excursions into vapor and back to liquid (flash and recovery).

NOTE These phases were selected to qualify the seal type for the operating ranges (temperatures and pressures) defined in each application group. Figures 28 through 32 show a graphical representation of the test operating parameters for all three phases and each test fluid. The test phases were selected to model actual pump operating conditions such as normal running, upset, standby, and start-up/shutdown.

Table 8 — Test fluid and application group selection chart

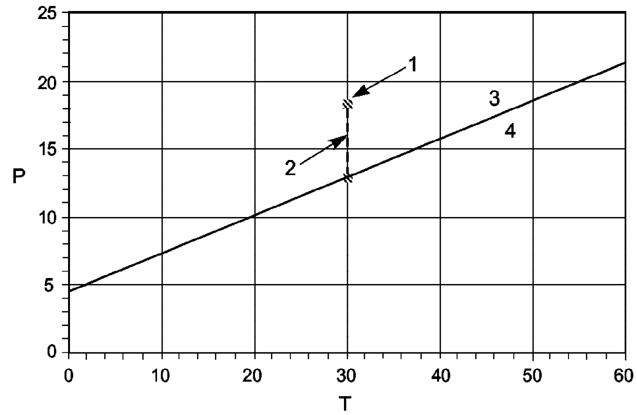
Application group	Water	Propane	NaOH (20%)	Mineral oil
	Test fluids			
Non hydrocarbons				
Water	X			
Sour water	X			
Caustic			X	
Acid	X			
Non-flashing hydrocarbons				
- 40°C to - 7 °C (- 40°F to + 20°F)		X		
- 7°C to 150°C (20°F to 300°F)				X
150°C to 260°C (300°F to 500°F)				X
Flashing hydrocarbons				
- 40°C to – 7°C (- 40°F to + 20°F)		X		
- 7°C to 38°C (20°F to 100°F)		X		
38°C to 150°C (100°F to 300°F)				X



Key

P absolute pressure in bar
T temperature °C
1 base point conditions
2 temperature cycle
3 pressure cycle
4 liquid phase
5 vapor phase

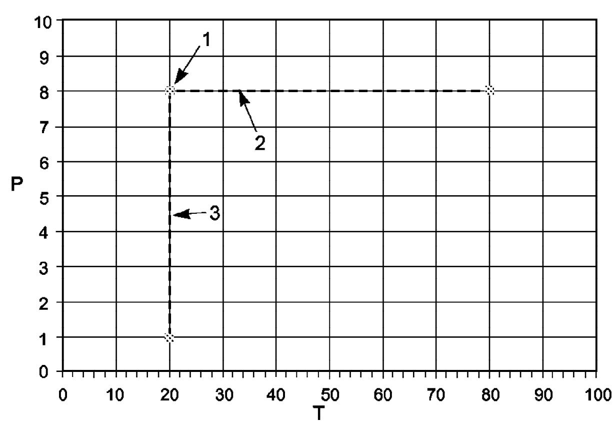
Figure 28 — Water test parameters



Key

P absolute pressure in bar
T temperature °C
1 base point conditions
2 pressure cycle
3 liquid phase
4 vapor phase

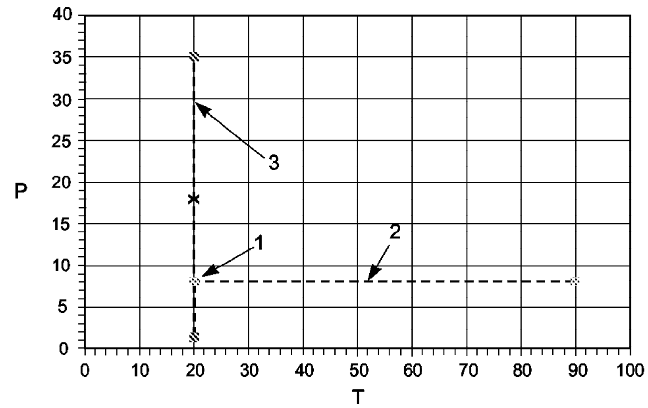
Figure 29 — Propane test parameters



Key

P absolute pressure in bar
T temperature °C
1 base point conditions
2 temperature cycle
3 pressure cycle

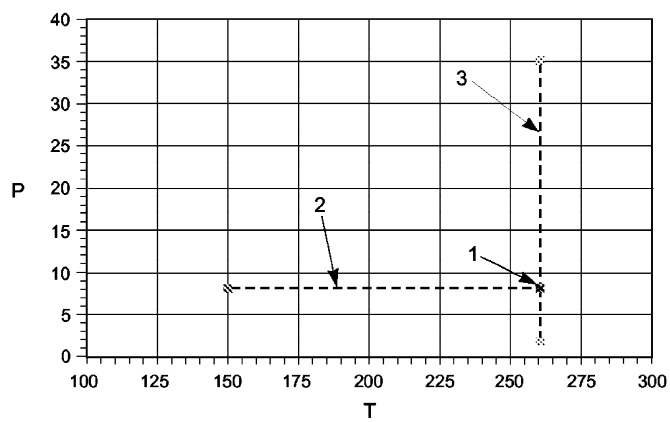
Figure 30 — Caustic (NaOH) test parameters



Key

P absolute pressure in bar
T temperature °C
1 base point conditions
2 temperature cycle
3 pressure cycle

Figure 31 — Mineral oil test parameters for applications between – 7ºC (20ºF) and 150ºC (300ºF)



Key

P absolute pressure in bar
T temperature °C
1 base point conditions
2 temperature cycle
3 pressure cycle

Figure 32 — Mineral oil test parameters for applications between 150ºC (300ºF) and 260ºC (500ºF)

10.3.1.2.7 The seal sizes tested, for each seal type and test fluid, shall be nominal balance diameters of 50 mm (2 in.) to 75 mm (3 in.) and 100 mm (4 in.) to 127 mm (5 in.).

NOTE Most seal applications are covered by this Standard. The testing of these sizes is considered representative of the range of sizes identified. The performance of sizes between the test sizes is considered to be similar to the test sizes. For seals outside the scope of this Standard, additional qualification testing should be considered.

10.3.1.2.8 For Arrangement 1 seals, demonstrate the performance of the seal in accordance with 10.3.1.3.

10.3.1.2.9 For Arrangement 2 seals using liquid buffer fluids (2CW-CW):

a) demonstrate the performance of the inner seal without the outer seal and the buffer fluid in accordance with 10.3.1.3;

b) demonstrate the performance of the arrangement with the outer seal and the buffer fluid in accordance with 10.3.1.3.

10.3.1.2.10 For Arrangement 2 seals using a containment seal, with or without a buffer gas purge (2CW-CS, 2NC-CS):

a) for arrangements using contacting inner seals (2CW-CS) only, demonstrate the performance of the inner seal without the outer seal and the buffer gas (purge) in accordance with 10.3.1.3;

b) demonstrate the performance of the arrangement with the inner seal and outer seal but without any buffer gas (purge) in accordance with 10.3.1.3;

c) after completion of step b), demonstrate the performance of the containment seal in accordance with 10.3.1.3.5.

10.3.1.2.11 For Arrangement 3 seals using liquid barrier fluids (3CW-FB, 3CW-FF, 3CW-BB):

a) demonstrate the performance of the inner seal without the outer seal and the barrier fluid in accordance with 10.3.1.3;

b) demonstrate the performance of the arrangement with the outer seal and the barrier fluid in accordance with 10.3.1.3.

10.3.1.2.12 For Arrangement 3 seals using a gas barrier:

a) the barrier gas used during qualification testing shall be nitrogen;

b) demonstrate the performance of the arrangement in accordance with 10.3.1.3;

c) demonstrate the performance of the arrangement at variable barrier gas pressures in accordance with 10.3.1.3.6:

10.3.1.3 Test procedure

10.3.1.3.1 The test sequence shall be in accordance with 10.3.1.3.2 through 10.3.1.3.11 and as shown in Figure 33. The test will consist of dynamic, static, and cyclic phases. The three test phases shall be run consecutively, without disassembly of the seal.

10.3.1.3.2 The dynamic phase of the qualification test shall be operated continuously for a minimum of 100 h at 3 600 r/min under the base point conditions, as specified in Table 9.

10.3.1.3.3 The static phase of the qualification test shall run for a minimum of 4 h at 0 r/min (shutdown) under the base point conditions, as specified in Table 9. No rotation of the shaft is allowed during the static test.

10.3.1.3.4 The cyclic phase of the qualification test shall be at the temperatures and pressures specified in Table 9 and performed as follows:

a) operate the seal at base point pressure and temperature conditions and at 3 600 r/min until equilibrium has been established;

b) drop the pressure to cause all fluid in the seal chamber to vaporize or down to a gauge pressure of 0 bar (0 psi) for non-flashing fluids (raise pressure for oil tests). Re-establish base pressure;

c) drop the fluid temperature in the seal chamber to the minimum cyclic test temperature in Table 9. Re-establish base point conditions;

d) raise the fluid temperature in the seal chamber to the maximum cyclic test temperature in Table 9. Re-establish the base point conditions. For the mineral oil tests, after the base condition is reached, raise the fluid pressure in the seal chamber to the maximum cyclic test pressure in Table 9. Re-establish the base point conditions;

e) turn off the seal flush for 1 min, if applicable;

f) shut down the test (0 r/min) for at least 10 min;

g) establish base point conditions and operate at 3 600 r/min;

h) repeat steps b) through g), three additional times;

i) repeat steps b) through e);

j) re-establish flush and allow test seal to reach equilibrium conditions (including emissions for hydrocarbons) at the base point; and

k) shut down the test (0 r/min). Maintain base point conditions for at least 10 min.

Table 9 — Seal qualifications test parameters

Qualification test conditions					
Test fluids	Barrier/buffer test fluids for dual seals	Base point		Cyclic ranges	
		Dynamic and static			
		Pressure[a]	Temperature[b]	Pressure[a]	Temperature[b]
		bar		bar	
Water	Glycol/water	4	80°C (180°F)	1 to 4	20°C to 80°C (70°F to 180°F)
Propane	Diesel	18	30°C (90°F)	11 to 17	30°C (90°F)
20% NaOH	Glycol/water	8	20°C (70°F)	1 to 8	20°C to 80°C (70°F to 180°F)
Mineral oil 20°C (70°F) to 90°C (200°F) applications	Diesel	8	20°C (70°F)	1 to 17 (Type B & C) 1 to 35 (Type A)	20°C to 90°C (70°F to 200°F)
Mineral oil 150°C (300°F) to 250°C (500°F) applications	Mineral oil	8	260°C (500°F)	1 to 17 (Type B & C) 1 to 35 (Type A)	150°C to 260°C 300°F to 500°F)

[a]The tolerance range for pressure shall be ± 2%

[b]The tolerance range for temperature shall be ± 3%

10.3.1.3.5 In addition to the requirements of 10.3.1.2.8, Arrangement 2 dry running containment seals shall be tested, without disassembly, with the inner seal at the base point conditions, as follows (see Figure 34):

a) continuously operate a gas-pressured phase for at least 100 h at 3 600 r/min in propane gas at a gauge pressure of 0,7 bar (10 psi) and a supply temperature between 20°C (68°F) and 40°C (104°F). Emissions shall be measured using EPA Method 21.

b) on completion of step a, pressurize the seal with nitrogen or air and test according to the air test procedure of 10.3.4 — the pressure decay may exceed the requirements of 10.3.4 but shall be recorded every minute, and no rotation of the shaft is permitted during this test.

c) on completion of step b, fill the containment seal chamber area with diesel at a temperature between 20°C and 40°C (68°F and 104°F) and pressurize to 2,8 bar (40 psi). Restart, maintain pressure and operate for at least 100 h at 3,600 r/min. Record the leakage rate.

d) on completion of step c, test the seal statically in diesel fuel for at least 4 h at 0 r/min (shutdown) at a gauge pressure of 17 bar (246 psi); no rotation of the shaft is permitted during the static test, and the leakage rate shall be reported.

NOTE During the qualification test of the Arrangement 2 seal, the containment seal runs at a low pressure and in the vapor or liquid leaked by the inner seal. The gauge pressure of 2,8 bar (40 psi) is referenced to an assumed maximum flare header pressure.

10.3.1.3.6 For Arrangement 3 seals using a gas barrier, the performance of the arrangement at variable barrier gas pressure shall be demonstrated as follows (see Figure 35):

a) hold the gas pressure at zero for at least 1 hour (this is a static test);

b) restore barrier gas pressure, restart and run until equilibrium is established; record any process leakage as well as barrier gas consumption;

c) while the seal is running, isolate the barrier gas supply immediately adjacent to the seal for a 1-min period; The purpose of this is to simulate field conditions of varying buffer gas supply.

NOTE The purpose of this is to simulate field conditions of varying buffer gas supply

d) restore barrier gas pressure and run until equilibrium is established and record any process leakage as well as barrier fluid consumption; and

e) shutdown the seal (0 r/min). With the gas control panel blocked in, maintain base point conditions for the process (inner) seal for 10 min and record any pressure rise in the barrier system.

NOTE This clause continues the testing of the Arrangement 3 gas pressurized seals after 10.3.1.3.4. It provides a test of the ability to survive upsets and startup problems.

10.3.1.3.7 Measurements shall be recorded on forms containing at least the data presented in annex I.

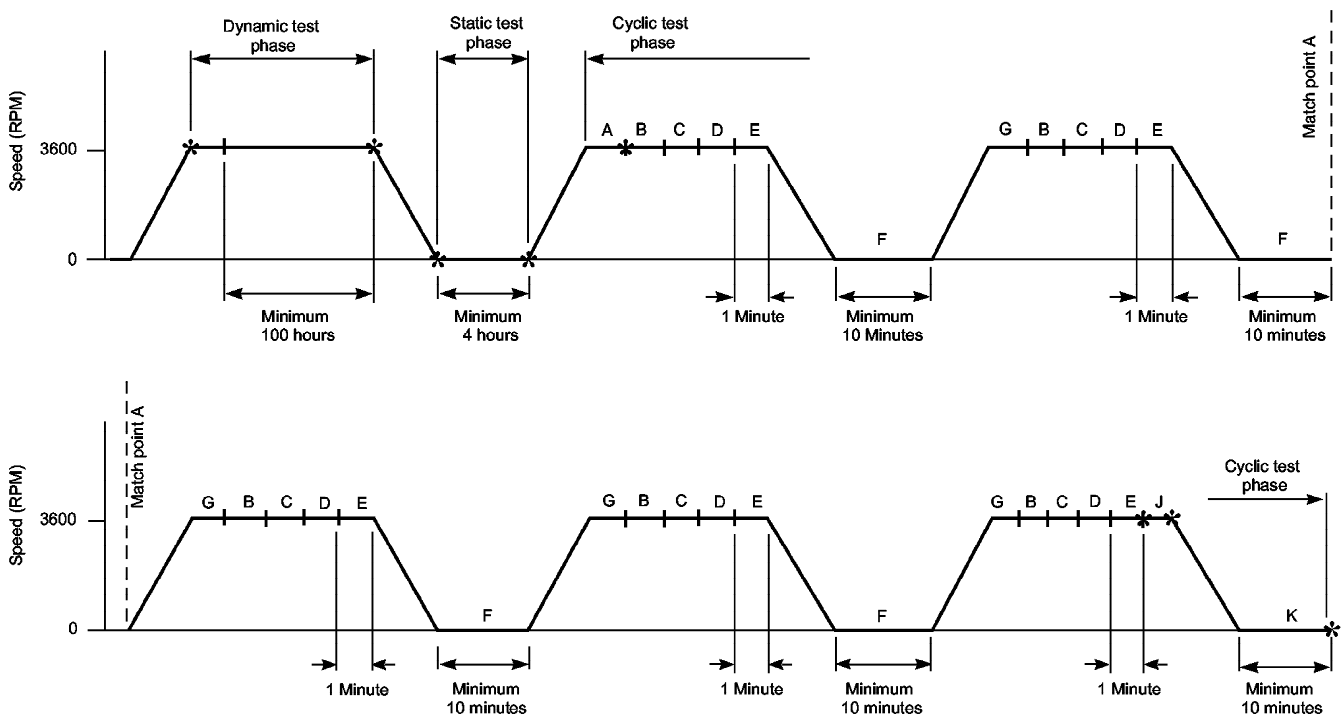
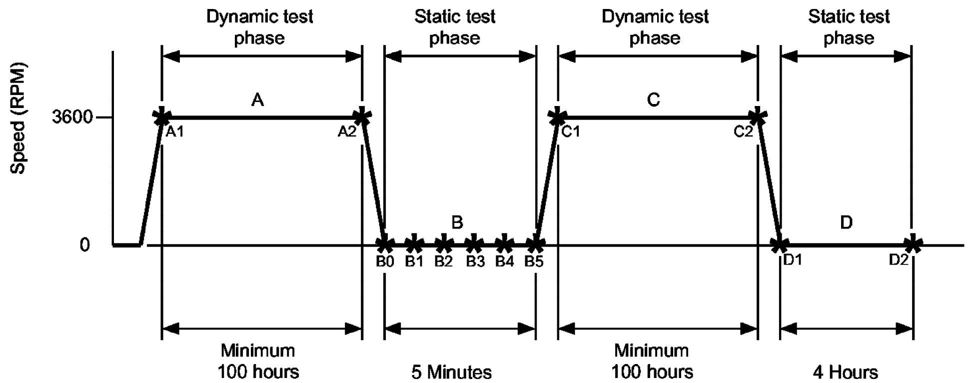


Figure 33 — Seal vendor qualification test procedure



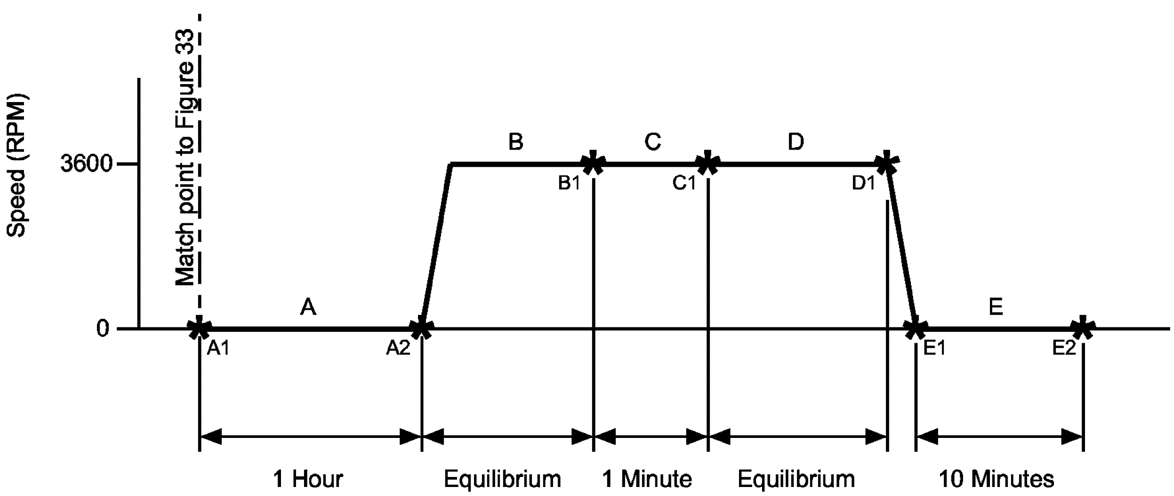
Key

A 0.7 bar (10 psi) Propane
B 1.7 bar (25 psi) Nitrogen
C 2.8 bar (40 psi) Diesel
D 17.2 bar (250 psi) Diesel

NOTE 1 Test cycle refers to steps according to 10.3.1.3.5

NOTE 2 *Indicates the timing and data point designations for measurements that are taken per 10.3.1.3.5 and Annex I

Figure 34 — Seal vendor qualification test procedure for containment seals



Key

A barrier at 0 bar (0 psi), inner seal at normal test pressure
B barrier at normal test pressure, inner seal at normal test pressure
C isolate barrier pressure from supply pressure, inner seal at normal test pressure
D barrier at normal test pressure, inner seal at normal test pressure
E barrier blocked in, inner seal at normal test pressure

NOTE 1 Test cycle refers to steps according to 10.3.1.3.6

NOTE 2 *Indicates the timing and data point designations for measurements that are taken per 10.3.1.3.6 and Annex I

Figure 35 — Seal vendor qualification test procedure for gas barrier seals

10.3.1.3.8 The temperature and pressure measurements are values taken to be representative of the majority of the seal chamber volume of fluid.

NOTE The measured seal chamber fluid temperature is an average between inlet and outlet temperatures.

10.3.1.3.9 Leakage concentration for VOC test fluids shall be measured with an organic vapor analyzer in accordance with EPA Method 21 (Appendix A of Title 40, Part 60 of the US Code of Federal Regulations).

NOTE This method of emission measurement is a concentration of VOC in the environment immediately surrounding the seal, not a VOC leakage rate. Allow time for the analyzer to complete measurements.

10.3.1.3.10 All gauge ranges shall preferably be selected so that the normal operating point is at the middle of the gauge's range.

10.3.1.3.11 Instruments and methods of measurement shall be in accordance with ASME PTC 8.2.

10.3.1.3.12 Seal face wear shall be computed based on the average change in length of the faces as measured before and after testing. Measurements shall be taken at four places approximately equally spaced around the circumference of the seal faces.

10.3.1.4 Minimum performance requirements

10.3.1.4.1 Unless otherwise specified (to meet more stringent local emissions regulations), when single seals are tested in accordance with 10.3.1.3.2, 10.3.1.3.3, and 10.3.1.3.4, the permitted leakage rate shall be less than:

a) 1 000 ml/m^3 (ppm vol) concentration of vapors using EPA Method 21;

b) an average liquid leakage rate less than 5,6 g/h per pair of sealing faces.

NOTE 1 All mechanical seals require face lubrication to achieve reliability and this results in a minimal level of leakage. On a water pump test of a contacting wet seal (1CW), the leakage will typically evaporate and be non-visible. Face design features, however, can increase leakage levels and visible droplets may occur (refer to Tutorial A.1.3). Pressurized dual contacting wet seals (3CW), when used with a non-evaporative, lubricating oil, barrier fluid, may also produce visible leakage in the form of droplets, but at a rate less than 5.6 gm/h (2 drops per minute).

NOTE 2 The owner or purchaser must determine the applicable emission/leakage limits at the intended point of application and compare these limits to the values listed above for the qualification test. Local limits may be lower than the stated values. If an Arrangement 1 seal will not comply with local emission or leakage requirements, than Arrangement 2 or 3 may be required to meet the applicable limits.

10.3.1.4.2 Unless otherwise specified to meet more stringent local emissions regulations, when containment seals are tested in accordance with 10.3.1.3.5, part a, the maximum permitted leakage shall be 1 000 ml/m^3 (1 000 ppm vol) concentration of vapors using EPA Method 21.

NOTE Part a) of this test is considered to be normal operation, the remainder of the test is considered to be an upset condition.

10.3.1.4.3 After completion of the qualification test, the total wear of the primary sealing faces shall be less than 1% of the available seal face wear.

NOTE 1 Excessive wear of a single seal in a particular test may be an indication that a dual seal is the preferred selection for that service.

NOTE 2 Seal face wear varies with size, speed, pressure, and fluid and is very non-linear. Most seal face wear occurs during startup or shortly thereafter.

10.3.1.4.4 For containment seals, the sum of the wear during testing according to clauses 10.3.1.3.2 to 10.3.1.3.5 shall be less than 1% of the available seal face wear.

10.3.1.5 Results of test

10.3.1.5.1 The seal manufacturer shall provide the results of the qualification tests and certification in accordance with Table 10. The results of the tests shall include at least the information shown on the qualification test results forms (annex I). Any conditions observed that would jeopardize the ability of the seal to meet the reliability and performance requirements of this Standard shall be reported.

10.3.2 Hydrostatic test for pressure containing mechanical seal parts and accessories

10.3.2.1 Pressure casing seal components except gland plates machined from a single piece of wrought material or bar stock shall be tested hydrostatically with liquid at a minimum of 1,5 times the maximum allowable working pressure but not less than a gauge pressure of 1,4 bar (20 psi). The test liquid shall be at a higher temperature than the nil ductility transition temperature of the material being tested.

10.3.2.2 If the part tested is to operate at a temperature at which the strength of a material is below the strength of that material at room temperature, the hydrostatic test pressure shall be multiplied by a factor obtained by dividing the allowable working stress for the material at room temperature by that at the operating temperature. The stress values used shall conform to those given in ASME B31.3 for piping or in ASME VIII, Division 1 for vessels. The pressure thus obtained shall then be the minimum pressure at which the hydrostatic test shall be performed. The data sheets shall list actual hydrostatic test pressures.

10.3.2.3 Where applicable, tests shall be in accordance with the ASME Boiler & Pressure Vessel Code. In the event that a discrepancy exists between the code test pressure and the test pressure in this Standard, the higher pressure shall govern.

10.3.2.4 The chloride content of liquids used to test austenitic stainless steel materials shall not exceed 50 mg/kg (50 ppm wt). To prevent deposition of chlorides as a result of evaporative drying, all residual liquid shall be removed from tested parts at the conclusion of the test.

10.3.2.5 Tests shall be maintained for a sufficient period of time to permit complete examination of parts under pressure. The hydrostatic test shall be considered satisfactory when neither leaks nor seepage through the chamber are observed for a minimum of 30 min.

10.3.3 Seal manufacturer test job seal

10.3.3.1 Each mechanical seal shall be tested with air by the seal manufacturer after final assembly in accordance with 10.3.4. Provisions for the test shall include the requirements of 10.3.3.1.1 through 10.3.3.1.3.

10.3.3.1.1 Seals shall be thoroughly inspected, cleaned, and faces verified to be free of lubricants and grease as they are assembled. The job type, size, material, and part number gasketing shall be used.

10.3.3.1.2 The testing fixture shall be capable of accommodating the entire seal without modification to the seal cartridge, seal chamber if provided by the seal manufacturer, or the gland plate.

10.3.3.1.3 Arrangement 2 and Arrangement 3 seals shall have provisions to test each sealing section independently.

10.3.3.2 Following the successful completion of the air test, the tested seal cartridge shall not be disassembled. Tag the cartridge assembly as "certified seal manufacturer air test acceptable" giving the test date, and the inspector's name.

10.3.3.3 In the event that the seal assembly does not pass the air test, the entire test shall be repeated until a successful test has been accomplished.

10.3.4 Air test

10.3.4.1 Set-up

The set-up for the air test shall have a fill and pressurizing system capable of being isolated from the sealing section being tested. The gauge used for the test shall have a range so that the gauge pressure of 1,8 bar (26 psi) is close to the midpoint.

10.3.4.2 Procedure

Each sealing section shall be independently pressurized with clean air to a gauge pressure of 1,8 bar (26 psi). The volume of each test set-up shall be a maximum of 28 l (1 ft^3). Isolate the test set-up from the pressurizing source and maintain the pressure for at least five minutes. The maximum pressure drop during the test shall be 0,14 bar (2 psi).

10.3.4.3 Dual seal

Each sealing section of an Arrangement 2 or Arrangement 3 shall be independently pressurized. Connections shall be provided to test each section independently.

10.3.5 Pump manufacturer seal test

10.3.5.1 Pump performance test — alternative seal or face

● 10.3.5.1.1 Modified seal faces

If specified, the air-tested seal shall be supplied to the pump manufacturer with modified seal faces for operation during the pump performance test. Following the pump performance test, the job seal faces shall be installed in the seal and air tested in accordance with 10.3.4.

● 10.3.5.1.2 Seal not operated during pump performance test

If specified, the seal being supplied shall not be operated in the pump during the pump performance test in order to prevent damage. During the pump performance test, the pump shall utilize a seal supplied by the pump manufacturer. The seal being supplied and, the seal chamber (if applicable), shall be installed after the pump performance test and air tested in accordance with 10.3.4. It shall be specified if the seal is to be shipped uninstalled.

10.4 Preparation for shipment

10.4.1 Unless otherwise specified, the equipment shall be prepared for the type of shipment as described in 10.4.3.

10.4.2 The manufacturer shall provide the purchaser with the instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site and before start-up.

10.4.3 The equipment shall be prepared for shipment after all testing and inspection have been completed and the equipment has been released by the purchaser. The preparation shall include the following:

a) Exterior surfaces, except for machined surfaces, shall be given at least one coat of the manufacturer's standard paint. The paint shall not contain lead or chromates Stainless steel parts need not be painted.

b) Carbon steel exterior machined surfaces shall be coated with a suitable rust preventive.

c) The interior of the equipment shall be clean and free from scale, welding spatter, and foreign objects.

d) Internal steel areas of carbon steel systems' auxiliary equipment, such as reservoirs, shall be coated with a suitable oil-soluble rust preventive.

e) Flanged openings shall be provided with metal closures at least 4,8 mm ($^3/_{16}$ in.) thick, with elastomer gaskets and at least four full-diameter bolts. For studded openings, all nuts needed for the intended service shall be installed.

f) Threaded openings shall be plugged in accordance with 6.1.2.18.

g) Lifting points and the centre of gravity shall be clearly identified on the equipment package if the mass exceeds 23 kg (50 lb) or if required by local regulations. The manufacturer shall provide the recommended lifting arrangement.

h) For Category 3 seals, the equipment shall be identified with item and serial numbers. Material shipped separately shall be identified with securely affixed, corrosion-resistant metal tags indicating the item and serial number of the equipment and shall be shipped with duplicate packing lists, one inside and one on the outside of the shipping container.

10.4.4 Auxiliary piping connections shall be die-stamped or permanently tagged to agree with the manufacturer's connection table or general arrangement drawing. Service and connection designations shall be indicated.

10.4.5 One copy of the seal manufacturer's installation instructions shall be packed and shipped with the equipment.

11 Data transfer

11.1 General

11.1.1 Completion of the data sheets (annex F) is the joint responsibility of the purchaser and the vendor. The purchaser may submit the data sheets to the vendor in a form other than that indicated herein. However, the alternative data sheets shall include, as a minimum, all the information provided in annex F. Mechanical seals can be described in a general manner by using the mechanical seal codes given in annex J.

NOTE This information is the basis for the selection, the specification and the purchasing agreement.

11.1.2 The minimum information to be furnished by the manufacturer is specified in Table 10 and Table 11 and described in 11.2 and 11.3. It shall be sent to the address or addresses noted on the enquiry or order.

11.1.3 The following information shall be identified on cover letters, and mechanical seal data sheets for Category 1 and Category 2 installations. Category 3 installations shall have the information on cover letters, mechanical seal data sheets, arrangement drawings, installation operation, and maintenance manuals:

a) the purchaser or user's corporate name;

b) the job or project reference;

c) the equipment item number and service name;

d) the enquiry or purchase order number;

e) any other identification specified in the enquiry or purchase order; and

f) the manufacturer's identifying proposal reference, shop order number, serial number, or other reference required to uniquely identify return correspondence.

● **11.1.4** If specified, the mechanical seal data requirements form (annex G) shall be completed by the purchaser and the vendor. The purchaser may require this information in a form similar to or other than that indicated herein, provided it includes at least the information provided in annex G.

11.2 Proposal data

11.2.1 The seal manufacturer's proposal shall include at least the information specified in Table 10.

11.2.2 The seal cross sectional drawing (a modified typical drawing is acceptable) shall include the following information:

a) sufficient dimensional information to check the fit of the installation in the equipment, including the seal chamber bore and depth, gland plate connections, and the distance to the nearest obstruction external to the seal chamber;

b) overall seal dimensions and any relevant seal setting dimensions;

c) seal axial tolerance to differential shaft/casing movement;

d) material specifications; and

e) a separate seal chamber drawing clarifying any pump modifications required to fit the proposed seal. This drawing shall either show the seal assembly or include a cross-reference to it.

Table 10 — Proposal data

	Category		
	1	2	3
Cross sectional drawing (typical)	X	X	X
Auxiliary system schematic			X
Appropriate completed data sheets	X	X	X
Alternatives proposed	X	X	X
Exceptions to this Standard	X	X	X
Detailed bill of materials for seal and auxiliary system			X
Estimated seal leakage of 2NC-CS at rated seal chamber pressure	X	X	X
Seal qualification test results and certification			X
Seal design performance parameters			X
Seal axial thrust force on shaft			X
Data requirements form	X[a]	X[a]	X[a]
[a] If specified			

11.2.3 The seal design performance parameters shall include the following information specific to the liquid and pump information in the data sheet:

a) dynamic sealing pressure rating;

b) static sealing pressure rating;

c) maximum reverse pressure (where appropriate);

d) maximum and minimum operating temperature.

11.2.4 Seal qualification test results shall include the following information:

a) the information shown on the qualification test results forms (annex I) plus any other relevant information;

b) certification that the qualification test was properly conducted and has met the requirements of this Standard;

c) clarification of any design or specification differences between the test and the proposed seal; and

d) any conditions observed that would jeopardize the ability of the seal to meet the reliability and performance requirements of this Standard.

11.3 Contract Data

11.3.1 The vendor shall supply to the purchaser at least the information specified in Table 11.

Table 11 — Contract data

	Category		
	1	2	3
Cross sectional drawing (typical)	X	X	
Cross sectional drawing (specific)	a	a	X
Auxiliary system schematic	X	X	X
Detailed drawing of auxiliary system			X
Appropriate completed data sheets	X	X	X
Detailed bill of materials for seal and auxiliary system	X	X	X
Seal energy and heat soak calculations			X
Seal axial thrust on shaft			X
Internal circulating device performance (test data)			X
System resistance curve			X
Installation, operation and maintenance instructions (typical)	X	X	
Installation, operation and maintenance instructions (specific)			X
Hydrostatic test certification			X
Material safety data sheets	b	b	X
Data requirements form	X[c]	X[c]	X[c]

[a] Shall be supplied if significant pump modifications are required

[b] If required by regulations

[c] If specified

11.3.2 The seal cross sectional drawing specific to the equipment shall include at least the following:

a) all seal components related to the order as well as pump components related to the seals;

b) dimensions to properly verify the seal setting position;

c) pump dimensions interfacing with the seal;

d) seal boundary dimensions;

e) seal chamber and gland plate connection dimensions;

f) auxiliary system and utility specifications;

g) connecting dimensions for the auxiliary system and utilities;

h) pump process and seal operating conditions;

i) seal allowable axial movement from set point;

j) seal category, type and arrangement as designated by this Standard; and

k) appropriate labelling and reference to the bill of materials, including materials of construction and item description.

11.3.3 The auxiliary system schematic drawing shall include:

a) piping and instrumentation diagram;

b) all external utility requirements and positions;

c) appropriate labelling and reference to the bill of materials;

d) barrier or buffer fluid specification;

e) hydrotest pressure, if applicable;

f) maximum design pressure and temperature;

g) size and set pressure of relief valves.

11.3.4 The detailed drawing of the auxiliary system shall include:

a) all mounting and overall boundary dimensions;

b) all external utility requirements and positions;

c) all connecting pipework locations, type and size;

d) appropriate labelling and reference to the bill of materials;

e) barrier or buffer fluid specification;

f) equipment and alarm set points;

g) hydrotest pressure, if applicable;

h) maximum design pressure and temperature;

i) orifice size; and

j) size and set pressure of relief valves.

11.3.5 The bill of materials for the seal shall also indicate the recommended spare parts.

11.3.6 Unless otherwise specified at the enquiry stage, the installation operation and maintenance manual shall be in English. A copy shall be included with the supplied seal and auxiliary system. It shall provide sufficient instructions and a cross-referenced list of all drawings and bills of materials to enable the purchaser to correctly install, operate, and maintain all of the equipment covered by the purchase order. The recommended torque values for all fasteners used in the seal, reservoir flange and level gauge shall be provided.

11.3.7 For Category 3 seals, the vendor shall provide sufficient written instructions and all necessary drawings to enable the purchaser to install, operate, and maintain all of the equipment covered by the purchase order. This information shall be compiled in a manual or manuals with a cover sheet showing the information listed in 11.1.3, an index sheet, and a complete list of the enclosed drawings by title and drawing number. The manual or manuals shall be prepared specifically for the equipment covered by the purchase order. "Typical" manuals are unacceptable.

11.3.8 Material safety data sheets shall be for the specific paints, preservatives, coatings and chemicals supplied with, or applied to, the seal or auxiliary system.

Annex A
(informative)

Recommended seal selection procedure

A.1 Assumptions and instructions

A.1.1 Application range

This selection procedure provides a recommended seal type, arrangement, flush plan, and barrier/buffer fluid given the intended service condition provided the conditions meet the seal operating envelope of Category 1 seals, Category 2 seals or Category 3 seals.

The fluids covered by this selection process include:

a) water;

b) sour water (containing H_2S);

c) caustics;

d) amines;

e) some acids;

f) most hydrocarbons.

A.1.2 Additional engineering required

This is a recommended procedure only. It is the responsibility of the purchaser or seal vendor using this procedure to ensure the selected seal and auxiliaries are suitable for the intended service condition. The use of alternative selection criteria from this procedure and more detailed engineering review is specifically recommended for the following service conditions.

a) High temperatures above:

    a. Category 1 seals: 260°C (500°F);

    b. Category 2 and Category 3 seals: 400°C (750°F).

b) Low temperatures below – 40°C (– 40°F).

c) High sealing pressure above:

    c. Category 1 seals: Gauge pressure 21 bar (300 psi);

    d. Category 2 and Category 3 seals: Gauge pressure 41 bar (600 psi).

d) Surface speed above 23 m/s (4500 ft/min).

e) Highly corrosive fluids for which the materials within this standard are not suitable.

f) Fluids with vapor pressures in excess of 34 bar (493 psi).

g) Unstable liquid properties for example multiphase or non-newtonian fluids, etc .

h) High solids concentration.

i) Shaft sizes above 110 mm (4,3 in) or below 20 mm (0,75 in).

j) High viscosity or pour point above or within 20°C (36°F) of minimum ambient temperature.

A.1.3 Seal leakage

There is always a mass flow rate across the face of a mechanical seal so all seals "leak" to some extent. Some seals, particularly non-contacting seals, are designed to have a certain flow between the faces. Nevertheless, for the vast majority of API 610 pumps, there will be no visible seal leakage depending on the state of the fluid being sealed. Leakage can occur regardless of seal category, type, or arrangement; however, with dual seals, leakage may be buffer or barrier fluid instead of process fluid. Buffer and barrier fluids are often lubricating oils, which are non-evaporative, and visible droplets will occur in these circumstances. Sometimes visible leakage is apparent only over time as the non-evaporative components of the process stream or buffer/barrier fluids accumulate.

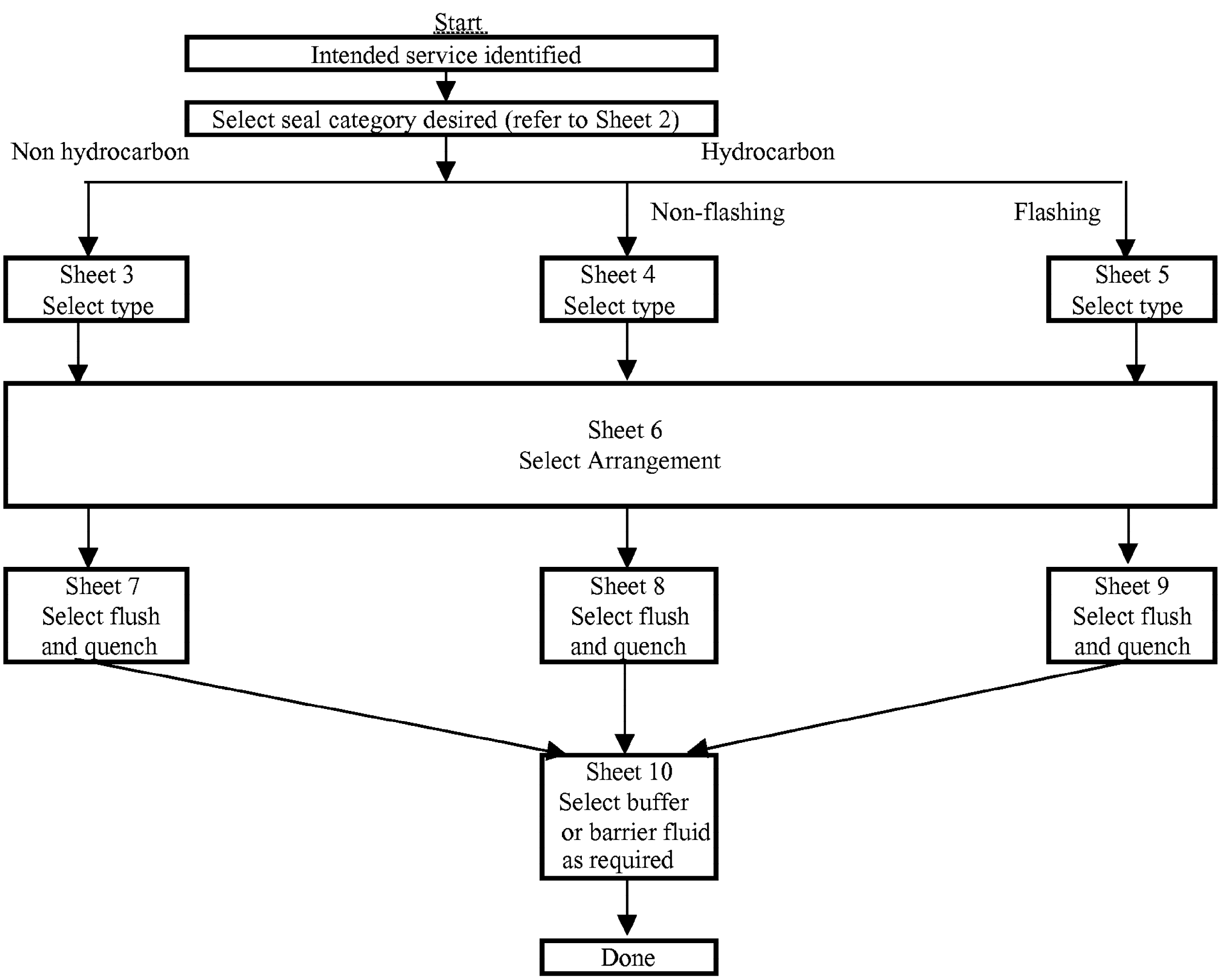
Contacting seals may use features such as variable or low seal balance ratio, or face enhancing features such as scallops, matte lapping or preferential lapping to reduce wear and extend the design envelope; however, leakage may be slightly higher than similar seals using plain faces under less difficult conditions. Seals designed for high pressures but actually used at low pressures may have unacceptable leakage. A single contacting wet seal (1CW) sealing water on a works pump test will ordinarily have a leakage that is evaporative and will be non-visible. The aforementioned design features, necessary for specific process reliability, in a water sealing environment may, however, alter leakage levels to an extent when a slight visible leakage may occur.

Factors other than design features may result in increased leakage as well; however, these may be the result of aberrant system conditions. In particular, after a contacting seal has worn-in to match a certain set of operating conditions, changing those conditions may result in increased leakage until the faces have worn to match the new conditions. Such changes include fluid type, viscosity or density in either the process or buffer/barrier fluid. Operating conditions such as temperature or pressure outside its design envelope may damage the seal and result in greater leakage rates. Other system factors that affect seal leakage rates besides condition of the seal parts include pump operation at off-design conditions, pipe strain, bearing problems, fitting leaks at the seal gland (often mistaken as seal leakage), impeller or sleeve gasket damage, etc.

A.1.4 Instructions and seal selection sheets

To use this procedure, begin on sheet 1 and consult each page given the service condition and fluid. Where alternative seal types are listed, they should be considered an acceptable equivalent to the standard (default) seal shown.

RECOMMENDED SEAL SELECTION PROCEDURE (SI UNITS)
SHEET 1 OF 10



RECOMMENDED SEAL SELECTION PROCEDURE (SI UNITS)
SEAL CATEGORY, TYPE, AND ARRANGEMENT SUMMARY
SHEET 2 OF 10

Seal category shall be Category 1, 2 or 3 as specified.

The major features of each category are summarized below. Options, where they exist for each feature, are listed in the text as "if specified". Clause numbers in parentheses indicate where the requirements are specified.

FEATURE	CATEGORY 1	CATEGORY 2	CATEGORY 3
Seal chamber size. (1.2)	ISO 3069-C, ANSI/ASME B73.1 and ANSI/ASME B73.2.	ISO 13709 and ISO 3069-H.	ISO 13709 and ISO-3069-H.
Temperature range. (1.2)	– 40ºC to 260ºC	– 40ºC to 400ºC	– 40ºC to 400ºC
Pressure range, absolute. (1.2)	22 bar	42 bar	42 bar
Face materials. (6.1.6.2.3)	Premium blister resistant carbon vs. self sintered silicon carbide.	Premium blister resistant carbon vs. reaction bonded silicon carbide.	Premium blister resistant carbon vs. reaction bonded silicon carbide.
Distributed inlet flush requirements, Arrangements 1 and 2 with rotating flexible elements.	When required per 6.1.2.14 or if specified. (6.2.1.2.1)	When required per 6.1.2.14 or if specified. (6.2.2.2.1)	Required. (6.2.3.2.1)
Gland plate metal to metal contact requirement.	Required. (6.2.1.2.2)	Required inside and outside of the bolt circle diameter. (6.2.2.2.2)	Required inside and outside of the bolt circle diameter. (6.2.2.2.2)
Cartridge seal sleeve size increments required.	None	10 mm increments. (6.2.2.3.1)	10 mm increments. (6.2.2.3.1)
Throttle bushing design requirement for Arrangement 1 seals. (7.1.2.1)	Fixed carbon. Floating carbon option. (7.1.2.2)	Fixed, non-sparking metal. Floating carbon option. (7.1.2.2)	Floating carbon.
Dual seal circulation device head flow curve provided.	Not applicable.	If specified. (8.6.2.2)	Required. (8.6.2.2)
Scope of vendor qualification test.	Test as Category 1 unless faces interchangeable with Category 3. (10.3.1.2.2)	Test as Category 2 unless faces interchangeable with Category 3. (10.3.1.2.2)	Test as Category 3, entire seal assembly as a unit. (10.3.1.2.1)
Proposal data requirements.	Minimal. (11.2.2)	Minimal. (11.2.2)	Rigorous, including qualification test results. (11.2.2)
Contract data requirements.	Minimal. (11.3.1)	Minimal. (11.3.1)	Rigorous. (11.3.1)

SHEET 2 OF 10 CONTINUED

Seal type shall be Type A, B, or C as specified.

The major features of each type are summarized below. Options, where they exist for each feature, are listed in the text as "if specified". Clause numbers in parentheses indicate where the requirements are specified.

FEATURE	TYPE A	TYPE B	TYPE C
Standard temperature application range. (1.2)	– 40ºC to 176ºC	– 40ºC to 176ºC	– 40ºC to 400ºC
Hydraulic balance requirement. (1.2 and 6.1.1.7)	Balanced (e.g. hydraulic balance less than 1).	Balanced (e.g. hydraulic balance less than 1).	Balanced (e.g. hydraulic balance less than 1).
Mounting requirement. (1.2)	Inside the seal chamber.	Inside the seal chamber.	Inside the seal chamber.
Cartridge requirement. (1.2 and 6.1.1.1)	Cartridge design.	Cartridge design.	Cartridge design.
Flexible element style. (1.2)	Pusher (e.g. sliding elastomer).	Non-pusher (e.g. bellows).	Non-pusher (e.g. bellows).
Flexible element orientation. (1.2)	Rotating. (6.1.1.2)	Rotating. (6.1.1.2)	Stationary. (6.1.1.3)
Bellows material. (6.1.6.6)	Not applicable.	Alloy C-276	Alloy 718
Spring type. (1.2)	Multiple coil springs. (6.1.5.1)	Single bellows.	Single bellows.
Limit for stationary element application. (6.1.1.5)	23 m/s	23 m/s	Not applicable.
Secondary sealing element material. (1.2)	Elastomer.	Elastomer.	Flexible graphite.

SHEET 2 OF 10 CONTINUED

Seal arrangement shall be Arrangement 1, 2, or 3 as specified.

The major features of each arrangement are summarized below. Options, where they exist for each feature, are listed in the text as "if specified". Clause numbers in parentheses indicate where the requirements are specified.

FEATURE	ARRANGEMENT 1	ARRANGEMENT 2	ARRANGEMENT 3
Number of "seals" per cartridge, see definition of seal in 3.61. (1.2)	One (3.2)	Two (3.3)	Two (3.4)
Uses a barrier or buffer fluid. (1.2)	No	Sometimes, but not required. Liquid or gas permitted.	Yes, barrier fluid required, liquid or gas permitted.
Allows non-contacting (wet or dry) seals. (1.2)	No	See Figure 1.	See Figure 1.
Arrangement 1 throttle bushing requirement. (7.1.2.1)	Category 1: Fixed carbon. Category 2: Floating, non-sparking metallic. Category 3: Floating carbon.	Not applicable.	Not applicable.
Arrangement 2 & 3 throttle bushing requirement.	Not applicable.	Fixed carbon, if specified. (7.2.3.1)	Fixed carbon, if specified. (7.3.3.1)
Arrangement 2 containment seal chamber bushing requirement.	Not applicable.	Required with dry running containment seal regardless of inner seal design. (7.2.5.1.1 and 7.2.6.1.1)	Not applicable.
Tangential buffer/barrier fluid outlet required?	Not applicable.	If specified, for Categories 1 and 2. Required for Category 3. (7.2.4.2.1)	If specified, for Categories 1 and 2. Required for Category 3. (7.3.4.3.1)
Maximum buffer/barrier fluid temperature rise.	Not applicable.	8°C aqueous or diesel, 16°C mineral oils. (7.2.4.1.1)	8°C aqueous or diesel, 16°C mineral oils. (7.3.4.1.1)
Seal chamber pressure/flush design requirement. (6.1.2.14.1)	Minimum margin of 30% of seal chamber pressure above fluid vapor pressure or 20°C margin.	Minimum margin of 30% of seal chamber pressure above fluid vapor pressure or 20°C margin.	None
Minimum operating seal chamber pressure requirement. (6.1.2.14.2)	0,35 bar above atmospheric.	0,35 bar above atmospheric.	None
Minimum gland plate connection sizes and orientation.	See Table 1.	See Table 1.	See Table 1.
Minimum barrier/buffer fluid liquid reservoir.	Not applicable.	12 l for shaft diameter below 60 mm; otherwise 20 l. (8.5.4.3.1)	12 l for shaft diameter below 60 mm; otherwise 20 l. (8.5.4.3.1)
Test requirements, inner seal.	Not applicable.	All, regardless of liquid, gas, or no buffer, contacting or non-contacting. (10.3.1.3.4)	Liquid barrier. (10.3.1.3.4) Gas barrier. (10.3.1.3.6)
Test requirements, outer seal.	Not applicable.	Liquid buffer. (10.3.1.3.4) Gas or no buffer. (10.3.1.3.5)	Liquid barrier. (10.3.1.3.4) Gas barrier. (10.3.1.3.5)

RECOMMENDED SEAL TYPE SELECTION PROCEDURE (SI UNITS)
Non-hydrocarbon services
SHEET 3 OF 10

			Operating conditions, recommended seal types and special features							
		Fluids	1	2	3	4	5	6	7	8
			Water	Water	Water	Sour Water	Sour Water	Caustic Amines Crystallize	Caustic Amines Crystallize	Acids[1] H_2SO_4, H_3PO_4
		Pumping Temp.ºC	< 80	< 80	> 80	< 80	< 80	< 80	< 80	< 80
		Seal Chamber Press. (Bar) Category I seals	< 22		< 22	< 22		< 22		< 22
		Seal Chamber Press. (Bar) Category II and III seals	< 22	22 to 42	< 42	< 22	22 to 42	< 22	22 to 42	< 22
		Standard seal type	A	A	A	A	A	A	A	A
		Options when specified	B C	ES 2	ES 2	B C	ES 2	B C	ES 2	B C
		Required special features			f	c	c	e	e	c & g
Special features	Contaminants	Abrasive particulates	d	d	d	d	d	d	d	d
Note 3										

This selection procedure chooses seal designs consistent with the default positions throughout this Standard. Listed options meeting this standard may perform equally well.

1) Up to 20% H_2SO_4 at 25ºC only. Up to 20% H_3PO_4 at 80ºC only. All other acids including hydrofluoric acid, fuming nitric, and hydrochloric acids require special engineering between owner and vendor.
2) ES = Totally engineered sealing system. Consult vendor to ensure special design considerations are accounted for
3) Special features listed above only apply in mixtures having a pH between 4 and 11.

Key to special features:

a. NH_3 resistant carbon graphite

b. Nitrile O-rings

c. Perfluoroelastomer

d. Hardface vs Hardface

e. Amine resistant perfluoroelastomer

f. Circulating device

g. Single spring for Type A seals

RECOMMENDED SEAL TYPE SELECTION PROCEDURE (SI UNITS)
Non-flashing hydrocarbon at vapor pressure < 1 Bar at PT
SHEET 4 OF 10

		Operating conditions, recommended seal types and special features							
		1	2	3	4	5	6	7	8
	Pumping Temp.ºC	– 40 to – 5	– 40 to – 5	– 5 to – 176	– 5 to – 176	176 to 260	176 to 260	260 to 400	260 to 400
	Seal chamber pressure (Bar) Category I seals	< 22		< 22		< 22		N/A	N/A
	Seal chamber pressure (Bar) Category II and III seals	< 22	22 to 42	< 22	22 to 42	< 22	22 to 42	< 22	22 to 42
	Standard seal type	A	A	A	A	C	ES[1]	C	ES[1]
	Option when specified	B	ES [1,2]	B	ES [1,2]	ES[1]		ES[1]	
	Option when specified	C		C					
	Required special features	b	b						
Special features / Contaminants	Caustic			c	c				
	Abrasive particulates	d	d	d	d	d	d	d	d
	Aromatics and/or H_2S			c	c				
	Amines			e	e				
Note 3									

This selection procedure chooses seal designs consistent with the default positions throughout this Standard. Listed options meeting this standard may perform equally well.

1) ES = Totally engineered sealing system. Consult vendor to ensure special design considerations are accounted for.
2) Engineered (high pressure) bellows
3) Special features listed above only apply in mixtures having a pH between 4 and 11.

Key to special features
Special Features:

a. NH_3 resistant carbon graphite

b. Nitrile O-rings

c. Perfluoroelastomer

d. Hardface vs hardface

e. Amine resistant perfluoroelastomer

f. Circulating device

g. Single spring for Type A seals

RECOMMENDED SEAL TYPE SELECTION PROCEDURE (SI UNITS)

Flashing hydrocarbon at vapor pressure < 1 Bar at PT

SHEET 5 OF 10

			Operating conditions, recommended seal types and special features							
			1	2	3	4	5	6	7	8
		Pumping Temp.ºC	– 40 to – 5	– 40 to – 5	– 5 to – 176	– 5 to – 176	176 to 260	176 to 260	260 to 400	260 to 400
		Seal chamber pressure (Bar) Category I seals	< 22		< 22		< 22		N/A	N/A
		Seal chamber pressure (Bar) Category II and III seals	< 22	22 to 42	< 22	22 to 42	< 22	22 to 42	< 22	22 to 42
		Standard seal type	A	A	A[4]	A[4]	C	ES[1,2]	C	ES[1,2]
		Option when specified	ES[1]	ES[1,2]	ES[1]	ES[1,2]	ES[1]		ES[1]	
		Required special features	b	b						
Special features	Contaminants	Caustic			c	c				
		Abrasive particulates	d	d	d	d	d	d	d	d
		Aromatics and/or H_2S			c	c				
		Amines			e	e				
		Ammonia	a	a	a	a	a	a	a	a
Note 3										

This selection procedure chooses seal designs consistent with the default positions throughout this Standard. Listed options meeting this standard may perform equally well.

1) ES = Totally engineered sealing system. Consult vendor to ensure special design considerations are accounted for.
2) Engineered bellows
3) Special features listed above only apply in mixtures having a pH between 4 and 11.
4) Requires special feature f (circulating device) above 60ºC, and special feature c (perfluoroelastomer) if PT is above 175ºC.

a. NH_3 resistant carbon graphite

b. Nitrile O-rings

c. Perfluoroelastomer

d. Hardface vs hardface

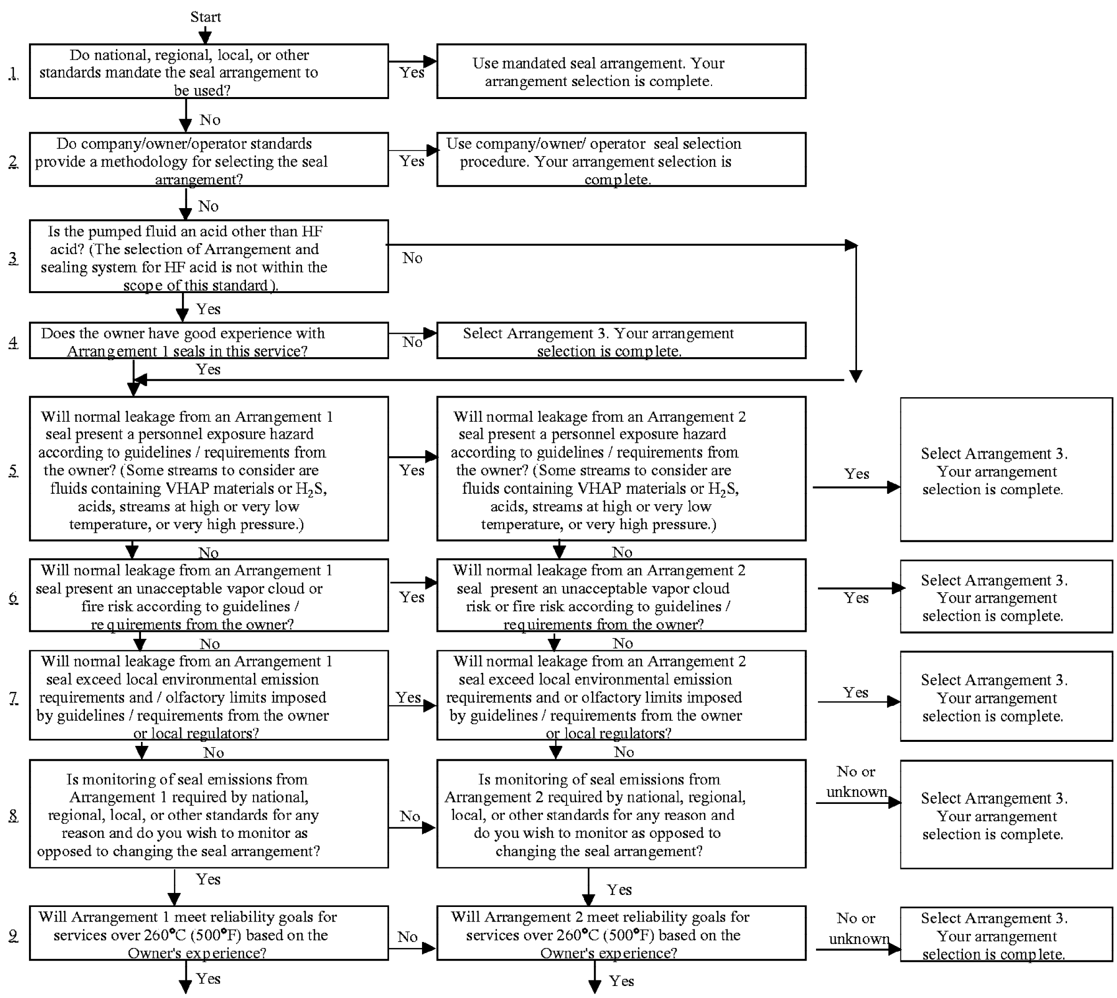
e. Amine resistant perfluoroelastomer

f. Circulating device

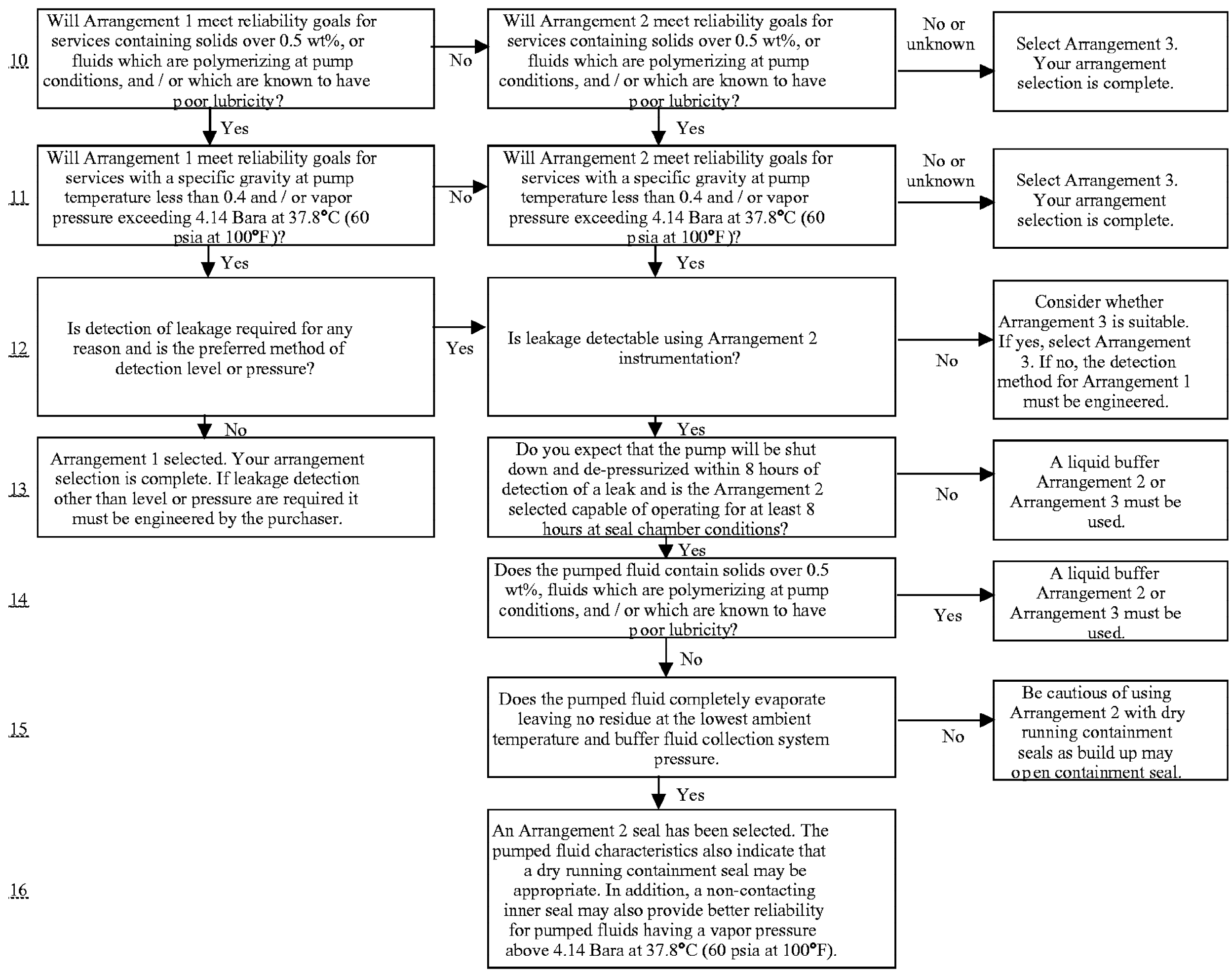
g. Single spring for Type A seals

RECOMMENDED SEAL ARRANGEMENT SELECTION PROCEDURE (SI UNITS)
SHEET 6 OF 10

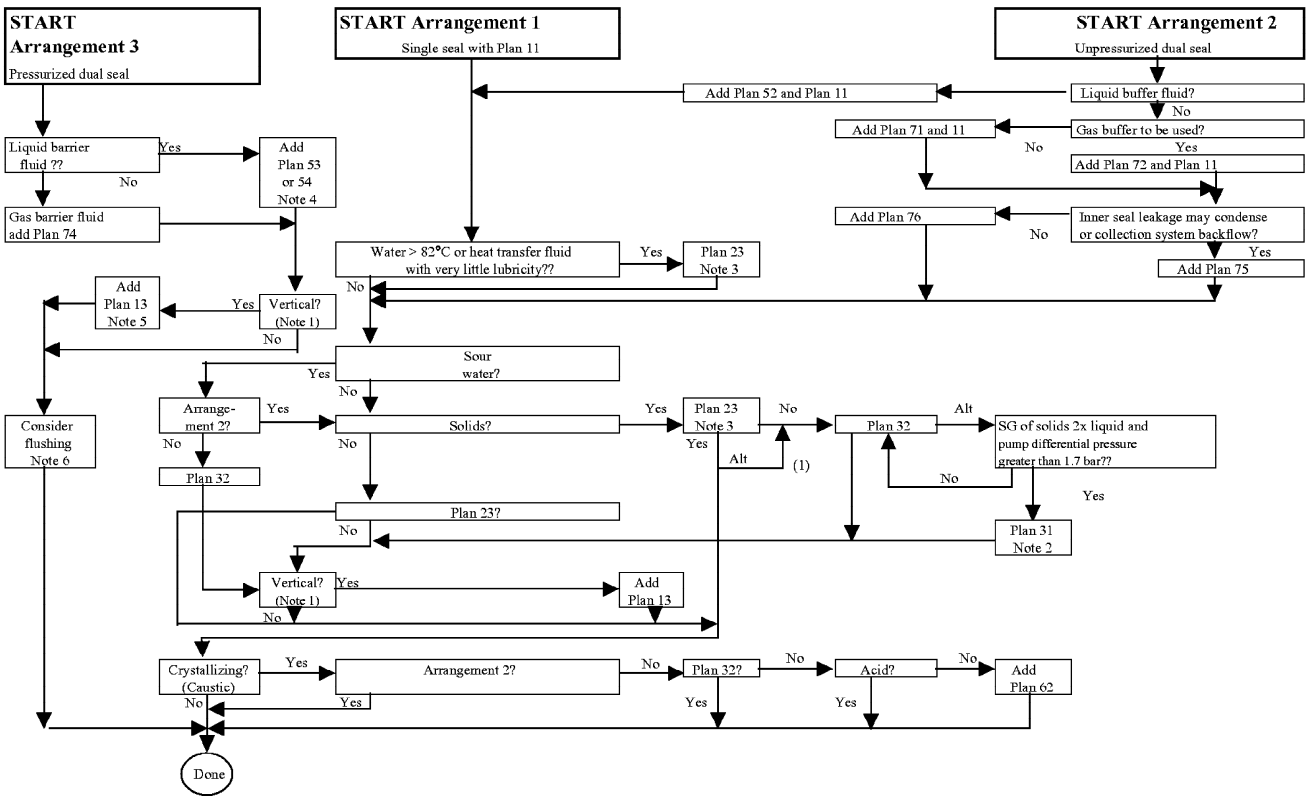
Assume Arrangement 1 to begin



RECOMMENDED SEAL ARRANGEMENT SELECTION PROCEDURE (SI UNITS)
SHEET 6 OF 10 — Continued



RECOMMENDED SEAL ARRANGEMENT SELECTION PROCEDURE (SI UNITS)
SHEET 7 OF 10
Non-hydrocarbon



Note 1 The user should evaluate whether to add Plan 13 or not considering such factors as the inclusion of a bleed bushing, contamination of the seal chamber with pumped fluid, the need for venting of the seal chamber, and the need to reduce seal chamber pressure due to static or dynamic pressure rating of the seal versus the expected static and dynamic seal chamber pressure.

Note 2: If a Plan 31 is selected and pump is vertical, Plan 13 will also be recommended. Users should consider installation of a "bleed bushing" design where an annulus and port cut into the throat bushing is Connected to suction to keep solids out of the seal chamber.

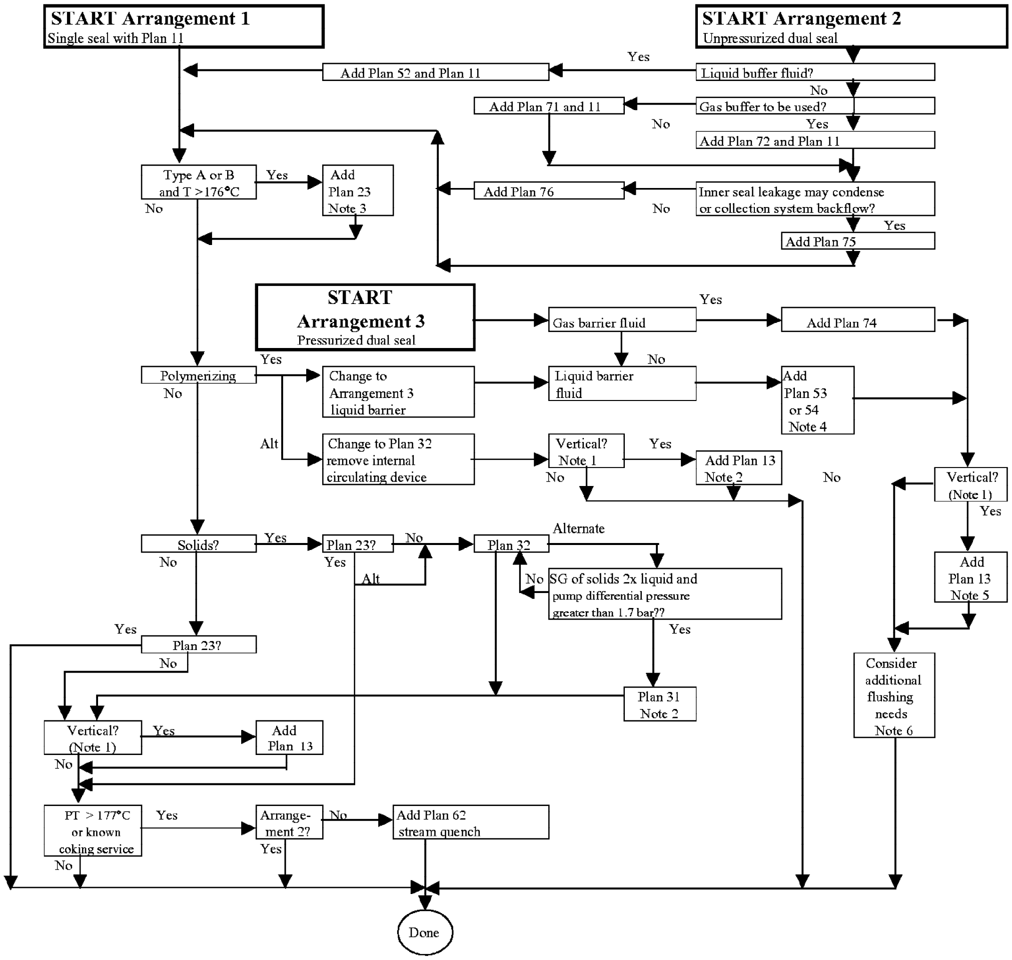
Note 3 Cooling is needed due to low lubricity at elevated temperature. The recommended flush plan is 23 because field experience has shown that this plan is much less prone to plugging than Plan 21 due to recirculation of cooler fluid from the seal chamber. However, the user may wish to re-consider using a Plan 21 due to the added seal complexity imposed by Plan 23 (size and cost) and other factors such as the use of an air cooler for Plan 21 in areas where water cannot be used or is not available. (An air cooler works better on Plan 21 due to the higher delta T between pumpage and the cooling medium.) The user may also wish to consider the use of Plan 32 if a suitable fluid is available, especially if the fluid is normally injected into the process anyway (such as make up water). See the flush descriptions later in this annex for additional detail.

Note 4 See tutorial this annex on selection of Plan 53a, 53b, or 53c.

Note 5 Consider adding Plan 13 to Arrangement 3 for venting especially for liquid barrier fluid. Consider the effects in Note 1 as well. Consult the pump vendor for the need for a Plan 13.

Note 6 Consider the need to add additional flushing to the process side of the inner seal (e.g. the seal chamber). This is sometimes needed for Arrangement 3 face to back (FB) orientation to provide additional cooling and may be a Plan 11. Other services may require a Plan 32 if the pumped fluid is extremely corrosive, aggresive or solids laden. Consult the seal vendor to determine if additional cooling of the inner seal is needed.

RECOMMENDED SEAL ARRANGEMENT SELECTION PROCEDURE (SI UNITS)
SHEET 8 OF 10
Non-flashing hydrocarbon



Note 1 The user should evaluate whether to add Plan 13 or not considering such factors as the inclusion of a bleed bushing, contamination of the seal chamber with pumped fluid,the need for venting of the seal chamber and the need to reduce seal chamber pressure due to static or dynamic pressure rating of the seal versus the expected static and dynamic seal chamber pressure.

Note 2: If a Plan 31, 32, or 41 is selected and pump is vertical, Plan 13 will also be recommended for venting. Users should consider installation of a "bleed bushing" design where an annulus and port cut into the throat bushing is connected to suction to keep solids or polymerizing agents out of the seal chamber. Ensure seal chamber is vented prior to start-up.

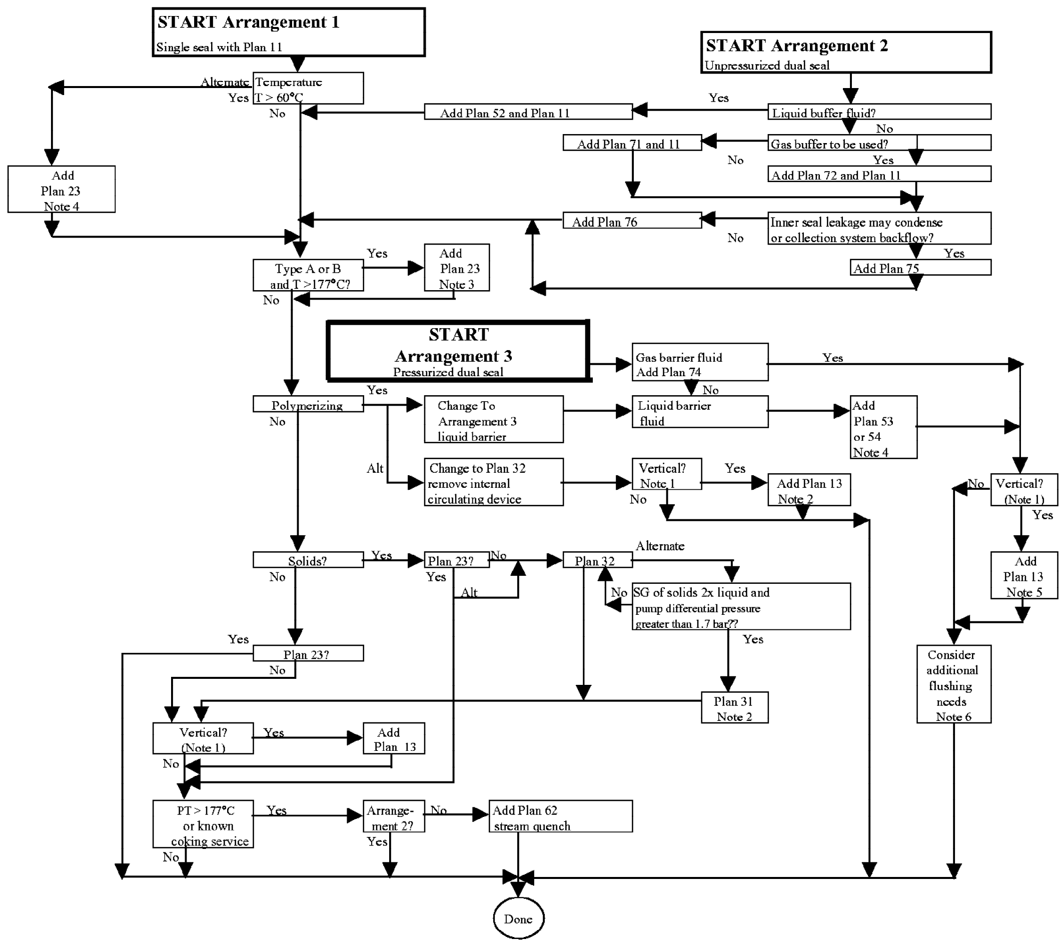
Note 3 Cooling is needed due to temperature limits of the standard secondary elastomers for Arrangement 1 and possibly for Arrangement 2 (consult the seal vendor).
Consideration may be given to changing to perflouroelastomer if cooling is not possible.
The recommended flush plan is 23 because field experience has shown that this plan is much less prone to plugging than Plan 21 due to recirculation of cooler fluid from the seal chamber. However, the user may wish to re-consider using a Plan 21 due to the added seal complexity imposed by Plan 23 (size and cost) and other factors such as the use of an air cooler for Plan 21 in areas where water cannot be used or is not available. (An air cooler works better on Plan 21 due to the higher delta T between pumpage and the cooling medium.) The user may also wish to consider the use of Plan 32 if a suitable fluid is available, especially if the fluid is normally injected into the process anyway (such as make up water). See the flush descriptions later in this annex for additional detail.

Note 4 See tutorial this annex on selection of Plan 53a, 53b, or 53c.

Note 5 Consider adding Plan 13 to Arrangement 3 for venting especially for liquid barrier fluid. Consider the effects in Note 1 as well. Consult the pump vendor for the need for a Plan 13.

Note 6 Consider the need to add additional flushing to the process side of the inner seal (e.g. the seal chamber). This is sometimes needed for Arrangement 3 face to back (FB) orientation to provide additional cooling and may be a Plan 11. Other services may require a Plan 32 if the pumped fluid is extremely corrosive, aggresive or solids laden. Consult the seal vendor to determine if additional cooling of the inner seal is needed.

RECOMMENDED SEAL ARRANGEMENT SELECTION PROCEDURE (SI UNITS)
SHEET 9 OF 10
Flashing hydrocarbon



Note 1 The user should evaluate whether to add Plan 13 or not considering such factors as the inclusion of a bleed bushing, contamination of the seal chamber with pumped fluid, the need for venting of the seal chamber, and the need to reduce seal chamber pressure due to static or dynamic pressure rating of the seal versus the expected static and dynamic seal chamber pressure.

Note 2: If a Plan 31, 32, or 41 is selected and pump is vertical, Plan 13 will also be recommended for venting. Users should consider installation of a "bleed bushing" design where an annulus and port cut into the throat bushing is connected to suction to keep solids or polymerizing agents out of the seal chamber. Ensure seal chamber is vented prior to start-up.

Note 3 Cooling is needed due to temperature limits of the standard secondary elastomers for Arrangement 1 and possibly for Arrangement 2 (consult the seal vendor).
Consideration may be given to changing to perflouroelastomer if cooling is not possible.
The recommended flush plan is 23 because field experience has shown that this plan is much less prone to plugging than Plan 21 due to recirculation of cooler fluid from the seal chamber. However, the user may wish to re-consider using a Plan 21 due to the added seal complexity imposed by Plan 23 (size and cost) and other factors such as the use of an air cooler for Plan 21 in areas where water cannot be used or is not available. (An air cooler works better on Plan 21 due to the higher delta T between pumpage and the cooling medium.) The user may also wish to consider the use of Plan 32 if a suitable fluid is available, especially if the fluid is normally injected into the process anyway (such as make up water). See the flush descriptions later in this annex for additional detail.

Note 4 See tutorial this annex on selection of Plan 53a, 53b, or 53c.

Note 5 Consider adding Plan 13 to Arrangement 3 for venting especially for liquid barrier fluid. Consider the effects in Note 1 as well. Consult the pump vendor for the need for a Plan 13.

Note 6 Consider the need to add additional flushing to the process side of the inner seal (e.g. the seal chamber). This is sometimes needed for Arrangement 3 face to back (FB) orientation to provide additional cooling and may be a Plan 11. Other services may require a Plan 32 if the pumped fluid is extremely corrosive, aggresive or solids laden. Consult the seal vendor to determine if additional cooling of the inner seal is needed.

RECOMMENDED SEAL ARRANGEMENT SELECTION PROCEDURE (SI UNITS)
Buffer/barrier fluid selection
SHEET 10 OF 10

The following should be considered when selecting a barrier/buffer fluid:

a) compatibility of the fluid with the process pumpage being sealed so as not to react with or form gels or sludge if leaked into the process fluid or the process fluid into the barrier/buffer fluid; and

b) compatibility of the fluid with the metallurgy, elastomers, and other materials of the seal/flush system construction.

On pressurized barrier fluid system where the method of pressurization is a gas blanket, special attention shall be given to the application conditions and barrier fluid selection. Gas solubility in a barrier fluid increases with increasing temperature and pressure. As pressure is relieved or temperatures cool, the gas is released from solution, and may result in foaming and loss of circulation of the barrier fluid. This problem is normally seen where higher viscosity barrier fluids, such as lube oils, are used at pressures above 10 bar.

The viscosity of the barrier/buffer fluid should be checked over the entire operating temperature range with special attention being given to start-up conditions. The viscosity should be less than 500 mm^2/s at the minimum temperature to which it is exposed.

a) For services above 10°C, hydrocarbon barrier/buffer fluids having a viscosity below 100 mm^2/s at 38°C, and between 1 mm^2/s and 10 mm^2/s at 100°C, have performed satisfactorily.

b) For services below 10°C, hydrocarbon barrier/buffer fluids having a viscosity between 5 mm^2/s and 40 mm^2/s at 38°C, and between 1 mm^2/s and 10 mm^2/s at 100°C, have performed satisfactorily.

c) For aqueous streams, mixtures of water and ethylene glycol or propylene glycol are usually adequate. Commercially available automotive anti-freeze should never be used. The additives in anti-freeze tend to plate out on seal parts and cause failure as a result of gel formation.

d) The fluid should not freeze at the minimum site ambient temperature.

Fluid volatility and toxicity of the fluid shall be such that leakage to the atmosphere or disposal does not impose an environmental problem.

a) The fluid should have an initial boiling point at least 28°C above the temperature to which it will be exposed.

b) Have a flash point higher than the service temperature if oxygen is present.

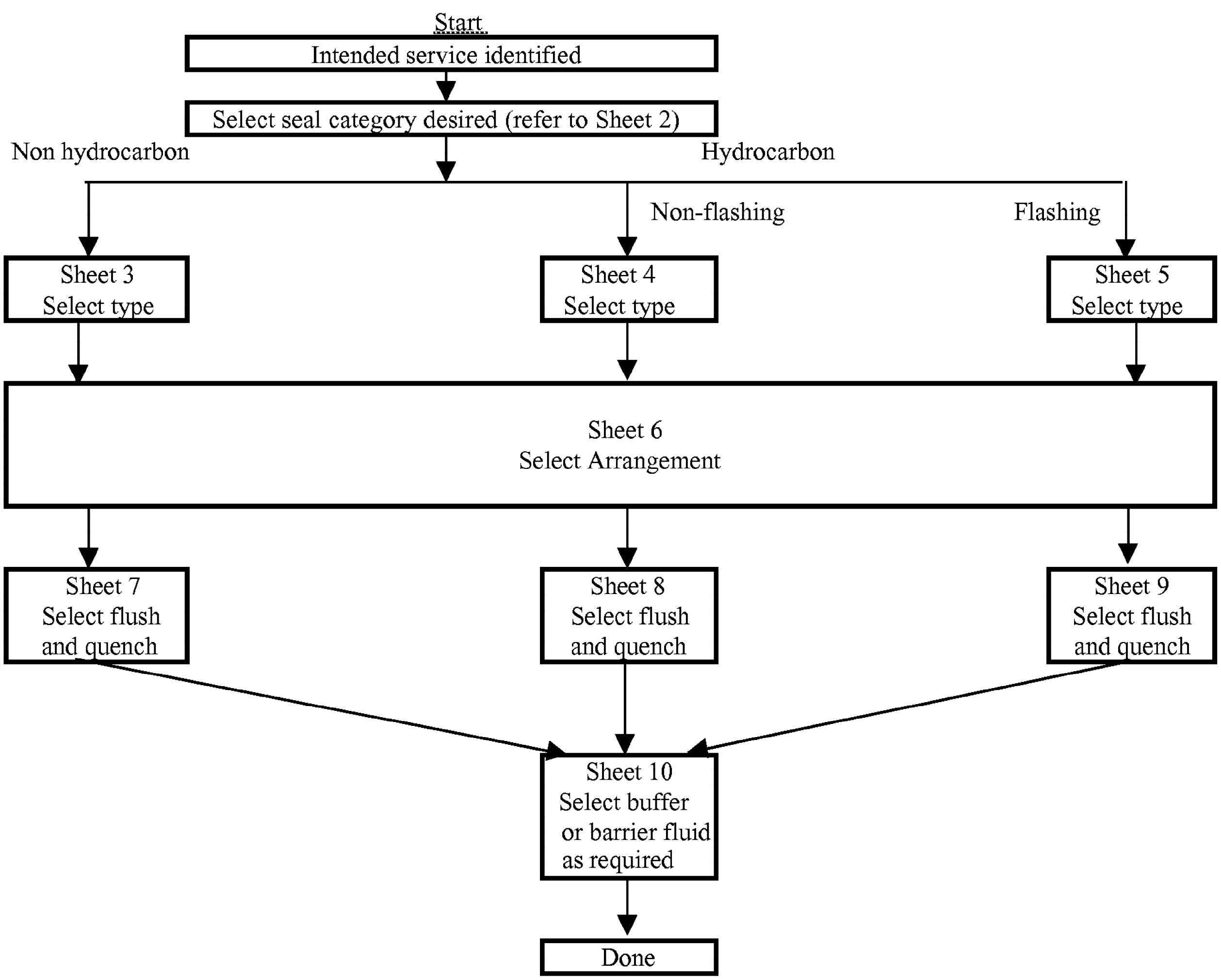
c) Ethylene glycol may be considered a hazardous material and/or hazardous waste when used as a barrier fluid.

The fluid should be able to meet the minimum 3-year continuous seal operation criteria without adverse deterioration. It should not form sludge, polymerize, or coke after extended use.

a) For hydrocarbon streams, paraffinic based high purity oils having little or no additives for wear/oxidation resistance or synthetic based oils have been used successfully.

b) Anti-wear/oxidation resistant additives in commercial turbine oils have been known to plate out on seal faces.

RECOMMENDED SEAL SELECTION PROCEDURE (US CUSTOMARY UNITS)
SHEET 1 OF 10



RECOMMENDED SEAL SELECTION PROCEDURE (US CUSTOMARY UNITS)
SEAL CATEGORY, TYPE, AND ARRANGEMENT SUMMARY
SHEET 2 OF 10

Seal category shall be Category 1, 2 or 3 as specified.

The major features of each category are summarized below. Options, where they exist for each feature, are listed in the text as "if specified". Clause numbers in parentheses indicate where the requirements are specified.

FEATURE	CATEGORY 1	CATEGORY 2	CATEGORY 3
Seal chamber size. (1.2)	ISO 3069 Type C, ANSI/ASME B73.1 and ANSI/ASME B73.2.	ISO 13709.	ISO 13709.
Temperature range. (1.2)	– 40ºF to 500ºF	– 40ºF to 750ºF	– 40ºF to 750ºF
Pressure range, absolute. (1.2)	315 psi	615 psi	615 psi
Face materials. (6.1.6.2.3)	Premium blister resistant carbon vs. self sintered silicon carbide.	Premium blister resistant carbon vs. reaction bonded silicon carbide.	Premium blister resistant carbon vs. reaction bonded silicon carbide.
Distributed inlet flush requirements, Arrangements 1 and 2 with rotating flexible elements.	When required per 6.1.2.14 or if specified. (6.2.1.2.1)	When required per 6.1.2.14 or if specified. (6.2.2.2.1)	Required. (6.2.3.2.1)
Gland plate metal to metal contact requirement.	Required. (6.2.1.2.2)	Required inside and outside of the bolt circle diameter. (6.2.2.2.2)	Required inside and outside of the bolt circle diameter. (6.2.2.2.2)
Cartridge seal sleeve size increments required.	None	10 mm increments. (6.2.2.3.1)	10 mm increments. (6.2.2.3.1)
Throttle bushing design requirement for Arrangement 1 seals. (7.1.2.1)	Fixed carbon. Floating carbon option. (7.1.2.2)	Fixed, non-sparking metal. Floating carbon option. (7.1.2.2)	Floating carbon.
Dual seal circulation device head flow curve provided.	Not applicable.	If specified. (8.6.2.2)	Required. (8.6.2.2)
Scope of vendor qualification test.	Test as Category 1 unless faces interchangeable with Category 3. (10.3.1.2.2)	Test as Category 2 unless faces interchangeable with Category 3. (10.3.1.2.2)	Test as Category 3, entire seal assembly as a unit. (10.3.1.2.1)
Proposal data requirements.	Minimal. (11.2.2)	Minimal. (11.2.2)	Rigorous including qualification test results. (11.2.2)
Contract data requirements.	Minimal. (11.3.1)	Minimal. (11.3.1)	Rigorous. (11.3.1)

SHEET 2 OF 10 CONTINUED

Seal type shall be Type A, B, or C as specified.

The major features of each type are summarized below. Options, where they exist for each feature, are listed in the text as "if specified". Clause numbers in parentheses indicate where the requirements are specified.

FEATURE	TYPE A	TYPE B	TYPE C
Standard temperature application range. (1.2)	– 40ºF to 176ºF	– 40ºF to 176ºF	– 40ºF to 750ºF
Hydraulic balance requirement. (1.2 and 6.1.1.7)	Balanced (e.g. hydraulic balance less than 1).	Balanced (e.g. hydraulic balance less than 1).	Balanced (e.g. hydraulic balance less than 1).
Mounting requirement. (1.2)	Inside the seal chamber.	Inside the seal chamber.	Inside the seal chamber.
Cartridge requirement. (1.2 and 6.1.1.1)	Cartridge design.	Cartridge design.	Cartridge design.
Flexible element style. (1.2)	Pusher (e.g. sliding elastomer).	Non-pusher (e.g. bellows).	Non-pusher (e.g. bellows).
Flexible element orientation. (1.2)	Rotating. (6.1.1.2)	Rotating. (6.1.1.2)	Stationary. (6.1.1.3)
Bellows material. (6.1.6.6)	Not applicable.	Alloy C-276	Alloy 718
Spring type. (1.2)	Multiple coil springs. (6.1.5.1)	Single bellows.	Single bellows.
Limit for stationary element application. (6.1.1.5)	4,500 ft/min	4,500 ft/min	4,500 ft/min
Secondary sealing element material. (1.2)	Elastomer.	Elastomer.	Flexible graphite.

SHEET 2 OF 10 CONTINUED

Seal arrangement shall be Arrangement 1, 2, or 3 as specified.

The major features of each arrangement are summarized below. Options, where they exist for each feature, are listed in the text as "if specified". Clause numbers in parentheses indicate where the requirements are specified.

FEATURE	ARRANGEMENT 1	ARRANGEMENT 2	ARRANGEMENT 3
Number of "seals" per cartridge, see definition of seal in 3.61. (1.2)	One (3.2)	Two (3.3)	Two (3.4)
Uses a barrier or buffer fluid. (1.2)	No	Sometimes but not required. Liquid or gas permitted.	Yes, barrier fluid required, liquid or gas permitted.
Allows non-contacting (wet or dry) seals. (1.2)	No	See Figure 1.	See Figure 1.
Arrangement 1 throttle bushing requirement. (7.1.2.1)	Category 1: Fixed carbon. Category 2: Floating, non-sparking metallic. Category 3: Floating carbon.	Not applicable.	Not applicable.
Arrangements 2 & 3 throttle bushing requirement.	Not applicable.	Fixed carbon, if specified. (7.2.3.1)	Fixed carbon, if specified. (7.3.3.1)
Arrangement 2 containment seal chamber bushing requirement.	Not applicable.	Required with dry running containment seal regardless of inner seal design. (7.2.5.1.1 and 7.2.6.1.1)	Not applicable.
Tangential buffer/barrier fluid outlet required?	Not applicable.	If specified, for Categories 1 and 2. Required for Category 3. (7.2.4.2.1)	If specified, for Categories 1 and 2. Required for Category 3. (7.3.4.3.1)
Maximum buffer/barrier fluid temperature rise.	Not applicable.	15°F aqueous or diesel, 30°F mineral oils. (7.2.4.1.1)	15°F aqueous or diesel, 30°F mineral oils. (7.3.4.1.1)
Seal chamber pressure/flush design requirement. (6.1.2.14.1)	Minimum margin of 30% of seal chamber pressure above fluid vapor pressure or 36°F margin.	Minimum margin of 30% of seal chamber pressure above fluid vapor pressure or 36°F margin.	None
Minimum operating seal chamber pressure requirement. (6.1.2.14.2)	5 psi above atmospheric.	5 psi above atmospheric.	None
Minimum gland plate connection sizes and orientation.	See Table 1.	See Table 1.	See Table 1.
Minimum barrier/buffer fluid liquid reservoir.	Not applicable.	3 gal for shaft diameter below 2,5 in.; otherwise 5 gal. (8.5.4.3.1)	3 gal for shaft diameter below 2,5 in.; otherwise 5 gal. (8.5.4.3.1)
Test requirements, inner seal.	Not applicable.	All, regardless of liquid, gas, or no buffer, contacting or non-contacting. (10.3.1.3.4)	Liquid barrier. (10.3.1.3.4) Gas barrier. (10.3.1.3.6)
Test requirements, outer seal.	Not applicable.	Liquid buffer. (10.3.1.3.4) Gas or no buffer. (10.3.1.3.5)	Liquid barrier. (10.3.1.3.4) Gas barrier. (10.3.1.3.5)

RECOMMENDED SEAL SELECTION PROCEDURE (US CUSTOMARY UNITS)
SHEET 3 OF 10
Non-hydrocarbon services

			Operating conditions, recommended seal types and special features							
		Fluids	1	2	3	4	5	6	7	8
			Water	Water	Water	Sour Water	Sour Water	Caustic Amines Crystallize	Caustic Amines Crystallize	Acids[1] H_2SO_4, H_3PO_4
		Pumping Temp.ºF	< 180	< 180	> 180	< 180	< 180	< 180	< 180	< 180
		Seal chamber press. (psig) Category I seals	<300		< 300	< 300		< 300		< 300
		Seal chamber press. (psig) Category II and III seals	< 300	300 to 600	< 600	< 300	300 to 600	< 300	300 to 600	< 300
		Standard seal type	A	A	A	A	A	A	A	A
		Options when specified	B C	ES [2]	ES [2]	B C	ES [2]	B C	ES [2]	B C
		Required special features			F	c	c	e	e	c & g
Special features	Contaminants	Abrasive particulates	d	d	D	d	d	d	d	d
Note 3										

This selection procedure chooses seal designs consistent with the default positions throughout this Standard. Listed options meeting this standard may perform equally well.

1) Up to 20% H_2SO_4 at 25ºC only. Up to 20% H_3PO_4 at 80ºC only. All other acids including hydrofluoric acid, fuming nitric, and hydrochloric acids require special engineering between owner and vendor.
2) ES = Totally engineered sealing system. Consult vendor to ensure special design considerations are accounted for
3) Special features listed above only apply in mixtures having a pH between 4 and 11.

Key to special features:

a. NH_3 resistant carbon graphite

b. Nitrile O-rings

c. Perfluoroelastomer

d. Hardface vs hardface

e. Amine resistant perfluoroelastomer

f. Circulating device

g. Single spring for Type A seals

RECOMMENDED SEAL SELECTION PROCEDURE (US CUSTOMARY UNITS)
SHEET 4 OF 10
Non-flashing hydrocarbon

		Operating conditions, recommended seal types and special features							
		1	2	3	4	5	6	7	8
	Pumping Temp.ºF	– 40 to + 20	– 40 to + 20	20 to 350	20 to 350	350 to 500	350 to 500	500 to 750	500 to 750
	Seal chamber pressure (psig) Category I seals	< 300		< 300		< 300		N/A	N/A
	Seal chamber pressure (psig) Category II and III seals	< 300	300 to 600	< 300	300 to 600	< 300	300 to 600	< 300	300 to 600
	Standard seal type	A	A	A	A	C	ES[1]	C	ES[1]
	Option when specified	B	ES [1,2]	B	ES [1,2]	ES[1]		ES[1]	
	Option when specified	C		C					
	Required special features	b	b						
Special features / Contaminants	Caustic			c	c				
Special features / Contaminants	Abrasive particulates	d	d	d	d	d	d	d	D
Special features / Contaminants	Aromatics and/or H_2S			c	c				
Special features / Contaminants	Amines			e	e				
Note 3									

This selection procedure chooses seal designs consistent with the default positions throughout this Standard. Listed options meeting this standard may perform equally well.

1) ES = Totally engineered sealing system. Consult vendor to ensure special design considerations are accounted for.
2) Engineered (high pressure) bellows.
3) Special features listed above only apply in mixtures having a pH between 4 and 11.

Key to special features
Special Features:

a. NH_3 resistant carbon graphite

b. Nitrile O-rings

c. Perfluoroelastomer

d. Hardface vs hardface

e. Amine resistant perfluoroelastomer

f. Circulating device

g. Single spring for Type A seals

RECOMMENDED SEAL TYPE SELECTION PROCEDURE (US CUSTOMARY UNITS)
SHEET 5 OF 10
Flashing hydrocarbon

		Operating conditions, recommended seal types and special features							
		1	2	3	4	5	6	7	8
	Pumping Temp.°F	– 40 to + 20	– 40 to + 20	20 to 350	20 to 350	350 to 500	350 to 500	500 to 750	500 to 750
	Seal chamber pressure (psig) Category I seals	< 300		< 300		< 300		N/A	N/A
	Seal chamber pressure (Bar) Category II and III seals	< 300	300 to 600	< 300	300 to 600	< 300	300 to 600	< 300	300 to 600
	Standard seal type	A	A	A[4]	A[4]	C	ES[1,2]	C	ES[1,2]
	Option when specified	ES[1]	ES[1,2]	ES[1]	ES[1,2]	ES[1]		ES[1]	
	Required special features	b	b						
Special features – Contaminants	Caustic			c	c				
	Abrasive particulates	d	d	d	d	d	d	d	d
	Aromatics and/or H_2S			c	c				
	Amines			e	e				
	Ammonia	a	a	a	a	a	a	a	a
Note 3									

This selection procedure chooses seal designs consistent with the default positions throughout this Standard. Listed options meeting this standard may perform equally well.

1) ES = Totally engineered sealing system. Consult vendor to ensure special design considerations are accounted for.
2) Engineered bellows
3) Special features listed above only apply in mixtures having a pH between 4 and 11.
4) Requires special feature f (circulating device) above 140°F, and special feature c (perfluoroelastomer) if PT is above 350°F.

a. NH_3 resistant carbon graphite

b. Nitrile O-rings

c. Perfluoroelastomer

d. Hardface vs hardface

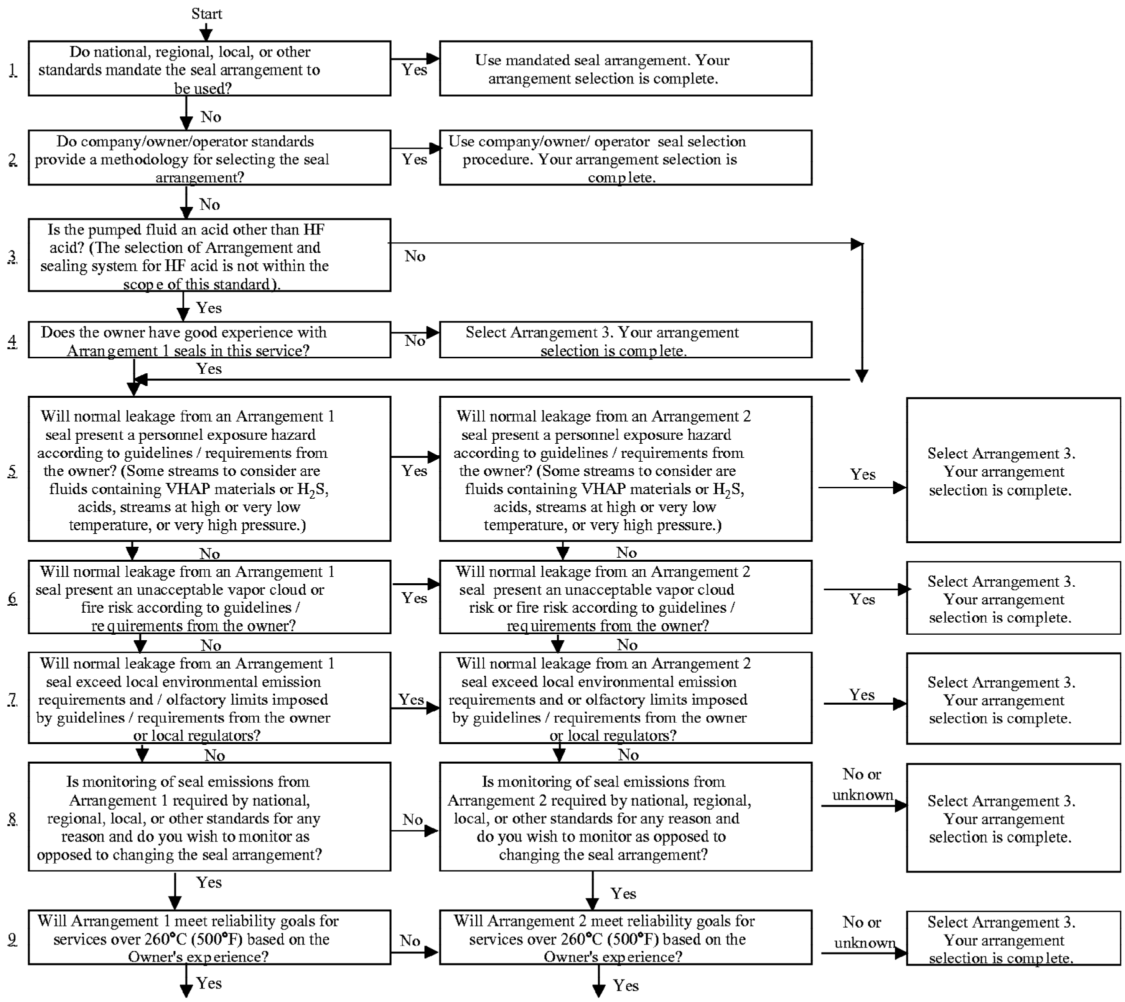
e. Amine resistant perfluoroelastomer

f. Circulating device

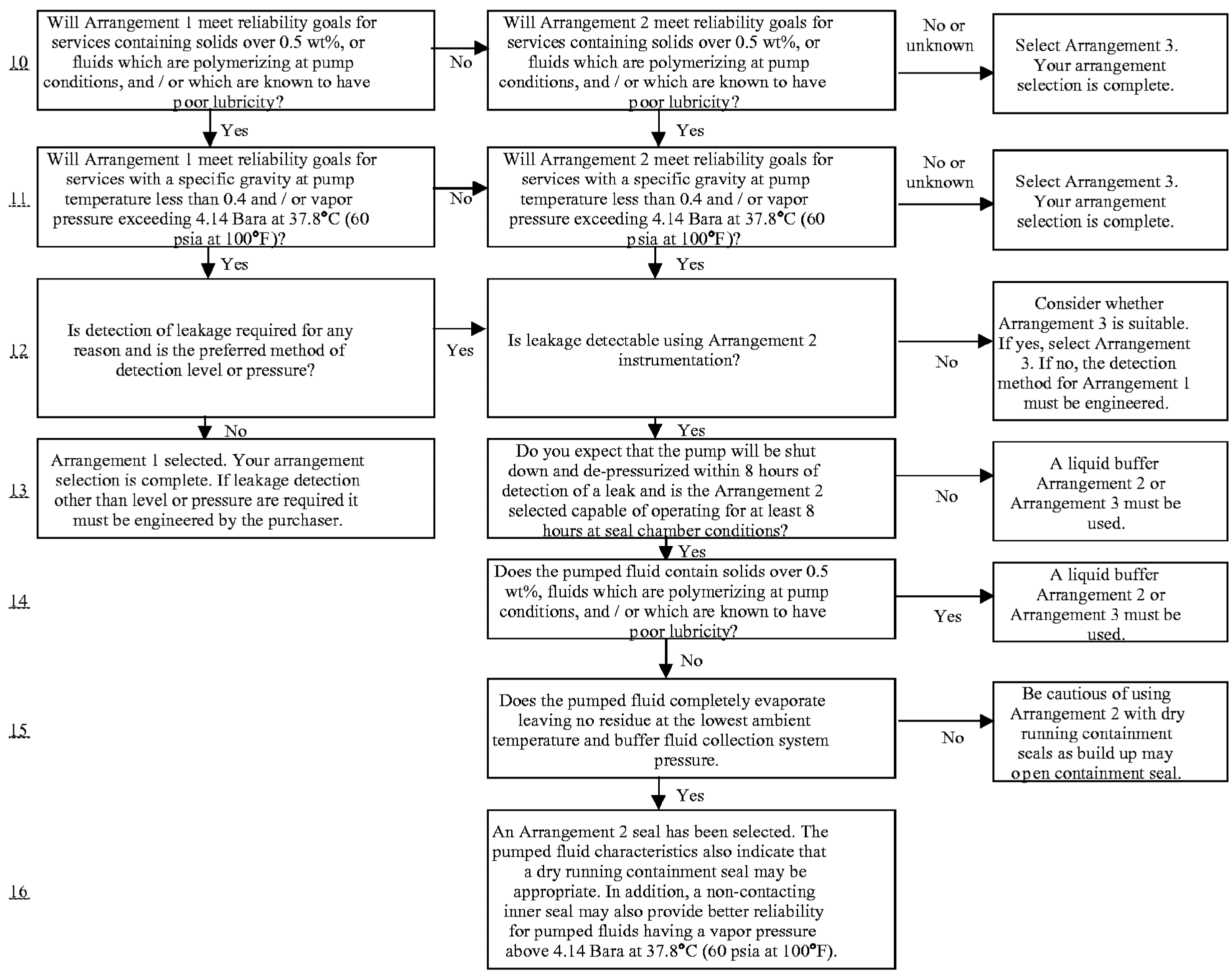
g. Single spring for Type A seals

RECOMMENDED SEAL ARRANGEMENT SELECTION PROCEDURE (US CUSTOMARY UNITS) SHEET 6 OF 10

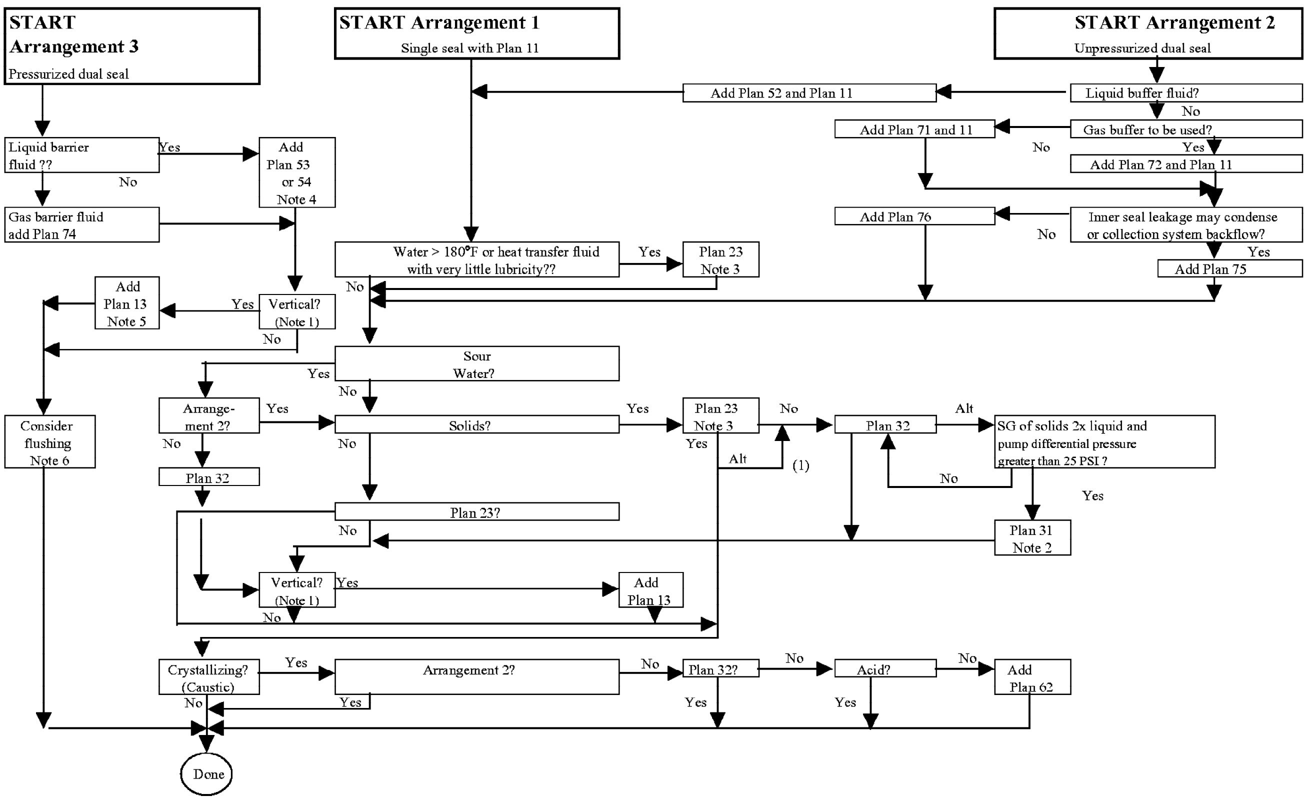
Assume Arrangement 1 to begin



RECOMMENDED SEAL ARRANGEMENT SELECTION PROCEDURE (US CUSTOMARY UNITS)
SHEET 6 OF 10 — Continued



RECOMMENDED SEAL TYPE SELECTION PROCEDURE (US CUSTOMARY UNITS)
SHEET 7 of 10
Non-hydrocarbon



Note 1 The user should evaluate whether to add Plan 13 or not considering such factors as the inclusion of a bleed bushing, contamination of the seal chamber with pumped fluid, the need for venting of the seal chamber, and the need to reduce seal chamber pressure due to static or dynamic pressure rating of the seal versus the expected static and dynamic seal chamber pressure.

Note 2: If a Plan 31 is selected and pump is vertical, Plan 13 will also be recommended. Users should consider installation of a "bleed bushing" design where an annulus and port cut into the throat bushing is connected to suction to keep solids out of the seal chamber.

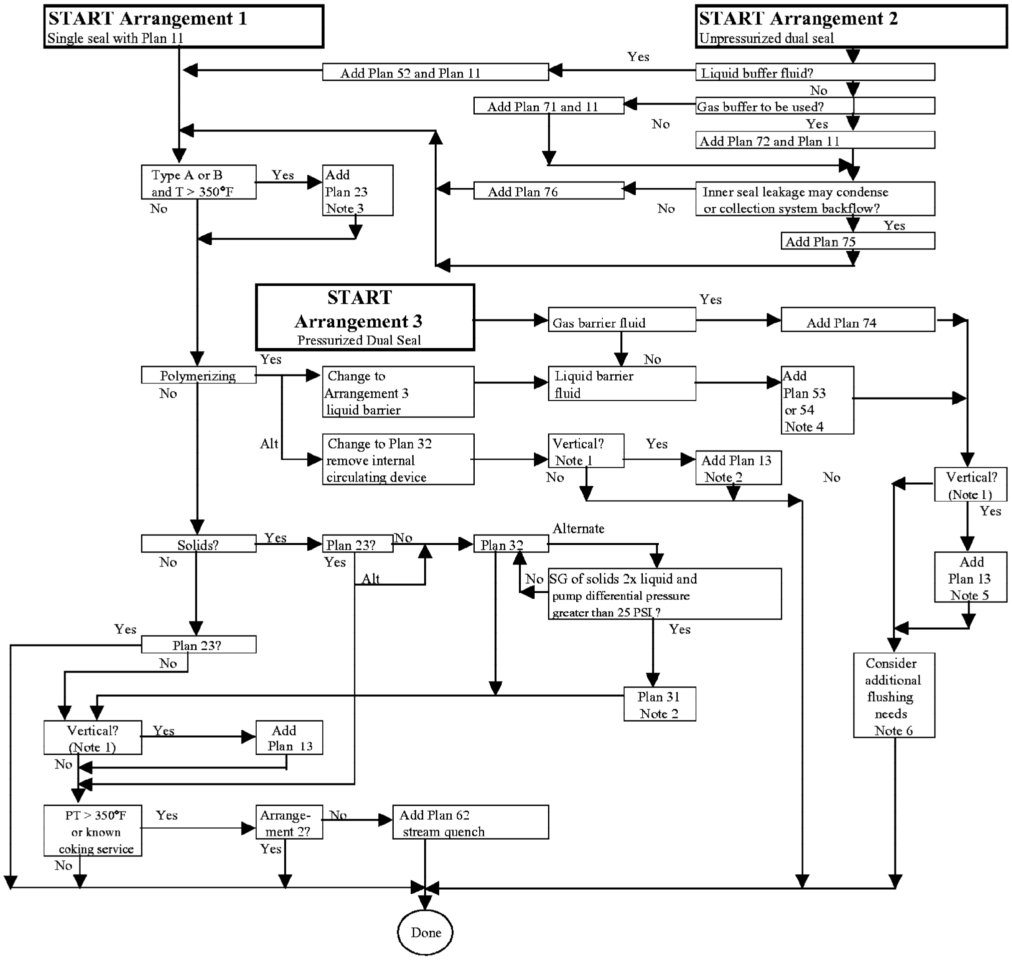
Note 3 Cooling is needed due to low lubricity at elevated temperature. The recommended flush plan is 23 because field experience has shown that this plan is much less prone to plugging than Plan 21 due to recirculation of cooler fluid from the seal chamber. However, the user may wish to re-consider using a Plan 21 due to the added seal complexity imposed by Plan 23 (size and cost) and other factors such as the use of an air cooler for Plan 21 in areas where water cannot be used or is not available. (An air cooler works better on Plan 21 due to the higher delta T between pumpage and the cooling medium.) The user may also wish to consider the use of Plan 32 if a suitable fluid is available, especially if the fluid is normally injected into the process anyway (such as make up water). See the flush descriptions later in this annex for additional detail.

Note 4 See tutorial this annex on selection of Plan 53a, 53b, or 53c.

Note 5 Consider adding Plan 13 to Arrangement 3 for venting especially for liquid barrier fluid. Consider the effects in Note 1 as well. Consult the pump vendor for the need for a Plan 13.

Note 6 Consider the need to add additional flushing to the process side of the inner seal (e.g. the seal chamber). This is sometimes needed for Arrangement 3 face to back (FB) orientation to provide additional cooling and may be a Plan 11. Other services may require a Plan 32 if the pumped fluid is extremely corrosive, aggresive or solids laden. Consult the seal vendor to determine if additional cooling of the inner seal is needed.

RECOMMENDED SEAL SELECTION PROCEDURE (CUSTOMARY UNITS)
SHEET 8 OF 10
Non-flashing hydrocarbon



Note 1 The user should evaluate whether to add Plan 13 or not considering such factors as the inclusion of a bleed bushing, contamination of the seal chamber with pumped fluid, the need for venting of the seal chamber, and the need to reduce seal chamber pressure due to static or dynamic pressure rating of the seal versus the expected static and dynamic seal chamber pressure.

Note 2: If a Plan 31, 32, or 41 is selected and pump is vertical, Plan 13 will also be recommended for venting. Users should consider installation of a "bleed bushing" design where an annulus and port cut into the throat bushing is connected to suction to keep solids or polymerizing agents out of the seal chamber. Ensure seal chamber is vented prior to start-up.

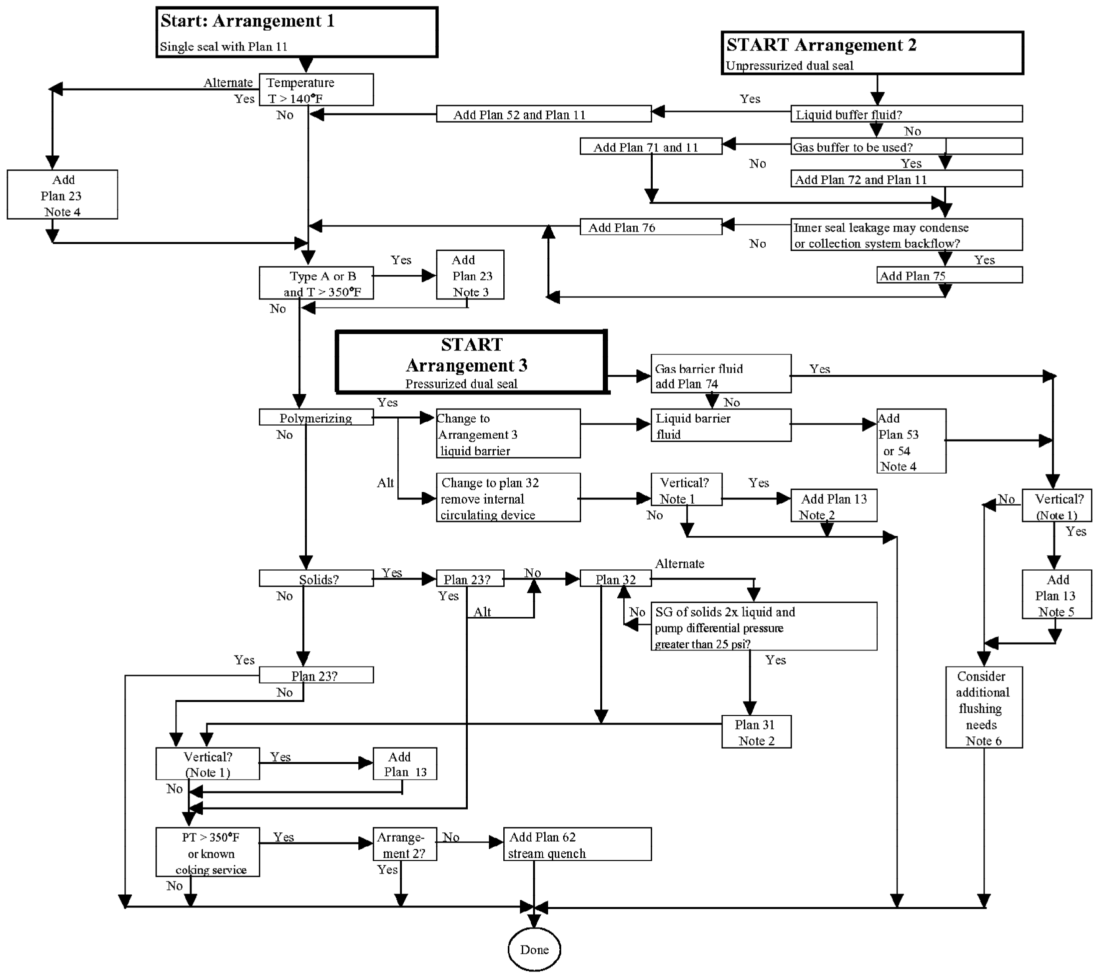
Note 3 Cooling is needed due to temperature limits of the standard secondary elastomers for Arrangement 1 and possibly for Arrangement 2 (consult the seal vendor). Consideration may be given to changing to perflouroelastomer if cooling is not possible. The recommended flush plan is 23 because field experience has shown that this plan is much less prone to plugging than Plan 21 due to recirculation of cooler fluid from the seal chamber. However, the user may wish to re-consider using a Plan 21 due to the added seal complexity imposed by Plan 23 (size and cost) and other factors such as the use of an air cooler for Plan 21 in areas where water cannot be used or is not available. (An air cooler works better on Plan 21 due to the higher delta T between pumpage and the cooling medium.) The user may also wish to consider the use of Plan 32 if a suitable fluid is available, especially if the fluid is normally injected into the process anyway (such as make up water). See the flush descriptions later in this annex for additional detail.

Note 4 See tutorial this annex on selection of Plan 53a, 53b, or 53c.

Note 5 Consider adding Plan 13 to Arrangement 3 for venting especially for liquid barrier fluid. Consider the effects in Note 1 as well. Consult the pump vendor for the need for a Plan 13.

Note 6 Consider the need to add additional flushing to the process side of the inner seal (e.g. the seal chamber). This is sometimes needed for Arrangement 3 face-to-back (FB) orientation to provide additional cooling and may be a Plan 11. Other services may require a Plan 32 if the pumped fluid is extremely corrosive, aggresive or solids laden. Consult the seal vendor to determine if additional cooling of the inner seal is needed.

RECOMMENDED SEAL ARRANGEMENT SELECTION PROCEDURE (CUSTOMARY UNITS)
SHEET 9 OF 10
Flashing hydrocarbon



Note 1	The user should evaluate whether to add Plan 13 or not considering such factors as the inclusion of a bleed bushing, contamination of the seal chamber with pumped fluid, the need for venting of the seal chamber, and the need to reduce seal chamber pressure due to static or dynamic pressure rating of the seal versus the expected static and dynamic seal chamber pressure.
Note 2:	If a Plan 31, 32, or 41 is selected and pump is vertical, Plan 13 will also be recommended for venting. Users should consider installation of a "bleed bushing"design where an annulus and port cut into the throat bushing is connected to suction to keep solids or polymerizing agents out of the seal chamber. Ensure seal chamber is vented prior to start-up.
Note 3	Cooling is needed due to temperature limits of the standard secondary elastomers for Arrangement 1 and possibly for Arrangement 2 (consult the seal vendor). Consideration may be given to changing to perflouroelastomer if cooling is not possible. The recommended flush Plan is 23 because field experience has shown that this plan is much less prone to plugging than Plan 21 due to recirculation of cooler fluid from the seal chamber. However, the user may wish to re-consider using a Plan 21 due to the added seal complexity imposed by Plan 23 (size and cost) and other factors such as the use of an air cooler for Plan 21 in areas where water cannot be used or is not available. (An air cooler works better on Plan 21 due to the higher delta T between pumpage and the cooling medium.) The user may also wish to consider the use of Plan 32 if a suitable fluid is available, especially if the fluid is normally injected into the process anyway (such as make up water). See the flush descriptions later in this annex for additional detail.
Note 4	See tutorial this annex on selection of Plan 53a, 53b, or 53c.
Note 5	Consider adding Plan 13 to Arrangement 3 for venting especially for liquid barrier fluid. Consider the effects in Note 1 as well. Consult the pump vendor for the need for a Plan 13.
Note 6	Consider the need to add additional flushing to the process side of the inner seal (e.g. the seal chamber). This is sometimes needed for Arrangement 3 face to back (FB) orientation to provide additional cooling and may be a Plan 11. Other services may require a Plan 32 if the pumped fluid is extremely corrosive, aggresive or solids laden. Consult the seal vendor to determine if additional cooling of the inner seal is needed.

RECOMMENDED SEAL ARRANGEMENT SELECTION PROCEDURE (US CUSTOMARY UNITS)
Buffer/barrier fluid selection
SHEET 10 OF 10

The following should be considered when selecting a barrier/buffer fluid:

a) compatibility of the fluid with the process pumpage being sealed so as not to react with or form gels or sludge if leaked into the process fluid or the process fluid into the barrier/buffer fluid; and

b) compatibility of the fluid with the metallurgy, elastomers, and other materials of the seal/flush system construction.

On pressurized barrier fluid systems where the method of pressurization is a gas blanket, special attention shall be given to the application conditions and barrier fluid selection. Normally, gas solubility in a barrier fluid increases with increasing pressure and decreases with increasing barrier fluid temperature. As pressure is relieved or temperatures rise, the gas is released from solution, and may result in foaming and loss of circulation of the barrier fluid. This problem is normally seen where higher viscosity barrier fluids, such as lube oils, are used at gauge pressures above 150 psi.

The viscosity of the barrier/buffer fluid should be checked over the entire operating temperature range with special attention being given to start-up conditions. The viscosity should be less than 500 cSt at the minimum temperature to which it is exposed.

a) For services above 50°F, hydrocarbon barrier/buffer fluids having a viscosity below 100 mm^2/s at 100°F and between 1 mm^2/s and 10 mm^2/s at 212°F have performed satisfactorily.

b) For services below 50°F, hydrocarbon barrier/buffer fluids having a viscosity between 5 mm^2/s and 40 mm^2/s at 100°F and between 1 mm^2/s and 10 mm^2/s at 212°F have performed satisfactorily.

c) For aqueous streams, mixtures of water and ethylene glycol or propylene glycol are usually adequate. Commercially available automotive antifreeze should never be used. The additives in antifreeze tend to plate out on seal parts and cause failure as a result of gel formation.

d) The fluid should not freeze at the minimum site ambient temperature.

Fluid volatility and toxicity of the fluid shall be such that leakage to the atmosphere or disposal does not impose an environmental problem.

a) The fluid should have an initial boiling point at least 50°F above the temperature to which it will be exposed.

b) The fluid should have a flash point higher than the service temperature if oxygen is present.

c) Ethylene glycol may be considered a hazardous material and/or hazardous waste when used as a barrier fluid.

The fluid should be able to meet the minimum 3-year continuous seal operation criteria without adverse deterioration. It should not form sludge, polymerize, or coke after extended use.

a) For hydrocarbon streams, paraffinic based high purity oils having little or no additives for wear/oxidation resistance or synthetic based oils have been used successfully.

b) Anti-wear/oxidation resistant additives in commercial turbine oils have been known to plate out on seal faces.

A.2 Tutorial clause

A.2.1 Seal selection justification

A.2.1.1 All seal selections by service were made with the following considerations in mind:

a) To produce a reliable sealing system that has a high probability of operating 3 years of uninterrupted service, meeting or exceeding environmental emission regulations.

b) personnel and plant safety in hazardous services; and

c) minimizing spare parts inventory required for insurance stock.

A.2.1.2 All selections were made using the group experience of engineering, purchasing, operating, retrofitting, and maintaining mechanical seals in various services and locations. The selections were made to ensure that, in our collective opinion, the best seal for the service will be installed. Surely, a seal not specified by this Standard, is operating successfully in a given service somewhere. This Standard, does not attempt to prevent the selection of other seals. However, if a seal not specified by this Standard is chosen, special engineering is recommended for successful operation.

Any seal operating with a seal chamber gauge pressure above a gauge pressure of 21 bar (300 psi) for Category 1 seals or a gauge pressure of 41 bar (600 psi) for Category 2 and Category 3 seals requires special engineering. Any product temperature above 260ºC (500ºF) for Category 1 seals and above 400ºC (750ºF) for Category 2 and 3 seals also requires special engineering design considerations. Therefore, the selection categories are limited to the above pressures and temperatures for this Standard.

A.2.1.3 The seal references in this Standard are:

a) Type A, standard pusher seal;

b) Type B, standard option for Type A, a non-pusher seal with rotating bellows and elastomeric secondary sealing elements; and

c) Type C, standard non-pusher seal with stationary bellows and flexible graphite secondary sealing elements.

See clause 2 and clause 5, and sheet 1 of this annex, for further description.

NOTE Pressure levels listed apply to Category 1, Category 2, or Category 3 as noted on the applicable sheet.

A.2.2 Non-hydrocarbon services — Sheet 3

A.2.2.1 Clean water below 80ºC (176ºF) and below a gauge pressure of 21 bar (300 psi)

The standard seal is a Type A standard pusher with no special features required.

The standard options are either a Type B or Type C metal bellows with no special features required.

A.2.2.2 Clean water below 80ºC (176ºF) and a gauge pressure of between 21 bar (300 psi) and 41 bar (600 psi)

The standard seal is a Type A standard pusher with no special features required.

Any seal other than a Type A should be specially engineered for high pressure. Seal manufacturers rate their bellows for gauge pressures above 21 bar (300 psi). The seal manufacturer should be consulted for specific performance data above this pressure.

A.2.2.3 Water above 80°C (176°F) and at a gauge pressure below 41 bar (600 psi)

The standard seal is a Type A pusher with special features. The required features are a single spring seal with an internal circulating device to circulate through an Plan 23 closed loop system. As shown on the sheet, a Plan 21 might also be used, especially if an air cooler is used. The elastomer configuration can be either O-ring or "U" cup.

The alternative seal is a Type A standard pusher with special features to include an internal circulating device to circulate through an Plan 23 closed loop system. This design will also require a close-clearance bushing in the bottom of the sealing chamber.

A Plan 23 flushing arrangement is the most efficient way of providing a cool flush to the seal faces. Using an internal circulating device to circulate the fluid through a closed-loop cooler allows the cooler to continuously cool a recirculated stream rather than a continuous hot stream from the discharge of the pump (Plan 21). The cooler now has to cool only that fluid in the loop, and the duty cycle is much less severe than a Plan 21.

A survey in one facility revealed that the average temperature of the inlet flush to the sealing chamber was 50°C (122°F). The average pumping temperature of the product was 219°C (426,2°F). The idle pump's average inlet temperature was 38°C (100,4°F). The idle pumps rely only on the thermosyphon through the cooler to cool the fluid. The cooler shall be mounted in accordance with this Standard to ensure proper thermosyphoning.

A.2.2.4 Sour water below 80°C (176°F) up to a gauge pressure of 41 bar (600 psi)

The standard seal is a Type A standard pusher with special features. The elastomers shall be changed to perfluoroelastomer to resist the H_2S, as H_2S is generally the agent that sours water.

The standard option up to a gauge pressure of 21 bar (300 psi) is either the Type B or Type C with the special feature of perfluoroelastomer for the Type B.

The use of Type B or Type C above a gauge pressure of 21 bar (300 psi) requires special engineering for the high pressure.

This selection is made to maximize the standardization process, as the Type A seal is recommended for all pressure ranges. Sour water may become flashing as the temperature and H_2S content increases.

A.2.2.5 Caustic, amines, and other crystallizing fluids below 80°C (176°F) and below a gauge pressure of 41 bar (600 psi)

The standard seal is a Type A standard pusher with the special features of perfluoroelastomer.

The standard alternative is a Type B metal bellows seal up to a gauge pressure of 21 bar (300 psi) with perfluoroelastomer.

The use of Type C seals up to a gauge pressure of 21 bar (300 psi) with flexible graphite secondaries should be specially engineered, as graphite is not recommended for some caustic applications.

For gauge pressures above 21 bar (300 psi) but below 41 bar (600 psi), the use of Type B and Type C metal bellows seals require special engineering for the high pressure.

Any application in a crystallizing fluid requires the use of a Plan 62 quench or a Plan 32 flush to keep the crystals from forming on the atmospheric side of the seal. Most facilities prohibit a quench from seals unless totally contained. A Plan

32 flush arrangement is generally not acceptable as it dilutes the product and is sometimes expensive to operate. In these conditions an Arrangement 2 dual seal arrangement (un-pressurized buffer) should be considered, using clean water (or other compatible fluid) as a buffer to keep the crystals in solution. The same special features apply to the dual seal and the single seals.

A.2.2.6 Acids: sulfuric, hydrochloric, phosphoric less than 80°C (176°F) and below a gauge pressure of 21 bar (300 psi)

The standard seal is a Type A standard pusher with special features. The special features are a single coil-spring.

The standard option is a Type B or Type C using flexible graphite as a secondary in the Type C.

Due to the thin cross section of multiple coil-springs and bellows plates, select the most corrosion-resistant material for the application.

Hydrofluoric, fuming nitric, and other acids are not covered in this selection. Specially engineered designs between the owner and the seal manufacturer should be used.

Acids over 80°C (176°F) require special engineering.

Acids at a gauge pressure above 21 bar (300 psi) require special engineering.

A.2.3 Non-flashing hydrocarbons [absolute vapor pressure less than 1 bar (14,7 psi) at pumping temperature] — Sheet 4

A.2.3.1 From – 40°C (– 40°F) to – 7°C (+ 20°F) and below a gauge pressure of 41 bar (600 psi)

The standard seal is a Type A standard pusher with the special feature of NBR elastomers for the low temperature service. The NBR shall also be compatible with the pumped fluid.

The standard alternative up to a gauge pressure of 21 bar (300 psi) is either a Type B with the special feature of NBR elastomers or a Type C with flexible graphite secondaries.

For gauge pressures over 21 bar (300 psi) Types B and C require engineered bellows designed for the high pressure.

The special feature of NBR elastomers is due to the low temperature requirements. The standard elastomer Viton is rated at – 17,7°C (0°F), but the committee conservatively recommends not using Viton below – 7°C (+ 20°F).

A.2.3.2 From – 7°C (+ 20°F) to 176°C (350°F) and gauge pressures below 41 bar (600 psi)

The standard seal is a Type A standard pusher with no special features required. (Check elastomer compatibility charts for pumped fluid).

The standard option for gauge pressures up to 21 bar (300 psi) is a Type B or Type C standard non-pusher. The Type C seal should be used with flexible graphite secondaries.

The standard alternative for gauge pressures above 21 bar (300 psi) is a Type B or Type C with engineered bellows for the high pressure.

The standard pusher seal elastomer is Viton, which is rated at 204°C (400°F). A pumping temperature of 176°C (350°F) is realistic for Viton, as the face friction will generate additional heat and raise the temperature the elastomer must endure.

A.2.3.3 From 176°C (350°F) to 260°C (500°F) and below a gauge pressure of 21 bar (300 psi)

The standard seal is a Type C stationary non pusher metal bellows seal using flexible graphite for secondaries.

The standard alternative is a Type A standard pusher with special features. The special features are an internal circulating device and perfluoroelastomer elastomers circulating through an Plan 23 closed-loop system in accordance with the flush selection diagram.

The Type C seal is selected as the standard due to the temperature range. This is generally the range where coking occurs. The stationary bellows design easily accepts a steam baffle for anti-coking protection, whereas a rotating bellows does not.

A Type A seal with an internal circulating device and a Plan 23 closed-loop system maintains the product temperature below the range where coking occurs.

A.2.3.4 From 176°C (350°F) to 260°C (500°F) and from a gauge pressure of 21 bar (300 psi) to 41 bar (600 psi)

A totally engineered sealing system is required for hot high pressure services.

A.2.3.5 From 260°C (500°F) to 400°C (750°F) and below a gauge pressure of 21 bar (300 psi)

The Type C seal is selected as the standard due to the temperature range. This is generally the range where coking occurs. The stationary bellows design easily accepts a steam baffle for anti-coking protection, whereas a rotating bellows does not.

The standard alternative is a totally engineered sealing system.

A.2.3.6 From 260°C (500°F) to 400°C (750°F) and from a gauge pressure of 21 bar (300 psi) to 41 bar (600 psi)

The only acceptable alternative is a totally engineered sealing system.

A.2.4 Flashing hydrocarbons [vapor pressure above 1 bar (14,7 psi) at pumping temperature] — Sheet 5

A.2.4.1 From – 40°C (– 40°F) to – 5°C (+ 20°F) and a gauge pressure below 41 bar (600 psi)

The standard seal is a Type A standard pusher with special features. The special feature is a NBR elastomer. Ensure NBR is compatible with the pumped fluid.

The standard alternative is an engineered sealing system with an engineered metal bellows for the flashing service.

Metal bellows seals in flashing service are prone to fatigue failure induced by “stick-slip” if marginal vapor suppression occurs. If metal bellows are desired, the seal should be a totally engineered sealing system with special attention to vapor suppression under all operating conditions of the pump, such as start-up, shutdown, and plant upsets.

A.2.4.2 From – 5°C (+ 20°F) to 176°C (350°F) and a gauge pressure below 41 bar (600 psi)

The standard seal is a Type A standard pusher with special features to maintain adequate vapor suppression. If the temperature is above 60°C (140°F), an internal circulating device and Plan 23 closed-loop system should be considered as an alternative to help reduce flashing at the seal face. If the temperature is above 176°C (350°F), perfluoroelastomer elastomer should be used.

The standard alternative is a totally engineered sealing system with an engineered metal bellows.

Vapor suppression by cooling is always preferred over pressurization. Therefore, a Type A seal with internal circulating device and Plan 23 closed-loop system is selected if the temperature is above 60°C (140°F). The 60°C (140°F) limit is based on the cooling water temperature in the hot months, where little cooling of a product below 60°C (140°F) will occur. Various locations may choose a higher or lower limit based on the maximum cooling water temperature in that specific location.

A.2.4.3 From 176°C (350°F) to 400°C (750°F) and below a gauge pressure of 21 bar (300 psi)

The standard seal is a Type C seal. The standard alternative is a totally engineered sealing system.

A.2.4.4 Above 176°C (350°F) and a gauge pressure from 21 bar (300 psi) to 41 bar (600 psi)

The seal should be a totally engineered sealing system.

A.3 Tutorial seal selection — Sheet 6

NOTE Sheet 6 is intended only as a guide to some of the aspects that might be considered in the selection of a seal arrangement. The user should evaluate the cost benefits and risk associated with any selection.

A.3.1 The first selection determines whether there are any regulations effective at the site of the equipment which require specific hardware. This hardware could include low emission single seal or dual seals. The question is intended to alert the user so that he can investigate the possibility that specific designs might be required.

A.3.2 The second question alerts the user to examine the pumped stream to determine if any owner or operator standards exist that would dictate or help define the required arrangement from the owner or operator. These standards might deem the stream hazardous and require specific methods of control or limits of exposure on emissions, even if local regulations do not. Seal designs shall then employ the required hardware or be designed to meet the required emission limit.

A.3.3 Question 3 addresses selection of arrangement for acids. If the stream is not an acid, question 3 will bypass to step 5.

A.3.4 Question 4 selects the arrangement for an acid as either a single seal or a pressurized dual seal. Unpressurized dual seals are not recommended due to the potential for build up of acid in the buffer system or containment seal chamber.

A.3.5 Question 5 addresses materials which may pose a personnel hazard, such as rich (in H_2S) amine streams, to highlight the need for control beyond a single seal without external flush. The highlight is needed because specifications often overlook the need for added control measures on this type of stream.

A.3.6 Question 6 is similar to question 5, except it addresses streams for which an Arrangement 1 seal will not meet safety requirements of the owner from a vapor cloud or fire risk potential.

A.3.7 Question 7 addresses the need for additional sealing control on those streams which will not meet local emission requirements with an Arrangement 1 seal. Arrangement 2 or Arrangement 3 is chosen as needed instead.

A.3.8 Question 8 alerts the user to the fact that in certain countries, Arrangement 1 seals in specific services are required to be monitored (or "sniffed") for emissions. If the user wishes to perform this monitoring then Arrangement 1 is suitable. However, the option is given to change the arrangement and possibly avoid monitoring.

A.3.9 Question 9 addresses reliability considerations for hot services. Experience has shown that Arrangement 2 or Arrangement 3 may provide better reliability.

A.3.10 Question 10 addresses reliability considerations for polymerizing agents, solids, and low lubricity fluids out of the seal faces in order to help meet the 3-year uninterrupted life goal.

A.3.11 Experience has shown Arrangement 1 and Arrangement 2 used in very light fluids often cannot meet the goal of a 3-year service. Special sealing arrangements involving the use of non-contacting inner seals in an Arrangement 2 have been known to provide very reliable service in fluids such as methane, ammonia, propane and other high vapor pressure hydrocarbon mixtures.

A.3.12 Question 11 is intended to alert the user to the possible need for alarming of leakage. An arrangement other than Arrangement 1 is generally needed if leakage must be detected.

A.3.13 Question 12 determines how the user intends to use the containment feature of an unpressurized dual seal. Because of heat generation and face load, dry containment seals may have limited life at full seal chamber conditions.

A.3.14 This step changes to an Arrangement 3 or recommends a liquid buffer if the pumpage contains solids or polymerizing agents. These contaminants may reduce the reliability of dry containment seals.

A.3.15 An Arrangement 2 seal has been selected and further guidance is provided on the possible use of non-contacting inner seals

A.4 Tutorial on sheet 7 through sheet 9 of seal selection procedure

To aid in understanding the logic behind the flow/decision charts in sheet 7 through sheet 9 of the seal selection procedure, the following descriptions of the prescribed seal flush plans are given.

A.4.1 Plan 01

Plan 01 is similar to a Plan 11 except that internal porting is used to direct flow to the seal chamber from an area behind the impeller near the discharge. This plan is recommended for clean fluids only. The Plan 01 may be useful with liquids that thicken or solidify at normal ambient temperatures to minimize the risk of freezing the fluid in flush piping. Special attention must be given to ensure that the recirculation supplied is sufficient for the seal operating requirements

A.4.2 Plan 02

Plan 02 is a dead-ended seal chamber with no flush fluid circulation. Plan 02 is more common in the chemical industry in applications with low seal chamber pressures and process temperatures. Typically, the plan is used in conjunction with a taper bore seal chamber modified with flow enhancers. The process fluid should be relatively clean to avoid excessive erosion of the seal gland, seal chamber, or seal parts created by the swirling flow pattern. The vapor pressure sensitivity of the process fluid must also be taken into consideration to avoid flashing conditions in the seal chamber or at the seal faces. Plan 02 can be used with cool clean fluids with high specific heats, such as water, in relatively low-speed pumps. The product temperature margin should be carefully reviewed for any application where the selection of Plan 02 is being considered.

A.4.3 Plan 11

Plan 11 is the default seal flush plan for all single seals. In Plan 11, product is routed from the pump discharge to the seal chamber to provide cooling for the seal and to vent air or vapors from the seal chamber. Fluid then flows from the seal cavity back into the process stream It is the most commonly used flush plan for clean general service equipment. For high-head applications, careful consideration should be given to calculation of the required flush flow rate. Calculations are required to determine the proper orifice and throat bushing dimensions to assure adequate seal flush flow.

A.4.4 Plan 13

Plan 13 is the standard flush plan selection for vertical pumps that are not provided with a bleed bushing below the seal chamber. The seal chamber pressure on vertical pumps supplied without a bleed bushing would normally operate at full discharge pressure. Due to this arrangement there is no pressure differential to allow a Plan 11 to work. In Plan 13, product is routed from the seal chamber back to the pump suction to provide cooling for the seal and to vent air or vapors from the seal chamber. API Plans 1, 11, 12, 21, 22, 31, or 41 are used in conjunction with Plan 13 for vertical suspended pumps.

Plan 13 provides self venting on vertical in-line pumps provided differential pressure is sufficient to ensure circulation and seal chamber pressure is sufficient to prevent vaporization.

Plan 13 is also used in high-head pumps where the use of Plan 11 would require too small an orifice or would produce too high a flush flow rate. This plan will generally not work well in low-head pumps because of the low pressure differential between the seal chamber and the pump suction. The suitability of the service for Plan 13 can be determined by calculating the required flush flow rate and then calculating the required orifice size.

A.4.5 Plan 14

Plan 14 is the combination of a Plan 11, recirculation from pump discharge, and Plan 13, recirculation to pump suction. It allows a cooling flow to be supplied to the seal chamber (Plan 11) while providing complete venting of the seal chamber (Plan 13). Plan 14 is most commonly used on vertical pumps.

A.4.6 Plan 21

Plan 21 provides a cool flush to the seal. This may be needed to improve the margin to vapor formation, to meet secondary sealing element temperature limits, to reduce coking or polymerizing, or to improve lubricity (as in hot water). The benefit of Plan 21 is that it not only provides a cool flush but also has sufficient delta P to allow good flow rates. The drawback is that the cooler duty is high leading to fouling and plugging on the water side and potential plugging on the process side if the fluid viscosity gets high quickly. Plan 21 works best in dry climates where an air fin cooler is used instead of a water cooler. Note that Plan 21 also uses more energy than Plan 23 because the pumped fluid that is used for the flush must be re-pumped from suction back to the discharge.

A.4.7 Plan 23

Plan 23 is the plan of choice for all hot water services, particularly boiler feed water, and many hydrocarbon services. This plan is the standard selection for hot water 80°C (180°F) and above and boiler feed water. Hot water has very low lubricity above 80°C (180°F) resulting in high seal face wear. This plan is also desirable in many hydrocarbon and chemical services where it is necessary to cool the fluid to establish the required margin between fluid vapor pressure (at the seal chamber temperature) and seal chamber pressure. In a Plan 23, the cooler only removes seal face-generated heat plus heat soak from the process. This duty is usually much less than that in a Plan 21 or Plan 22.

Lessening the duty is very desirable because it extends the life of the cooler. The industry has considerable negative experience with Plan 21 and Plan 22 because of cooler plugging.

In Plan 23, product in the seal chamber is isolated from that in the impeller area of the pump by a throat bushing. The seal is equipped with an internal circulating device that circulates seal chamber fluid through a cooler and back to the seal chamber. In this arrangement the cooler only cools that fluid in which the seal operates and this cool fluid does not enter the process. This results in high energy efficiency.

High freeze point and viscous products shall be considered when selecting a Plan 23 flush system. The cooler may cool the fluid below the point of circulation. In these applications, consider using steam as a cooling medium or utilize a Plan 21 system.

A.4.8 Plan 31

Plan 31 is specified only for services containing solids with a specific gravity twice or more that of the process fluid. A typical use of this plan is water service to remove sand or pipe slag. In Plan 31, product is routed from the discharge of the pump into a cyclone separator. Solid particles are centrifuged from the stream and routed back to suction. The seal flush is routed from the cyclone separator into the flush connection on the seal plate. If the process stream is very dirty or is a slurry, Plan 31 typically is inadequate and is not recommended. The use of a pump throat bushing is recommended when a Plan 31 is specified.

A.4.9 Plan 32

Plan 32 is used in services containing solids or contaminants where a suitable cleaner or cooler external flush will improve the seal environment. It is also used to reduce flashing or air intrusion (in vacuum services) across the seal faces by providing a flush that has a lower vapor pressure or that will raise the seal chamber pressure to an acceptable level. The external flush shall be continuous and reliable even during non-standard situations such as start-up or shutdown. The external flush shall also be compatible with the process stream because it will flow from the seal chamber into the process fluid.

In Plan 32, the flushing product is brought from an external source to the seal. This plan is almost always used in conjunction with a close-clearance throat bushing. The bushing can function as a throttling device to maintain an elevated pressure in the stuffing box or as a barrier to isolate the pumped product from the seal chamber.

Plan 32 is not recommended for cooling only, as the energy costs can be very high. Product degradation costs shall also be considered when using a Plan 32.

A.4.10 Plan 41

Plan 41 is a combination of Plans 21 and 31 and is specified only for hot services containing solids. Contained solids should have a specific gravity twice or more that of the process fluid. For this seal plan to be used, the seal should require a cool flush. This cool flush may be needed to improve the temperature margin over the fluid vapor pressure, or to meet secondary sealing element temperature limits, or to reduce coking or polymerizing, or to improve lubricity (as in hot water). A typical use of this plan is in a hot water service to remove sand or pipe slag.

In API Plan 41, product is routed from the discharge of the pump into a cyclone separator. Solid particles are centrifuged from the stream and routed back to suction. The seal flush is then routed from the cyclone separator through an exchanger and into the flush connection on the seal plate.

If the process stream is very dirty or is a slurry, API Plan 41 typically is inadequate and is not recommended. The benefits, detriments, and the best conditions for the use of the exchanger in the flush stream can be found in the write-up on Plan 21. The use of a pump throat bushing is recommended when a Plan 41 is specified.

A.4.11 Plan 52

Plan 52 or Arrangement 2, unpressurized dual seal systems, are used in services where no leakage to atmosphere can be tolerated. A Plan 52 system consists of dual mechanical seals with a buffer fluid between them. The buffer fluid is contained in a seal pot which is vented to a vent system, thus maintaining the buffer fluid pressure close to atmospheric. Inner seal leakage will be product leakage into the buffer fluid. There will always be some leakage.

Plan 52 works best with clean, non-polymerizing products which have a vapor pressure higher than the buffer fluid pressure. These products will flash in the seal pot and the vapor can escape to the vent system. If the product has a vapor pressure lower than the buffer fluid or seal pot pressure, the leakage will remain a liquid and will contaminate the buffer fluid.

Should an inner seal leak not be detected early, the heavier process fluid will displace the buffer fluid and can result in the area between the two seals being completely filled with product. In that case, an outer seal leak can result in product being released to the atmosphere.

Plan 52 should not be used for dirty or polymerizing products as well. Plan 53 should be considered as an alternative for these situations.

A.4.12 Plan 53a, Plan 53b, Plan 53c

Plan 53 or Arrangement 3 pressurized dual seal systems are used in services where no leakage to atmosphere can be tolerated. A Plan 53a system consists of dual mechanical seals with a barrier fluid between them. The barrier fluid is contained in a seal pot which is pressurized to a pressure of approximately 1,5 bar (23 psi) greater than the pump seal chamber. Inner seal leakage will be barrier fluid leakage into the product. There will always be some leakage. If seal chamber pressures vary significantly, or are above 500 psig, the <u>outer</u> seal stresses can be reduced by the application of a controlled differential pressure regulator set 20 to 25 psi higher than the pump seal chamber pressure.

Plan 53b is also a pressurized dual seal and differs from Plan 53a in that pressure is maintained in the seal circuit through the use of a bladder type accumulator.

Plan 53c is a pressurized dual seal as well but utilizes a piston type accumulator to maintain pressure above seal chamber pressure.

Plan 53 is usually chosen over Plan 52 for dirty, abrasive, or polymerizing products which would either damage the seal faces or cause problems with the buffer fluid system if Plan 52 were used. There are two disadvantages to Plan 53 which shall be considered. There will always be some leakage of barrier fluid into the product. The leakage rate can be monitored by monitoring the seal pot level. However, the product must be able to accommodate a small amount of contamination from the barrier fluid. Second, a Plan 53 system is dependent on having the seal pot pressure maintained at the proper level. If the seal pot pressure drops, the system will begin to operate like a Plan 52, or unpressurized dual seal, which does not offer the same level of sealing integrity. Specifically, the inner seal leakage direction will be reversed and the barrier fluid will, over time, become contaminated with the process fluid with the problems that result, including possible seal failure.

A.4.13 Plan 54

Plan 54 systems are also pressurized dual seal systems with inner seal leakage into the pumped product. In a Plan 54, a cool clean product from an external source is supplied to the seal as a barrier fluid. The supply pressure of this product is at least 1,4 bar (20 psi) greater than the pressure the inner seal is sealing against. This results in a small leakage of barrier fluid into the process. This arrangement should never be used where the barrier fluid pressure is less than the sealed pressure. If it were, the failure of one inner seal could contaminate the entire barrier fluid system and cause additional seal failures.

Plan 54 is often used in services where the pumped fluid is hot, contaminated with solids, or both. If Plan 54 is specified, carefully consider the reliability of the barrier fluid source. If the source is interrupted or contaminated, the resulting seal failures are very expensive. A properly engineered barrier fluid system is typically complex and often expensive. Where these systems are properly engineered, they provide among the most reliable systems.

A.4.14 Plan 62

In Plan 62, a quench stream is brought from an external source to the atmospheric side of the seal faces. The quench stream can be low-pressure steam, nitrogen, or clean water. It is used in selected single seal applications to exclude the presence of oxygen to prevent coke formation (for example, hot hydrocarbon services) and to flush away undesirable material buildup around the dynamic seal components (for example, caustic and salt services).

A.4.15 Plan 71

Plan 71 is used on Arrangement 2, unpressurized dual seals, which utilize a dry containment seal and where no buffer gas is supplied but the provision to supply a buffer gas is desired. Buffer gas may be needed to sweep inner seal leakage away from the outer seal into a collection system or to dilute the leakage but is not specified.

A.4.16 Plan 72

Plan 72 may be used on Arrangement 2, unpressurized dual seals which also uses a dry containment seal. The buffer gas may be used to sweep inner seal leakage away from the outer seal into a collection system and/or provide dilution of the leakage so that emissions from the containment seal are reduced.

Plan 72 is typically used where the pumped material has some emission, exposure, or olfactory limit that must be met or where it is desirable to detect and alarm leakage from the inner seal prior to total failure such that an orderly shutdown and repair can be planned.

The Plan 72 system is intended to function as follows: the barrier gas first flows through an isolation block valve and check valve provided by the purchaser. It then enters a system, usually mounted on a plate or panel, provided by the seal vendor. An inlet block valve on the panel is followed by a 10 μm filter coalescer (if specified) to remove any particles and liquid that might be present. The gas then flows through a back pressure regulator (if specified) which is set at least 0,5 bar (7 psi) above atmospheric pressure. Next comes an orifice to provide flow regulation followed by a flow indicator to measure flow (Some users prefer to substitute a needle or globe valve for the orifice to allow flow regulation). The pressure indicator is used to ensure the pressure is not above the seal chamber pressure. The last elements on the panel are a check valve and block valve. Buffer gas is then routed to the seal using tubing. A containment seal vent (CSV) and drain (CSD) are also located on the gland and may be plugged or routed to a vent system usually using Plan 75 or Plan 76.

A.4.17 Plan 74

Plan 74 systems are used on Arrangement 3, dual pressurized seals, where the barrier medium is a gas. They are the gas barrier equivalent to the traditional Plan 54 liquid barrier system. The most common barrier gas is plant nitrogen. The supply pressure to the seal is typically at least 1,75 bar (25 psi) greater than the seal chamber pressure. This results in a small amount of gas leakage into the pump with most of the gas barrier leaking to atmosphere. This arrangement should never be used where the barrier gas pressure can be less than the sealed pressure. If this were to happen, the entire barrier gas system could become contaminated with the pumped fluid.

Plan 74 systems are typically used in services which are not too hot (within elastomer limits) but which may contain toxic or hazardous materials whose leakage cannot be tolerated. Because they are a pressurized dual seal, leakage to the atmosphere is eliminated under normal conditions. Plan 74 may also be used to obtain very high reliability since solids or other materials which may lead to premature seal failure cannot enter the seal faces. For services containing sticky or polymerizing agents or where dehydration of the pumpage causes solids buildup, Plan 74 systems are not generally recommended.

The Plan 74 system is intended to function as follows: the barrier gas first flows through an isolation block valve and check valve provided by the purchaser. It then enters a system, usually mounted on a plate or panel, provided by the seal vendor. An inlet block valve on the panel is followed by a 2 μm to 3 μm filter coalescer to remove any particles and liquid that might be present. The gas then flows through a back pressure regulator which is set at least 1,75 bar (25 psi) greater than the seal chamber pressure (In some cases, users prefer to install an orifice after the regulator to limit the amount of nitrogen that is used in the event of a seal that sticks open). A flow indicator follows the regulator and is used to indicate positive flow while the pressure indicator is used to confirm adequate pressure. The low pressure switch is used to alarm loss of barrier gas or excessive leakage of the seals. The last elements on the panel are a check valve and block valve. Barrier gas is then routed to the seal using tubing. A drain is mounted on the Gas Barrier Drain to allow venting/draining for maintenance.

A.4.18 Plan 75

Plan 75 systems are typically used on Arrangement 2, unpressurized dual seals, which also utilize a dry containment seal and where the leakage from the inner seal may condense. They may be used with a buffer gas (Plan 72) or without a buffer gas (Plan 71).

If an unpressurized dual seal is installed, usually it is because of the need to restrict leakage of the pumped fluid to the atmosphere more than can be done with an Arrangement 1 seal. Therefore, a means is needed to collect the leakage and route it to a collection point. The Plan 75 system is intended to perform this collection function for pumped fluids that may form some liquid (condense) at ambient temperature. Note that even if the pumped liquid does not condense, users may wish to install this system due to the back flow of condensation from the collection system.

Plan 75 is intended to work as follows. Leakage from the inner seal is restricted from escape by the containment seal and routed into the drain line. The collector accumulates any liquid while vapor passes through into the collection system. A level indicator on the collector is used to determine when the collector must be drained. An orifice in the outlet line of the collector restricts flow such that high leakage of the inner seal will cause a pressure increase and trigger the PSH set at a gauge pressure of 0,7 bar (10 psi). The block valve in the outlet of the collector serves to isolate the collector for maintenance. It may also be used to test the inner seal by closing while the pump is in operation and noting the time/pressure buildup relationship in the collector. If specified, a connection on the collector may be used to inject nitrogen or other gas for the purpose of testing the containment seal.

A.4.19 Plan 76

Plan 76 systems are typically used on Arrangement 2, unpressurized dual seals, which also utilize a dry containment seal and where leakage from the inner seal will not condense. They may be used with a buffer gas (Plan 72) or without a buffer gas (Plan 71).

If an unpressurized dual seal is installed, usually it is because of the need to restrict leakage of the pumped fluid to the atmosphere more than can be done with an Arrangement 1 seal. Therefore, a means is needed to route the leakage to a collection point. The Plan 76 system is intended for services where no condensation of the inner seal leakage or from the collection system will occur. Should liquid accumulate in the containment seal chamber, excessive heat could be generated leading to hydrocarbon coking and possible seal failure.

Plan 76 is intended to work as follows. Leakage from the inner seal is restricted from escape by the containment seal and goes out the containment seal vent. An orifice in the outlet line of the collector restricts flow such that high leakage of the inner seal will cause a pressure increase and trigger the PSH set at a gauge pressure of 0,7bar (10 psi). The block valve in the outlet serves to isolate the system for maintenance. It may also be used to test the inner seal by closing while the pump is in operation and noting the time/pressure buildup relationship in the collector. If specified, a drain connection on the piping harness may be used to inject nitrogen or other gas for the purpose of testing the containment seal as well as for checking for any liquid buildup.

Annex B
(informative)

Heat generation and heat soak calculations

B.1 Estimating of seal-generated heat

While the calculation of the heat generated by a mechanical seal appears to be a simple matter, several assumptions must be made which introduce potentially large variations in the results. Two variables that are particularly suspect are K, the pressure drop coefficient, and f, the effective coefficient of friction.

K is a number between 0,0 and 1,0 which represents the pressure drop as the sealed fluid migrates across the seal faces. For flat seal faces (parallel fluid film) and a non-flashing fluid, K is approximately equal to 0,5. For convex seal faces (converging fluid film) or flashing fluids, K is greater than 0,5. For concave seal faces (diverging fluid film), K is less than 0,5. Physically, K is the factor which is used to quantify the amount of differential pressure across the seal faces which is transmitted into opening forces. The opening force is equal to the area times differential pressure times K:

$$F_{\text{opening}} = \text{Area} \times \text{Differential Pressure} \times K \qquad (1)$$

For practical purposes, K varies between 0,5 and 0,8. As a standard practice for non-flashing fluids though, a value of 0,5 is selected for K. Although K is known to vary depending upon seal fluid properties (including multi-phase properties) and film characteristics (including thickness and coning), this value is selected as a benchmark for consistent calculation. The engineer must be aware that this assumption has been made.

The effective coefficient of dynamic friction, f, is a figure that is similar to the standard coefficient term that most engineers are familiar with. The standard coefficient of friction term is used to represent the ratio of parallel forces to normal forces. This is normally applied to the interaction between two relatively moving surfaces. These surfaces may be of the same material or different materials.

In a mechanical seal, the two relatively moving surfaces are the seal faces. If the seal faces were operating dry, it would be a simple matter to determine the coefficient of friction. In actual operation, the seal faces will be operating under various lubrication regimes and various types of friction will be present.

If there is significant asperity contact, f is highly dependent on the materials and less dependent on the fluid viscosity. If there is a very thin fluid film (only a few molecules thick), friction may depend upon interaction between the fluid and the seal faces. With a full fluid film, these is no mechanical contact between the faces and f is solely a function of viscous shear in the fluid film. All of these types of friction may be present at the same time on the same seal face.

An effective coefficient of friction is used to represent the gross effects of the interaction between the two sliding faces and the fluid film. Actual testing has shown that normal seals will operate with f between about 0,01 to 0,18. For normal seal applications we have selected a value of 0,07 for f. This is reasonably accurate for most water and medium hydrocarbon applications. Viscous fluids (such as oils) will have a higher value while less viscous fluids (such as LPG or light hydrocarbons) can have a lower value.

The combination of the assumption of K and the assumption of f can lead to a significant deviation between calculated heat generation results and actual results. Therefore, the engineer must keep in mind that these calculations are useful only as an order of magnitude approximation of the expected results. These results must never be stated as a guarantee of performance.

B.1.1 Calculation method

Required inputs:

a) OD is the seal face contact outer diameter, expressed in millimeters;

b) ID is the seal face contact inner diameter, expressed in millimeters;

c) BD is the effective seal balance diameter, expressed in millimeters;

d) F_{sp} is the spring force at working length, expressed in Newtons;

e) dP is the pressure across the seal face, expressed in bar;

f) N is the face rotational speed, expressed in revolutions per minute;

g) f is the coefficient of friction (assume 0,07);

h) K is the pressure drop coefficient (assume 0,5).

B.1.2 Formula

B.1.2.1 Face area (mm²):

$$A = \left(\frac{\pi}{4}\right) \times (OD^2 - ID^2) \tag{2}$$

B.1.2.2 Seal balance ratio:

$$B = \left(\frac{OD^2 - BD^2}{OD^2 - ID^2}\right) \tag{3}$$

B.1.2.3 Spring pressure (N/mm²):

$$P_{sp} = F_{sp}/A \tag{4}$$

B.1.2.4 Total face pressure (N/mm²):

$$P_{tot} = dP(B - K) + P_{sp} \tag{5}$$

B.1.2.5 Mean face diameter (mm):

$$MD = \frac{(OD + ID)}{2} \tag{6}$$

B.1.2.6 Running torque (in $N \times M$):

$$RT = P_{tot} \times A \times f \times \left(\frac{MD}{2\,000}\right) \tag{7}$$

B.1.2.7 Starting torque (in $N \times M$) estimated at 3 to 5 times running torque:

$$ST = RT \times 4 \tag{8}$$

Power (kW):

$$P = \frac{(RT \times N)}{9\,550} \tag{9}$$

B.1.3 Example of calculation

B.1.3.1 Application

Fluid: Water
Pressure: 50 bar
Speed: 3 000 r/min

Inputs:

OD = 61,6 mm;

ID = 48,9 mm;

BD = 52,4 mm;

F_{sp} = 190 N;

dP = 20 bar;

N =3 000 r/min;

f =0,07;

K =0,5.

$$A = \left(\frac{\pi}{4}\right) \times \left(\frac{61,6^2}{48,9^2}\right) = 1\,102\ \text{mm}^2 \tag{2}$$

$$B = \frac{\left(61,6^{2-}52,4^2\right)}{61,6^2 - 48,9^2} = 0,746 \tag{3}$$

$$P_{sp} = \frac{90}{1\,102} = 0,72\frac{N}{\text{mm}^2} \tag{4}$$

$$P_{tot} = \left(\frac{290}{10}\right)(0,746 - 0,5) + 0,172 = 0,666\frac{N}{\text{mm}^2} \tag{5}$$

$$MD = \left(\frac{61,6+48,9}{2}\right) = 55,25 \text{ mm} \tag{6}$$

$$RT = 0,666 \times 1\ 102 \times 0,07 \times \left(\frac{55,25}{2\ 000}\right) = 1,42\ N \times M \tag{7}$$

$$ST = 1,402 \times 4 = 5,68\ N \times M \tag{8}$$

$$P = \left(\frac{1,42 \times 3\ 000}{9\ 550}\right) = 0,446.kW$$

B.2 Temperature rise in the seal chamber

The steady state temperature of the fluid in the seal chamber is a function of a simple thermodynamic balance. The heat flow into the seal chamber fluid minus the heat flow out of the seal chamber yields a net heat flow. The fluid temperature will either increase or decrease depending upon whether the net heat flow is positive or negative. This is deceptively simple. In actual applications, the heat flows into and out of the seal chamber fluids are extremely complex.

There are several sources of heat flow into the fluid. These include heat generated due to friction and fluid shear at the seal faces, heat generated due to windage (or turbulence) caused by the rotating seal components, and heat conducted from the pump through the seal chamber and shaft (or positive heat soak). There are also several sources of heat flow out of the seal chamber. These include heat conducted back into the pump through the seal chamber or shaft (or negative heat soak) and heat lost to the atmosphere through convection and radiation.

In some cases, assumptions can be made which simplify the model. For example, consider a single seal with an Piping Plan 11, 12, 13, or 31. With these piping plans, the fluid injected into the seal chamber will be at pump temperature and heat soak can be ignored. Unless the pump is at a very high temperature, heat loss to the atmosphere can also be ignored. Except in the case of large seals at high speeds, heat generation due to windage is usually insignificant and can be ignored. The increase in temperature can then be calculated if the following variables are known:

P is the heat generation at the seal faces (kW);

Q_{inj} is the injection flow rate (lpm);

SG is the specific gravity of the injected fluid at pump temperature;

C is the specific heat of the injected fluid at pump temperature.

The differential temperature, dT (in degrees Celcius), can be calculated by the following formula:

$$dT = \frac{(14,35 \times P)}{(SG \times Q_{inj} \times C)} \tag{11}$$

In applications that use a piping Plan 21, 22, 32, or 41, the fluid injected into the seal chamber may be at a significantly lower temperature then the pump temperature. If this is the case, there can be a significant heat flow or heat soak into the seal chamber from the pump. The calculation of heat soak is a complex matter, requiring detailed analysis or testing and a thorough knowledge of the specific pump construction and pumped product properties. If this data is not available, the heat soak [$Q_{heatsoak}$ (kW)] can be estimated by the equation:

$$Q_{heatsoak} = U \times A \times S \times dT \tag{12}$$

where

U is the material property coefficient;

A is the heat transfer area;

S is the seal size, expressed in millimeters;

dT is the differential temperature = (pump temperature – desired seal chamber temperature), in °C.

A typical value for UA which can be used for estimating purposes with stainless steel sleeve and gland construction and steel pump construction is 0,000 25. This value will generally provide a conservative estimate of heat soak.

B.2.1 Example of estimation of Q_{heatsoak}

UA = 0,000 25

S = 55 mm (seal balance diameter)

175°C = pump temperature

65°C = desired seal chamber temperature

dT = 175°C – 65°C = 110°C

Q_{heatsoak} = 0,000 25 × 55 × 110 = 1,5 kW.

If the heat soak is known, the temperature rise (dT, in °C) can be calculated by the following equation:

$$dT = 14{,}35\frac{(P + Q_{\text{heatsoak}})}{(SG \times Q_{\text{inj}} \times C)} \tag{13}$$

In the previous equations, the temperature rise is the average temperature rise of the fluid in the seal chamber. Within the seal chamber, there will be areas that are much hotter and much cooler than the sealing chamber fluid temperature. An efficient seal injection is required to ensure that the area around the seal face is effectively cooled. For example, the injection should be directed at the sealing interface or multiport injection may be used.

In some applications, it is necessary to specify the amount of injection required to maintain the seal chamber temperature below a certain level. In this case, the maximum allowable temperature rise would be calculated by subtracting the maximum allowable temperature in the seal chamber from the injection temperature. For good seal performance, the maximum temperature rise should be maintained at 2,8 °C to 5,6 °C. It is then a simple matter of rearranging the equations 11, 12, and 13 to solve for the injection flow rate.

For an Piping Plan 11, 12, 13, or 31, the equation would be:

$$Q_{\text{inj}} = \frac{(14{,}35 \times P)}{(SG \times dT \times C)} \tag{14}$$

For an Piping Plan 21, 22, 32, or 41, the equation would be:

$$Q_{\text{inj}} = 14{,}35\frac{(P + Q_{\text{heatsoak}})}{(SG \times dt \times C)} \tag{15}$$

The temperature rise used in these calculations is the sealing chamber temperature rise. The temperature rise at the seal faces will be greater than the chamber temperature rise. If equations 14 and 15 are used to calculate a minimum flow rate based on sealing chamber temperature, the seal faces may overheat and perform poorly. A design factor of at least two should be applied to the flow rate. The injection must also be directed at the seal interface to ensure proper cooling.

B.2.2 Example of calculation of dT

B.2.2.1 Given:

P = 0,9 kW

Q_{inj} = 11 l/min

SG = 0,75

C = 0,55

B.2.2.2 Formula:

$$dT = \frac{(14,35 \times 0,9)}{0,75 \times 11 \times 0,55}$$

$$= 2,8 \text{ °C} \qquad (13)$$

B.2.3 Example of calculation of Q_{inj}

B.2.3.1 Given:

P = 0,9 kW

Max dT = 5°C

SG = 0,90

C = 0,62

B.2.3.2 Formula:

$$Q_{inj} = \frac{(14,35 \times 0,9)}{(0,92 \times 5 \times 0,62)} = 4,5 \text{ l/min} \qquad (15)$$

With a design factor of two, the minimum injection flow rate should be 9 l/min.

Annex C
(normative)

Materials and material descriptions

C.1 International materials for mechanical seal parts

Material Class	Applications	U.S.A.			Europe			Japan	
		ASTM	Grade	UNS	Standard	Symbol	Mat. No.	JIS	
12% Chrome Steel	Pressure Casting	A 217	Gr CA 15	J 91150	EN10213-2	GX8CrNi12	1.4107	G 5121	SCS 1
		A 487	Gr CA6NM	J 91540	EN10213-2	GX4CrNi13-4	1.4317	G 5121	SCS 6
	Forging: Pressure	A 182 A 182	Gr F6a Cl 1 Gr F6 NM	S 41000 S 41500	EN10250-4 EN10222-5	X12Cr13 X3CrNi13-4	1.4006 1.4313	G 3214	SUS F6B SUS F6NM
	Bar Stock: General	A 276 A 582	Type 410 Type 416	S 41000 S 41600	EN10088-3 EN10088-3	X12Cr13 X12CrS13	1.4006 1.4005	G4303	SUS 403 or 420
					EN10088-3	X39CrMo17-1	1.4122		
	Bolts and Studs Nuts	A 193 A 194	Gr B6 Gr. 6	S 41000	EN ISO 3506-1;-2		C4-70		
Austenitic Stainless Steel	Pressure Casting	A 351	Gr CF3	J 92500	EN10213-4	GX2CrNi19-11	1.4309	G 5121	SCS 19
		A 351	Gr CF3M	J 92800	EN10213-4	GX2CrNiMo19-11-2	1.4409	G 5121	SCSI 4 A 02M
	Forging	A 182	Gr F 304L	S 30403	EN10222-5 EN10250-4	X2CrNi19-11	1.4306	G 3214	SUS F 304 L
		A 182	Gr F 316L	S 31603	EN10222-5 EN10250-4	X2CrNiMo17-12-2	1.4404	G 3214	SUS F 316 L
	Bar	A 276	Type 316	S 31600	EN10088-3	X5CrNiMo17-12-2	1.4401	G 4303	SUS 316
		A 276	Type 316L	S 31603	EN10088-3	X2CrNiMo17-12-2	1.4404	G 4303	SUS 316L
		A 276	Type 316Ti	S 31635	EN10088-3	X6CrNiMoTi17-12-2	1.4571	G4303	SUS 316Ti
	Bolts and Studs Nuts	A 193 A 194	Gr B8M Cl2 Gr 8M	S 31600	EN ISO 3506-1; 2		A4-80*		

Material Class	Applications	U.S.A.			Europe			Japan	
		ASTM	Grade	UNS	Standard	Symbol	Mat. No.	JIS	
Duplex and Super Duplex Stainless Steel	Forging	A 182	Gr F 51	S 31803	EN10222-5 EN10250-4	X2CrNiMoN22-5-3	1.4462	G 4319	SUS 329J3L SUS 329J3L
		A 182	Gr F 55	S 32760	EN10250-4	X2CrNiMoCuWN25-7-4	1.4501		
	Bar	A 276		S 31803	EN10088-3	X2CrNiMoN22-5-3	1.4462	G 4303	SUS 329J3L
		A 276		S 32550	EN10088-3	X2CrNiMoCuN25-6-3	1.4507		
		A 276		S 32760	EN10088-3	X2CrNiMoCuWN25-7-4	1.4501		
Alloy 20	Cast	A 744	CN 7M	N 08007				G5121	SCS 23
	Bar	B 473		N 08020		NiCr20CuMo	2.4660		
Low carbon Nickel, Molybdenum-Chromium Alloy Alloy-C276	Forging	B 564		N 10276	DIN17744	NiMo16Cr15W	2.4819		
	Bar and Rod	B 574		N 10276	DIN17744	NiMo16Cr15W	2.4819		
	Plate, Sheet & Strip	B 575		N 10276	DIN17744	NiMo16Cr15W	2.4819		
	Weldable Cast	A 494	Gr.CW2M						
Nickel Copper Alloy Alloy 400	Forging	B 564		N 04400	DIN17743	NiCu30Fe	2.4360		
	Bar and Rod	B 164	Class A	N 04400	DIN17743	NiCu30Fe	2.4360		
	Plate, Sheet & Strip	B 127		N 04400	DIN17743	NiCu30Fe	2.4360		
	Weldable Cast	A 494	Gr. M30C			G-NiCu30Nb	2.4365		

Material Class	Applications	U.S.A.			Europe			Japan	
		ASTM	Grade	UNS	Standard	Symbol	Mat. No.	JIS	
Precipitation-Hardening Nickel Alloy Alloy 718	Forging and Bar	B 637		N 07718	DIN17742	NiCr19NbMo	2.4668		
	Plate, Sheet & Strip	B 670		N 07718	DIN17742	NiCr19NbMo	2.4668		
Austenitic cast iron	Austenitic cast iron	A 436	Type 1 Type 2 Type 3	F 41000 F 41002 F 41004	ISO 2892	L-NiCuCr15-6-2 L-NiCr20-2 L-NiCr30-3	0.6655** 0.6660** 0.6676**		
	Austenitic ductile cast iron	A 439	Type D2	F 43000	ISO 2892	S-NiCr20-2	0.7660**		
Elastomer	Nitrile-Butadiene	D 1418		NBR	1629	NBR	P#		
	Ethylene-Propylene-Diene	D 1418		EPDM	1629	EPDM	E#		
	Fluorocarbon	D 1418		FKM	1629	FPM	V#		
	Perfluorocarbon	D 1418		FFKM	-	-	K#		
Flexible Graphite	Pure Graphite						G#		
Gasket	Spiral wound stainless steel with graphite								

Note: For more information, consult API Standard 610, ASTM Standards Volumes 1.01/.02/.03/.04/.05; and Metals and Alloys in the Unified Numbering System, SAE HS J1086, ASME DS-56 C. The European symbol and material numbers conform to the definitions described in EN 10027-1 and EN 10027-2.

* Although Grade A4-80 is the nearest equivalent, in Europe A4-70 is a more common treatment level and is a legislative requirement in some countries.
** These material numbers are not defined by ISO 2892 but are referenced in the German Standard DIN 1694 and conform to the definitions described in EN 10027-1 and EN 10027-2.
# These are material codes originating from a coding system in EN 12756. It is not a requirement of this European Standard (Mechanical seals) that seals are marked with a designation derived from this system.

C.2 Typical temperature limitations for seal materials in hydrocarbon service

Face Material	Maximum temperature °C (°F)
Tungsten carbide	400 (750)
Silicon carbide (solid)	425 (800)
Carbon-graphite:	
Oxidizing	275 (525)
Non-oxidizing	425 (800)

C.2.1 Tutorial on silicon carbide

Silicon carbide is widely used as a material for seal rings. Its primary advantages are high hardness, excellent corrosion resistance, high thermal conductivity, and low coefficient of friction against carbon. Silicon carbides may be classified according to composition and manufacturing process. For mechanical seals, reaction-bonded silicon carbide and self-sintered silicon carbide are widely used. Reaction bonded silicon carbide is manufactured by reacting silicon metal with carbon in a silicon carbide matrix. The resulting material contains free silicon metal usually in the range of 8% to 12%. Self-sintered silicon carbide, on the other hand, consists strictly of silicon carbide. In addition, within these classifications, there are various grades, grain structures, etc. As a result, the two classifications of silicon carbide have some variation in performance when used as a seal face material.

Although there are differences within the two classifications of silicon carbide, there are general characteristics as well. Reaction bonded silicon carbide is regarded as having a marginally lower coefficient of friction against carbon under certain conditions. It is less brittle, and is not as hard as the self-sintered material. Although real, these differences are small. One substantial difference is in corrosion resistance. As a rough rule of thumb, reaction bonded silicon carbide is recommended for service where the pH is between 4 and 11; outside this range, self sintered silicon carbide should be used.

C.2.2 Tutorial on hard face combinations

Although the preferred seal face material combination is carbon versus a hard face, there are many services which require the use of two hard faces. Factors, which dictate the use of two hard faces, include:

a) the presence of abrasive particles in the sealed fluid;

b) the viscosity of the fluid;

c) crystallization of the fluid;

d) products which set up;

e) presence of high vibration and shock.

The main choices for hard faces are silicon carbide and tungsten carbide. As a general rule silicon carbide will work satisfactorily against itself where there is sufficient liquid lubrication. However, tungsten carbide versus tungsten carbide can also be a very sensible combination.

There are general rules to consider:

a) Tungsten carbide vs. silicon carbide has shown excellent performance where the medium sealed is oil. Even in less viscous liquid services, such as water with abrasives, tungsten carbide vs. silicon carbide is the most common selection if two hard faces are required.

b) Tungsten carbide vs. tungsten carbide has shown excellent performance in heavy oils, tars and asphalts. It gives poor performance in water but can give good performance in caustic solution. Special attention must be accorded to the PV conditions as the limits for this combination are low.

c) Sintered silicon carbide vs. itself can give excellent results in corrosive service and is the preferred combination of two hard faces for many chemical users. However, this combination will experience irreversible damage if run under dry conditions and thus is not recommended in cases where there will be marginal lubricating conditions.

d) Reaction bonded silicon carbide vs. itself has also been used extensively in hydrocarbon processing. It provides good performance for services where abrasive particles are present such as crude oil.

e) Note that, as a general rule, the science of tribology frowns on using two like materials in frictional contact. For this reason reaction bonded silicon carbide, narrow face, has been used against a sintered silicon carbide wide face. Practical concerns, such as corrosion resistance and increased inventory costs, make this a less popular combination.

Promising new materials and techniques are being developed for seal faces if hard face combinations are required. As these are in the development or early stages of application, application guidelines are beyond the scope of this standard.

C.3 Typical temperature limitation guidelines for secondary seal materials

Material	Minimum temperature °C (°F)	Maximum temperature °C (°F)
Fluoroelastomer (FKM):		
Hydrocarbon service	– 7 (20)	175 (350)
Water based service	– 7 (20)	120 (250)
Perfluoroelastomer (FFKM)	– 7 (20)	290 (550)
Nitrile (NBR)	– 40 (– 40)	120 (250)
Flexible graphite	– 240 (– 400)	480 (900)

C.4 Tutorial on selection of elastomers

Elastomers are a complex integration of polymer architecture, fillers, cure chemistries, and design considerations. Properly selected, compounded, cured and designed elastomeric seals, such as O-rings, will perform predictably in a defined service (medium, time, temperature, pressure, static/dynamic, etc.). However, if compromises are made then the elastomeric seal may perform inconsistently with shortened service life.

The proprietary nature of elastomers make writing a specification difficult. This Standard provides only limited, general guidance for selection of elastomers and provides no specifics for selection of a particular compound, cure filler, etc. The seal selection guide in annex A recommends polymer families (such as fluoroelastomer, nitrile, etc.) based on general experience. The particulars of the compound must be suitable for that service.

Some considerations for selection of particular polymers and compounds include the following:

a) the polymer should be identified by ASTM designation and should not use reprocessed materials;

b) recognize that there are different compounds with different characteristics and performance within a specific polymer family;

c) although most elastomers use carbon black as a filler, there are other fillers that may be used;

d) there are critical properties, such as compression set, that may be more important for some mechanical seal types than for others;

e) media compatibility can vary considerably with time, temperature and concentration — in particular, high temperature elastomers, such as perfluoroelastomers, may have reduced temperature ratings in some media;

f) dynamic secondary sealing elements may also have reduced temperature ratings.

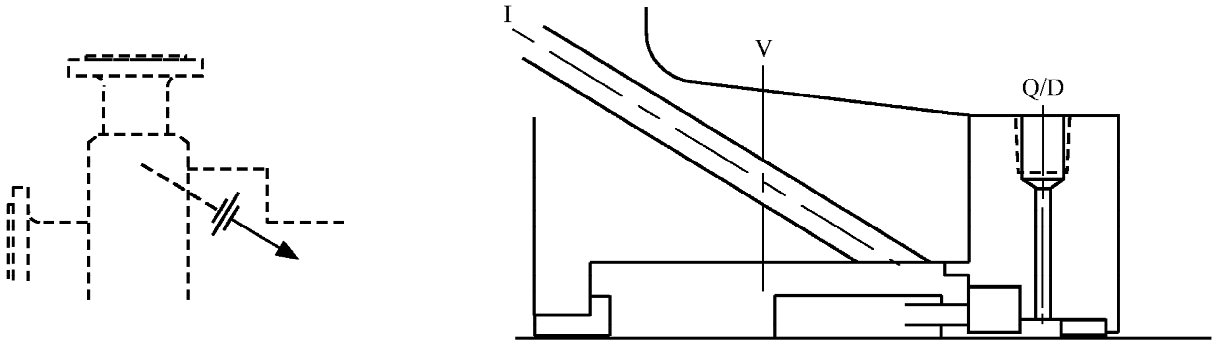
g) indication of all polymers used in a compound.

Annex D
(normative)

Standard flush plans and auxiliary hardware

NOTE 1 This annex contains drawings of standard flush plans and auxiliary hardware which have been used in industry. While not all of these plans are recommended or referenced in this Standard, they may have applications in special cases with purchaser approval.

NOTE 2 The drawing on the left reflects the overall piping and instrumentation schematic of the plan. The drawing on the right reflects only the seal chamber details. Instrumentation shown in the drawings is always an option.

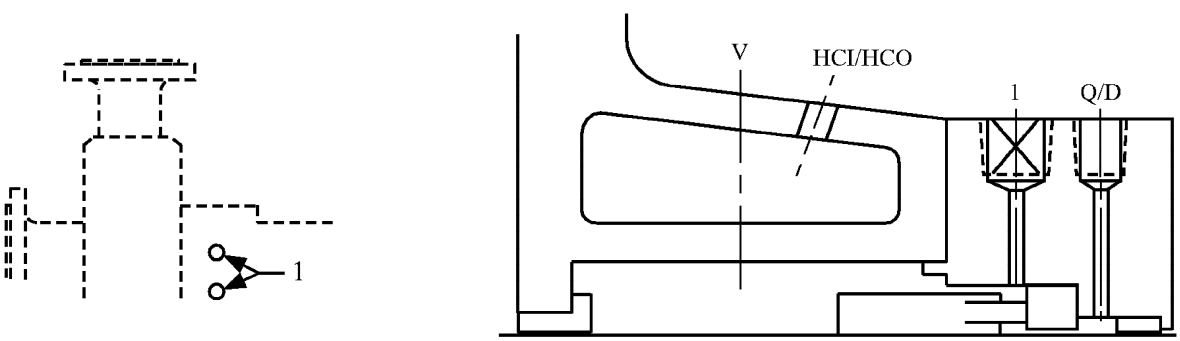


SEAL CHAMBER FOR PLAN 01

Key
V = vent (if required)
I = inlet
Q/D = quench/drain

Integral (internal) recirculation from pump discharge to seal. Recommended for clean pumpage only. Care must be taken to insure that integreal recirculation is sufficient to maintain stable face conditions.

Figure D.1 — Standard seal flush Plan 01

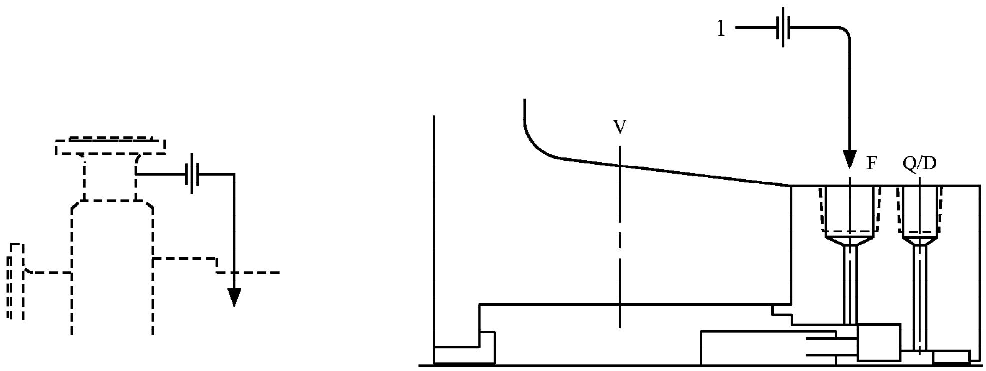


SEAL CHAMBER FOR PLAN 02

Key
1 Plugged connections for possible future circulating fluid
HCI = heating/cooling inlet if required
HCO = heating/cooling outlet if required
Q/D = quench/drain
V = vent (if required)

Dead-ended seal chamber with no recirculation of flushed fluid.

Figure D.2 — Standard seal flush Plan 02

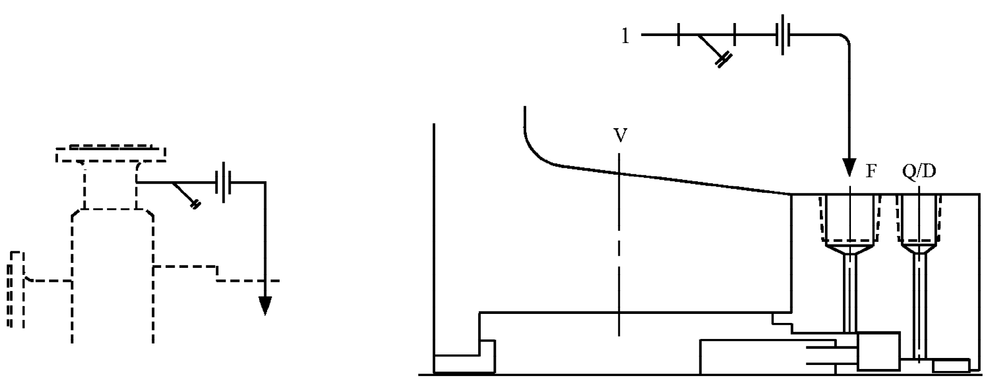


SEAL CHAMBER FOR PLAN 11

Key
1 From pump discharge
F = flush
Q/D = quench/drain
V = vent (if required)

Recirculation from pump discharge through a flow control orifice to the seal. The flow enters the seal chamber adjacent to the mechanical seal faces, flushes the faces, and flows across the seal back into the pump.

Figure D.3 — Standard seal flush Plan 11

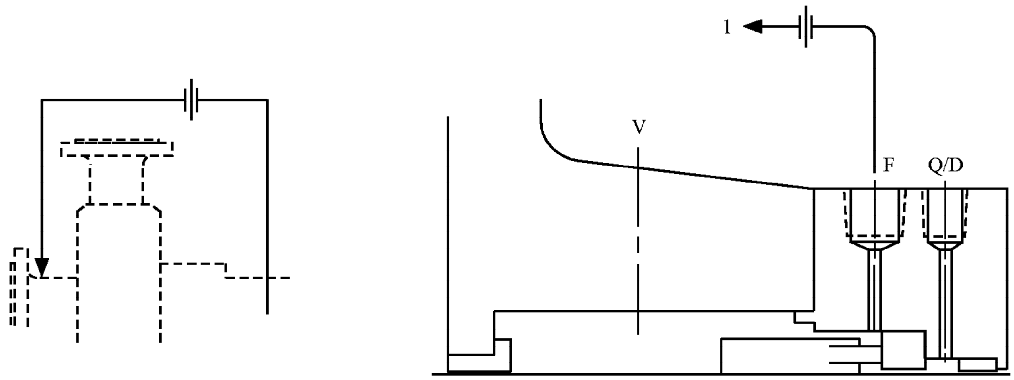


SEAL CHAMBER FOR PLAN 12

Key
1 From pump discharge
F = flush
Q/D = quench/drain
V = vent (if required)

Recirculation from pump discharge through a strainer and flow control orifice to the seal. This plan is similar to Plan 11 but with the addition of a strainer to remove occasional particles. Strainers are not normally recommended because blockage of the strainer will cause seal failure. This plan has been included in the Standard as a reference but it has not been proven to achieve a 3-year operating life. The plan has thus not been included elsewhere in the main document and associated annexes.

Figure D.4 — Standard seal flush Plan 12

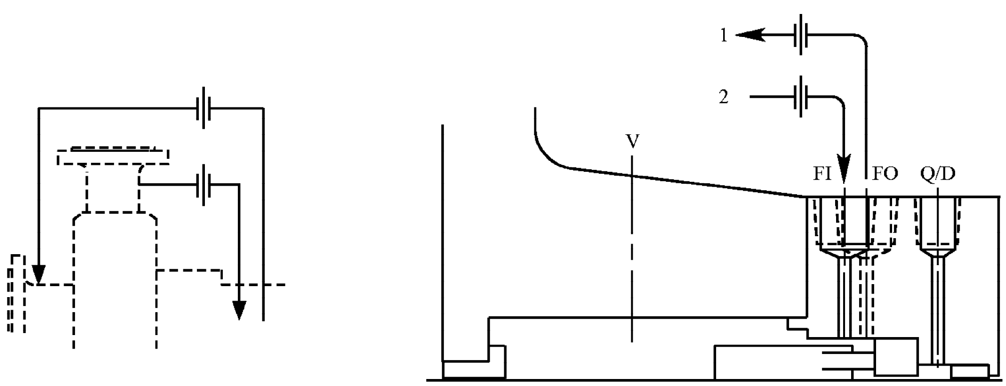


SEAL CHAMBER FOR PLAN 13

Key
1 To pump suction
F = flush
Q/D = quench/drain
V = vent (if required)

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

Figure D.5 — Standard seal flush Plan 13

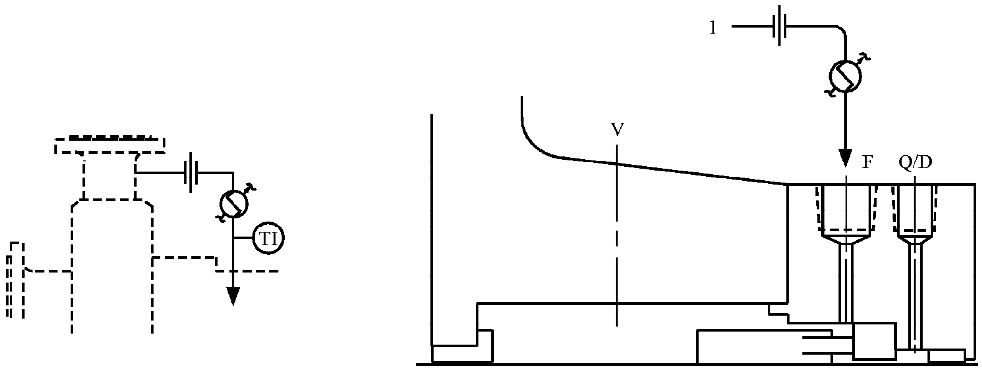


SEAL CHAMBER FOR PLAN 14

Key
1 To pump suction
2 From pump discharge
F I = flush inlet
FO = flush outlet
Q/D = quench/drain
V = vent (if required)

Recirculation from pump discharge through a flow control orifice to the seal and simultaneously from the seal chamber through a control orifice (if required) to pump suction. This allows fluid to enter the seal chamber and provide cooling while continually venting and reducing the pressure in the seal chamber. Plan 14 is a combination of Plan 11 and Plan 13.

Figure D.6 — Standard seal flush Plan 14

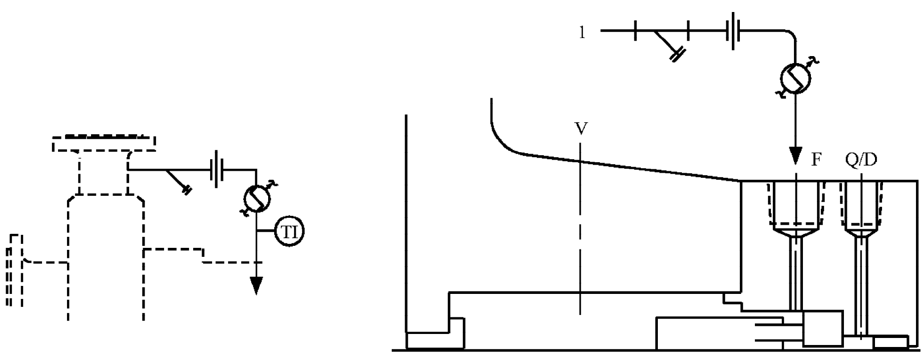


SEAL CHAMBER FOR PLAN 21

Key
1 From pump discharge
F = flush
Q/D = quench/drain
TI = temperature indicator
V = vent (if required)

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

Figure D.7 — Standard seal flush Plan 21

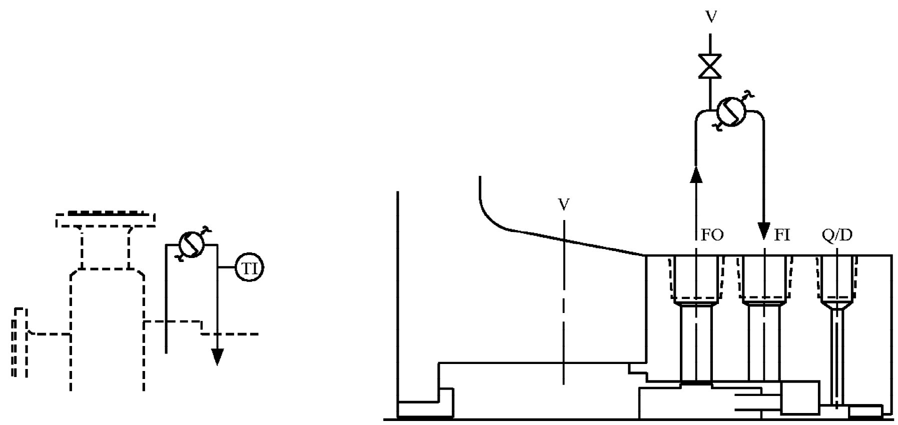


SEAL CHAMBER FOR PLAN 22

Key
1 From pump discharge
F = flush
Q/D = quench/drain
TI = temperature indicator
V = vent (if required)

Recirculation from pump discharge through a strainer, a flow control orifice, and a cooler and into to the seal chamber. Strainers are not normally recommended because blockage of the strainer will cause seal failure. This plan has been included in the Standard as a reference but it has not been proven to achieve a 3-year operating life. The plan has thus not been included elsewhere in the main document and associated annexes.

Figure D.8 — Standard seal flush Plan 22

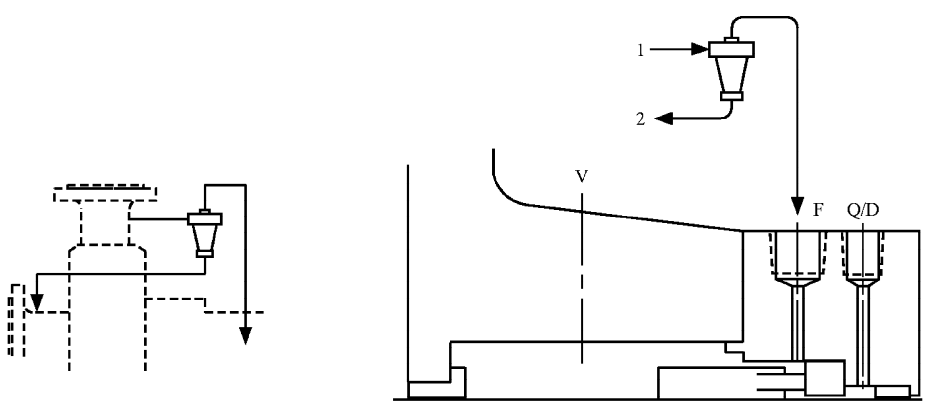


SEAL CHAMBER FOR PLAN 23

Key
FI = flush inlet
FO = flush outlet
Q/D = quench/drain
TI = temperature indicator
V = vent (if required)

Recirculation from a pumping ring in the seal chamber through a cooler and back into the seal chamber. This plan can be used on hot applications to minimize the heat load on the cooler by cooling only the small amount of liquid that is recirculated.

Figure D.9 — Standard seal flush Plan 23

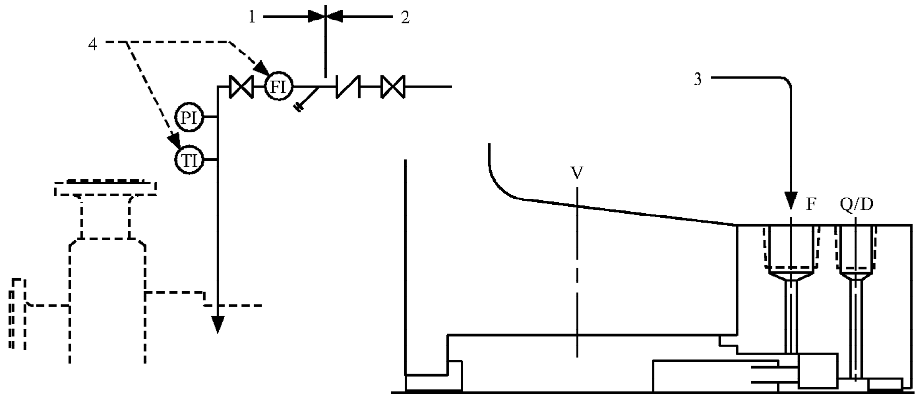


SEAL CHAMBER FOR PLAN 31

Key
1 From pump discharge
2 To pump suction
F = flush
Q/D = quench/drain
V = vent (if required)

Recirculation from pump discharge through a cyclone separator delivering the clean fluid to the seal chamber. The solids are delivered to the pump suction line.

Figure D.10 — Standard seal flush Plan 31



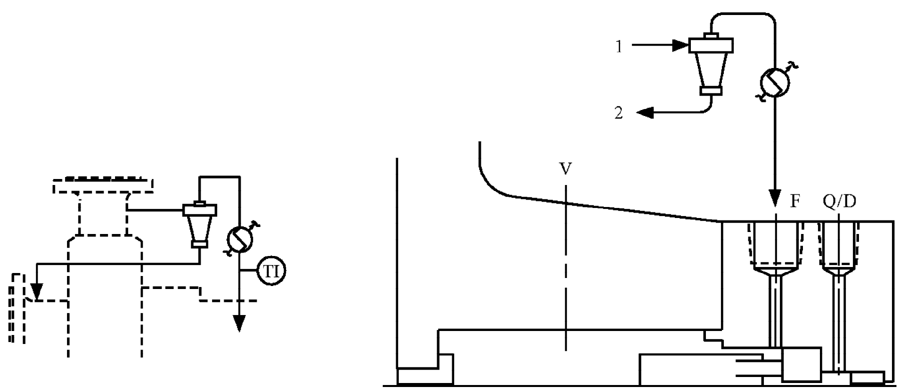
SEAL CHAMBER FOR PLAN 32

Key
1 By vendor
2 By purchaser
3 From external source
4 Optional

F = flush
FI = flow indicator
PI = pressure indicator
Q/D = quench/drain
TI = temperature indicator
V = vent (if required)

Flush is injected into the seal chamber from an external source. Care must be exercised in choosing a proper source of seal flush to eliminate potential for vaporization of the injected fluid and to avoid contamination of the fluid being pumped with the injected flush.

Figure D.11 — Standard seal flush Plan 32

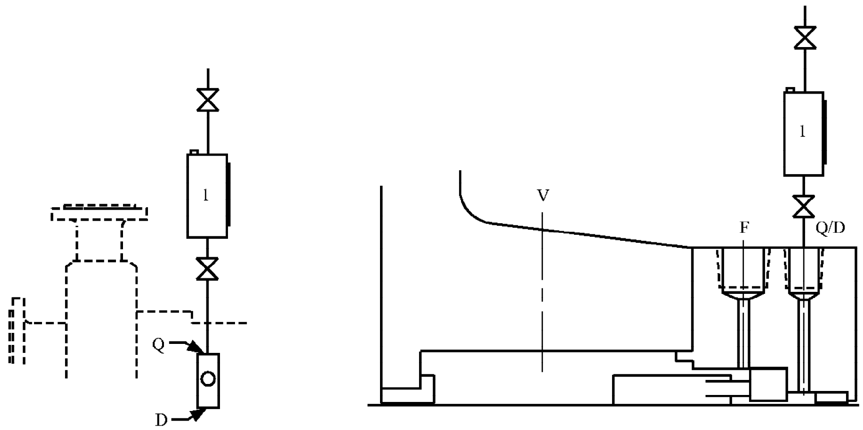


SEAL CHAMBER FOR PLAN 41

Key
1 From pump discharge
2 To pump suction
F = Flush
Q/D = quench/drain
V = vent (if required)

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

Figure D.12 — Standard seal flush Plan 41

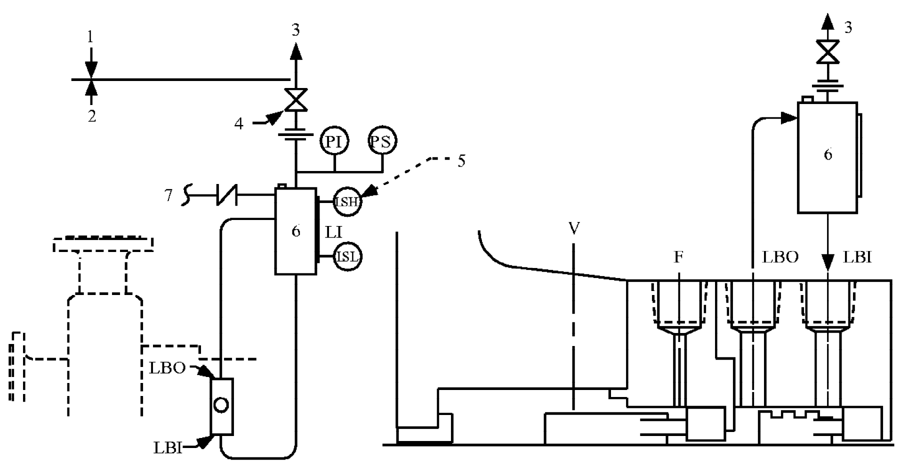


SEAL CHAMBER FOR PLAN 51

Key
1 Reservoir
F = flush
Q = quench
D = drain (plugged)
V = vent (if required)

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

Figure D.13 — Standard seal flush Plan 51



SEAL CHAMBER FOR PLAN 52

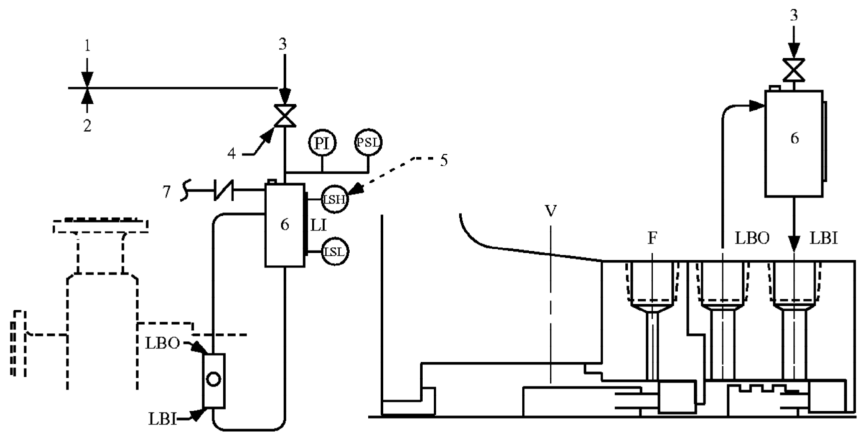
Key
1 By purchaser
2 By vendor
3 To collection system
4 Normally open
5 If specified
6 Reservoir
7 Make up buffer fluid

LBI = liquid buffer inlet
LBO =liquid buffer outlet
LSH = level switch high
LSL = level switch low
LI = level indicator
F = flush
FI = flow indicator

PI = pressure indicator
PS = pressure switch
V = vent (if required)

External reservoir providing buffer fluid for the outer seal of an Arrangement 2 seal. During normal operation, circulation is maintained by an internal pumping ring. The reservoir is usually continuously vented to a vapor recovery system and is maintained at a pressure less than the pressure in the seal chamber.

Figure D.14 — Standard seal flush Plan 52



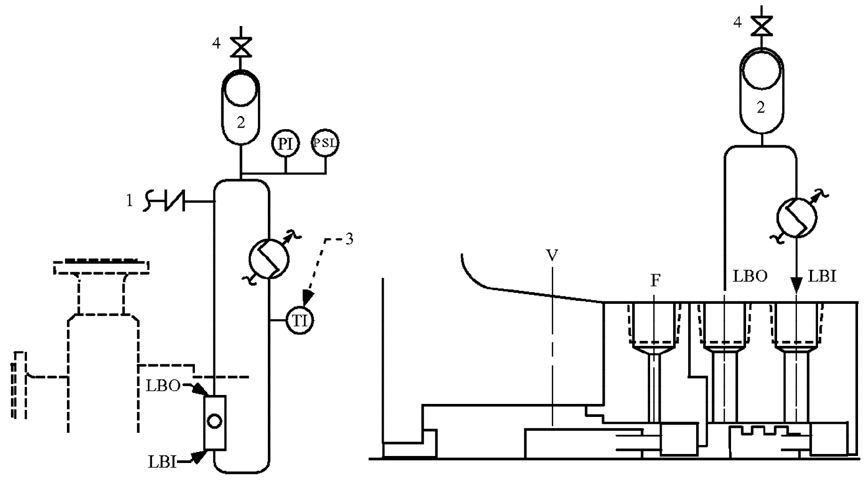
SEAL CHAMBER FOR PLAN 53A

Key

1 By purchaser	LBI = liquid barrier inlet	LSL = level switch low
2 By vendor	LBO = liquid barrier outlet	PI = pressure indicator
3 From external pressure source	F = flush	PSL = pressure switch low
4 Normally open	FI = flow indicator	V = vent (if required)
5 If specified	LI = level indicator	
6 Reservoir	LSH = level switch high	
7 Make up barrier fluid		

Pressurized external barrier fluid reservoir supplying clean fluid to the seal chamber. Circulation is by an internal pumping ring. Reservoir pressure is greater than the process pressure being sealed. This plan is used with an Arrangement 3 seal.

Figure D.15 — Standard seal flush Plan 53A



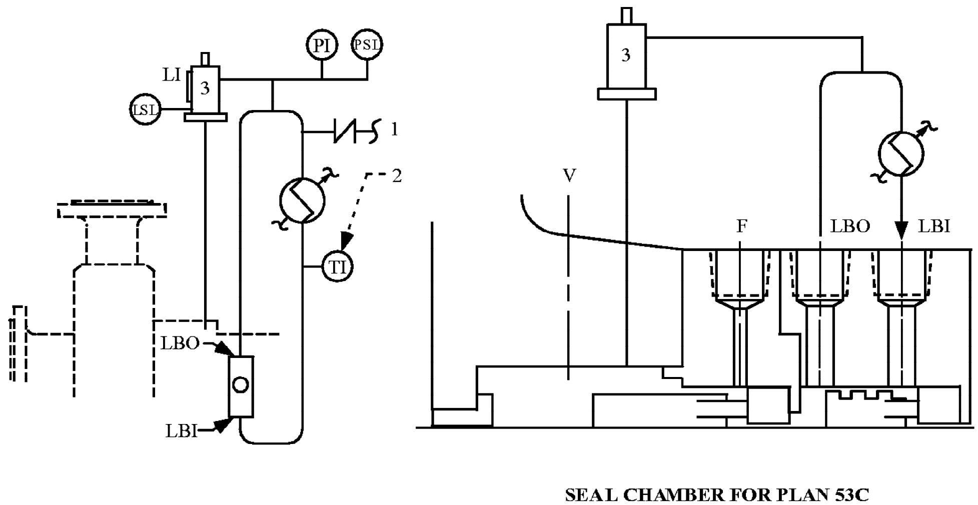
SEAL CHAMBER FOR PLAN 53B

Notes:

1 Make up barrier fluid	LBI = liquid barrier inlet
2 Bladder accumulator	LBO = liquid barrier outlet
3 If specified	F = flush
4 Bladder charge connection	PI = pressure indicator
	PSL = pressure switch low
	V = vent (if required)

External piping provides fluid for the outer seal of a pressurized dual seal arrangement. Pre-pressurized bladder accumulator provides pressure to the circulation system. Flow is maintained by an internal pumping ring. Heat is removed from the circulation system by an air-cooled or water-cooled heat exchanger. This plan is used with an Arrangement 3 seal.

Figure D.16 — Standard seal flush Plan 53B

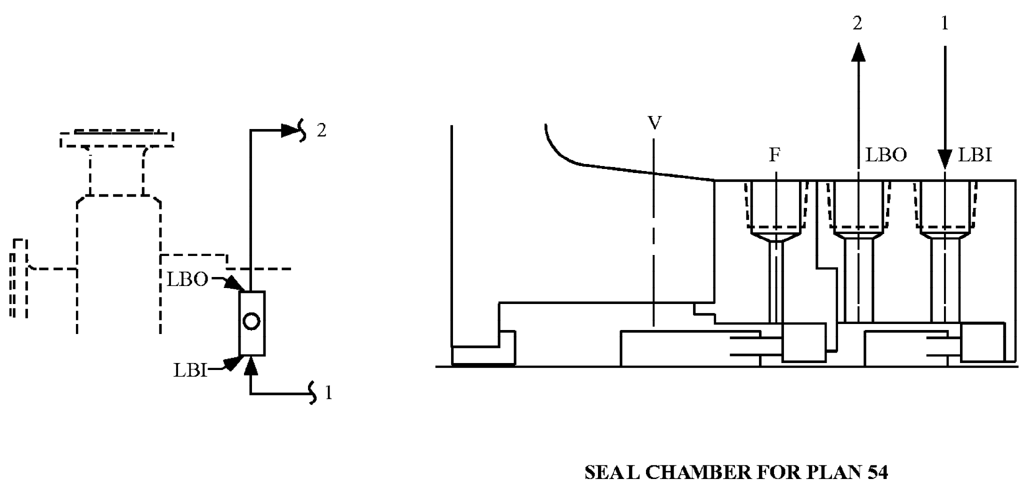


Notes:

1 Make up barrier fluid	LBI = liquid barrier inlet	LSL = level switch low
2 If specified	LBO = liquid barrier outlet	PI = pressure indicator
3 Piston accumulator	F = flush	TI = temperature indicator
	LI = level indicator	V = vent (if required)

External piping provides fluid for the outer seal of a pressurized dual seal arrangement. Reference line from the seal chamber to a piston accumulator provides pressure to the circulation system. Flow is maintained by an internal pumping ring. Heat is removed from the circulation system by an air-cooled or water-cooled heat exchanger.

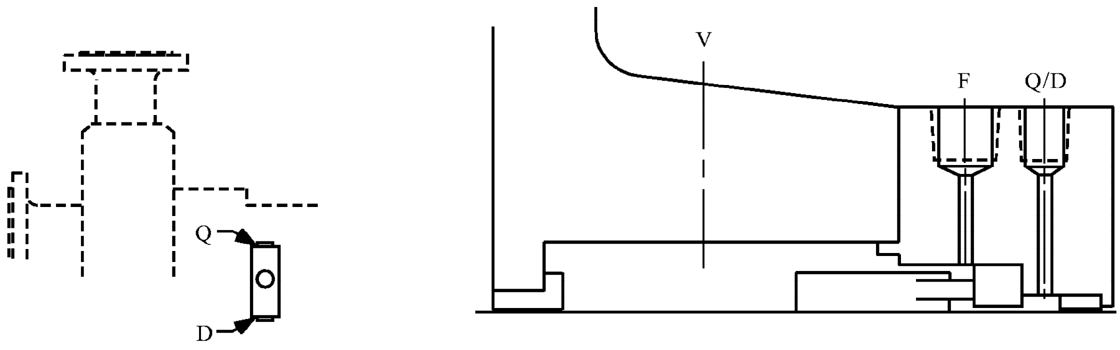
Figure D.17 — Standard seal flush Plan 53C



Key
1 From external source
2 To external source
LBI = barrier inlet
LBO = barrier outlet
F = flush
V = vent (if required)

Pressurized external barrier fluid reservoir or system supplying clean fluid to the seal chamber. Circulation is by an external pump or pressure system. Reservoir pressure is greater than the process pressure being sealed. This plan is used with an Arrangement 3 seal.

Figure D.18 — Standard seal flush Plan 54

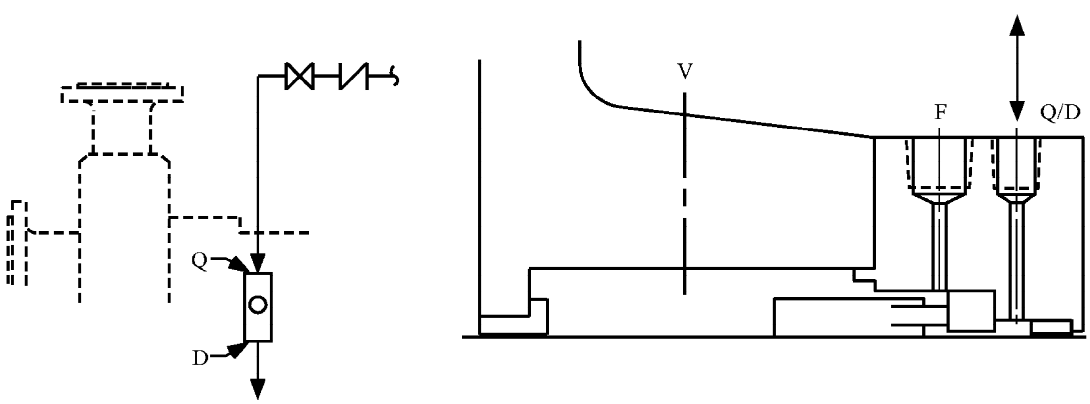


SEAL CHAMBER FOR PLAN 61

Key
F = flush
D = drain (plugged)
Q = quench (plugged)
V = vent (if required)

Tapped and plugged connections for the purchaser's use. Typically this plan is used when the purchaser is to provide fluid (such as steam, gas, or water) to an external sealing device.

Figure D.19 — Standard seal flush Plan 61

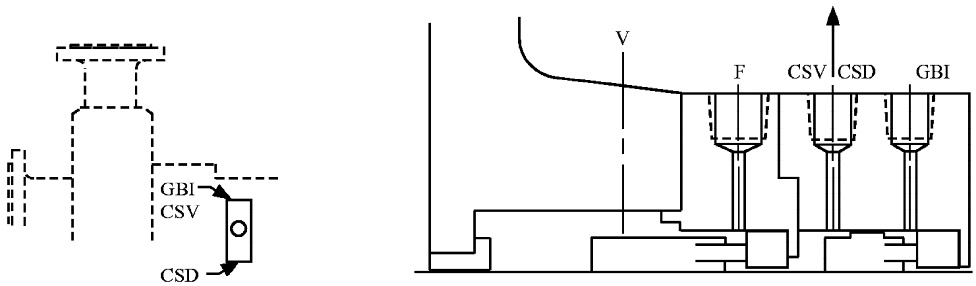


SEAL CHAMBER FOR PLAN 62

Key
F = flush
D = drain
Q = quench
V = vent (if required)

Exterior source providing a quench. The quench may be required to prevent solids from accumulating on the atmospheric side of the seal. Typically used with a close-clearance throttle bushing.

Figure D.20 — Standard seal flush Plan 62

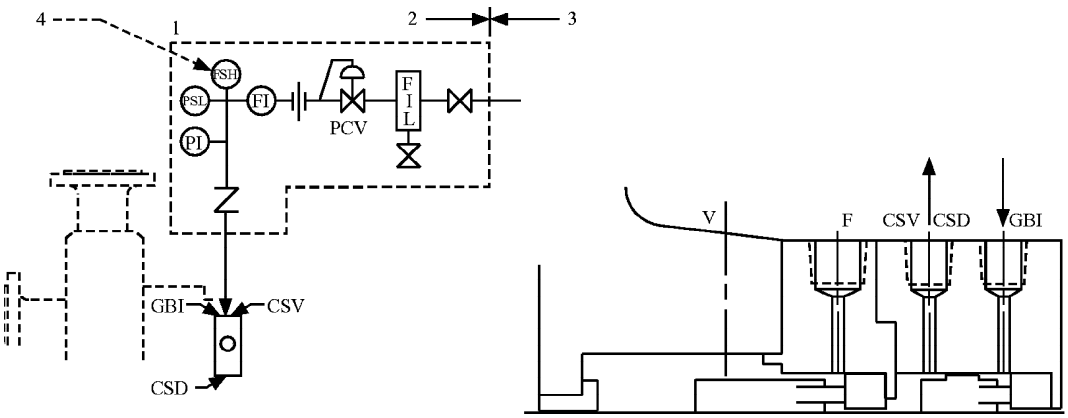


SEAL CHAMBER FOR PLAN 71

Key
F = flush
GBI = gas buffer inlet (plugged)
CSV = containment seal vent (plugged)
CSD = containment seal drain (plugged)
V = vent (if required)

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

Figure D.21 — Standard seal flush Plan 71



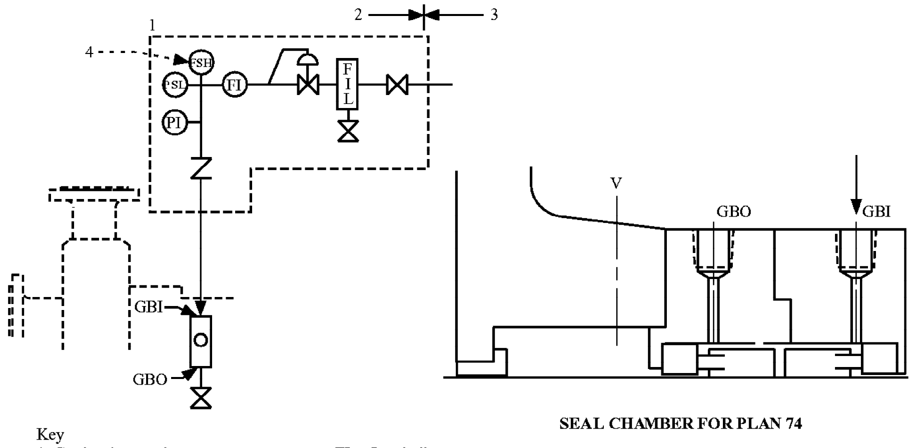
SEAL CHAMBER FOR PLAN 72

Key
1 Buffer gas panel
2 By vendor
3 By purchaser
4 If specified

F = flush
GBI = gas buffer inlet
CSV = containment seal vent
CSD = containment seal drain
FI = flow indicator
FIL = Coalescing Filter, used to ensure solids and/or liquids which might be present in buffer gas supply do not contaminate seals
FSH = flow switch high
PCV = pressure control valve, used to limit buffer gas pressure to prevent reverse pressurization of inner seal and/or limit pressure applied to containment seal.
PI = pressure indicator
PSL = pressure switch low
V = vent (if required)

Externally supplied gas buffer for Arrangement 2 seals. Buffer gas may be used alone to dilute seal leakage or in conjunction with Plan 75 or 76 to help sweep leakage into a closed collection system. Pressure of buffer gas is lower than process side pressure of inner seal.

Figure D.22 — Standard seal flush Plan 72

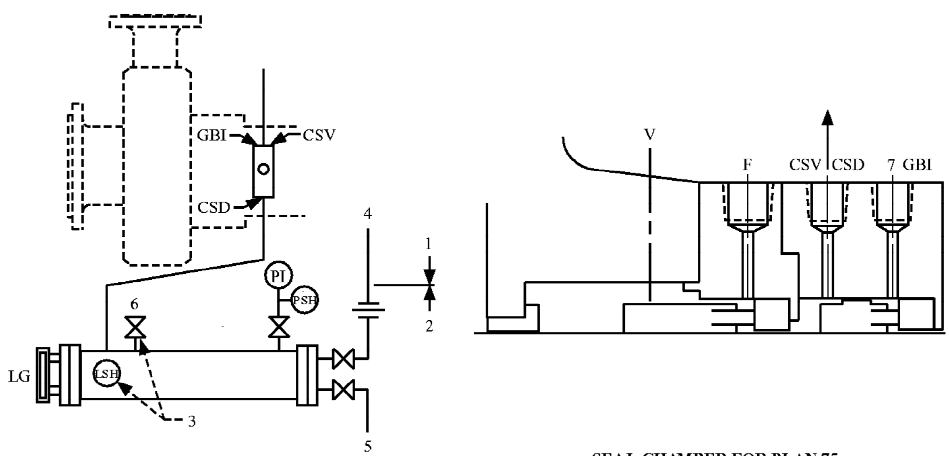


Key
1 Gas barrier panel
2 By vendor
3 By purchaser
4 If specified

FI = flow indicator
FIL = Coalescing filter, used to ensure solids and/or liquids which might be present in barrier gas supply do not contaminate seals
FSH = flow switch high
GBI = gas barrier inlet
GBO = gas barrier outlet (normally closed), used only to depressurize seal chamber
PI = pressure indicator
PCV = pressure control valve, set pressure above process side of inner seal
PSL = pressure switch low
V = vent (if required)

Externally supplied barrier gas used to positively prevent process fluid from leaking to atmosphere. Pressure of barrier gas is higher than process side of inner seal. Venting of the seal chamber may be required prior to start-up and operation to avoid the collection of gas in the pump.

Figure D.23 — Standard seal flush Plan 74

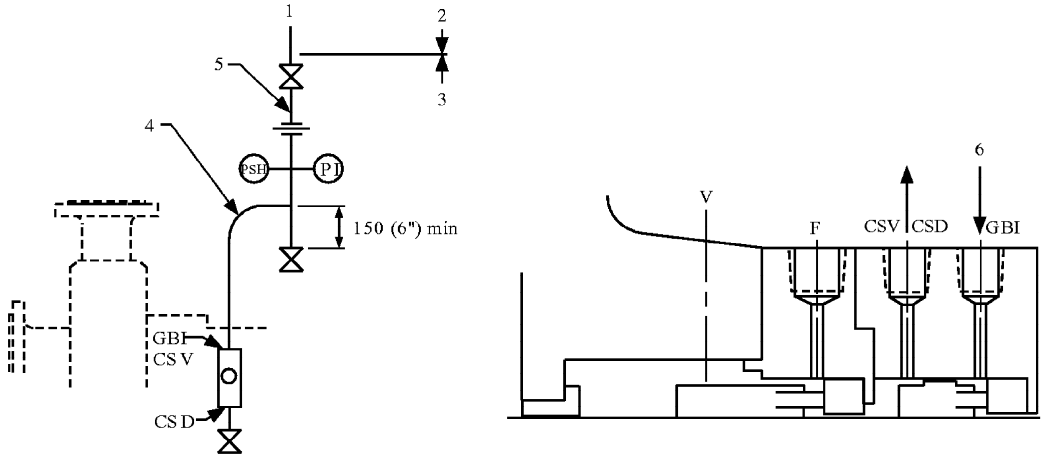


Key
1 By purchaser
2 By vendor
3 If specified
4 To vapor collection system
5 To liquid collection system
6 Test connection
7 From external source

F = flush
GBI = gas buffer inlet (plugged unless a Plan 72 connected)
CSV = containment seal vent
CSD = containment seal drain
LG = level gauge
LSH = level switch high
PSH = pressure switch high
V = vent (if required)

Containment seal chamber drain for condensing leakage on Arrangement 2 seals. This plan is used when pumped fluid condenses at ambient temperatures. System is supplied by vendor.
Valves to be installed per figure and must be accessible for operator use relative to ground clearance and other obstructions.

Figure D.24 — Standard seal flush Plan 75



SEAL CHAMBER FOR PLAN 76

Key

1 To collection system
2 By purchaser
3 By vendor
4 Tube, see note 1
5 Pipe, see note 2
6 From external source

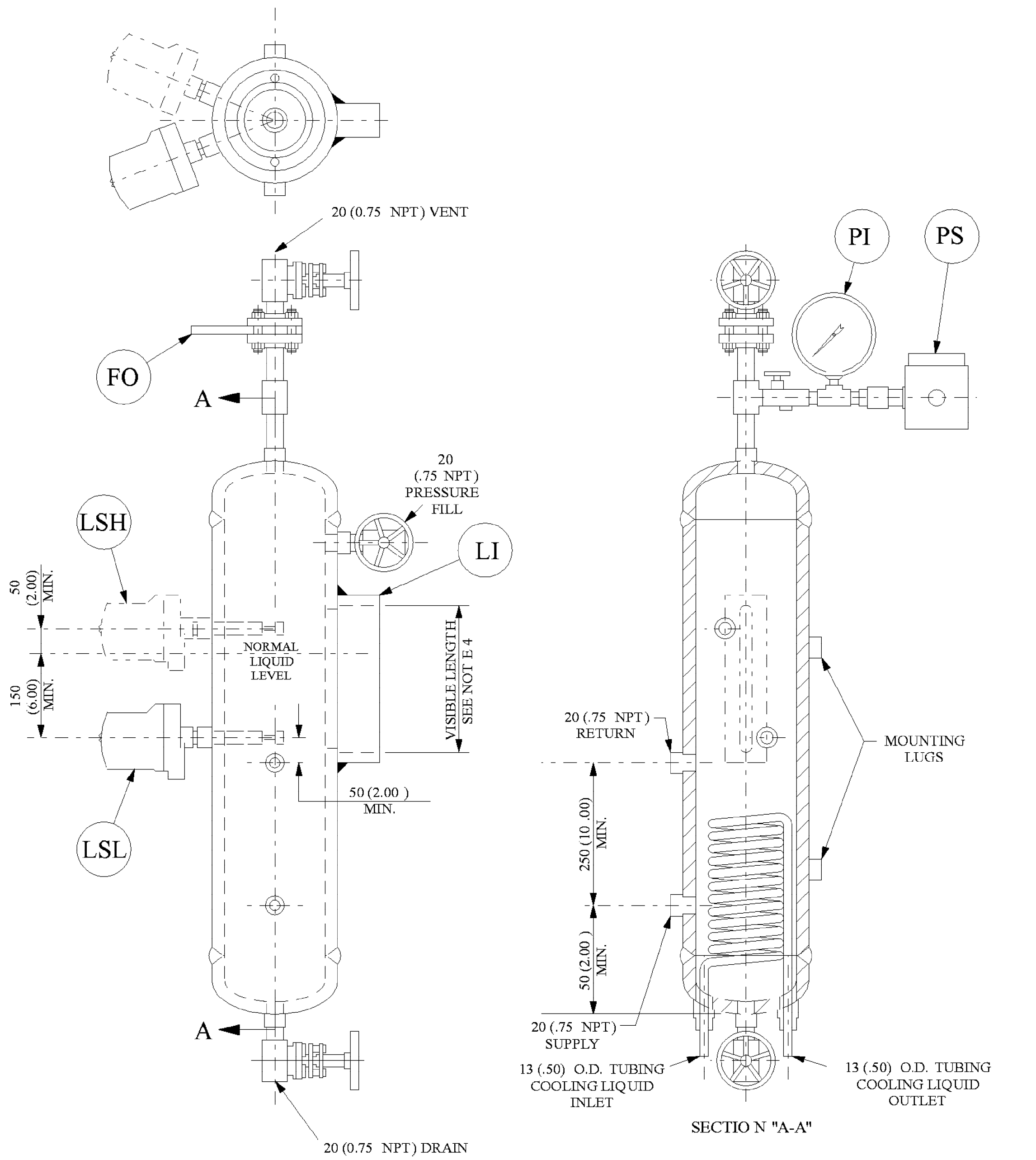
F = flush
GBI = gas buffer inlet
CSV = containment seal vent
CSD = containment seal drain
PSH = pressure switch high
V = vent (if required)

Notes:

1. Tubing shall be 13mm (1/2") minimum and shall rise continuously from the CSV connection to the piping/instrument harness.
2. Harness shall be DN 15 (1/2") minimum pipe. Harness shall be supported from overhead structure or side stand such that that no strain is put on tubing connected to seal gland.

Containment seal chamber drain for non-condensing leakage on Arrangement 2 seals. This plan is used when pumped fluid does not condense at ambient temperatures. System is supplied by purchaser.

Figure D.25 — Standard seal flush Plan 76



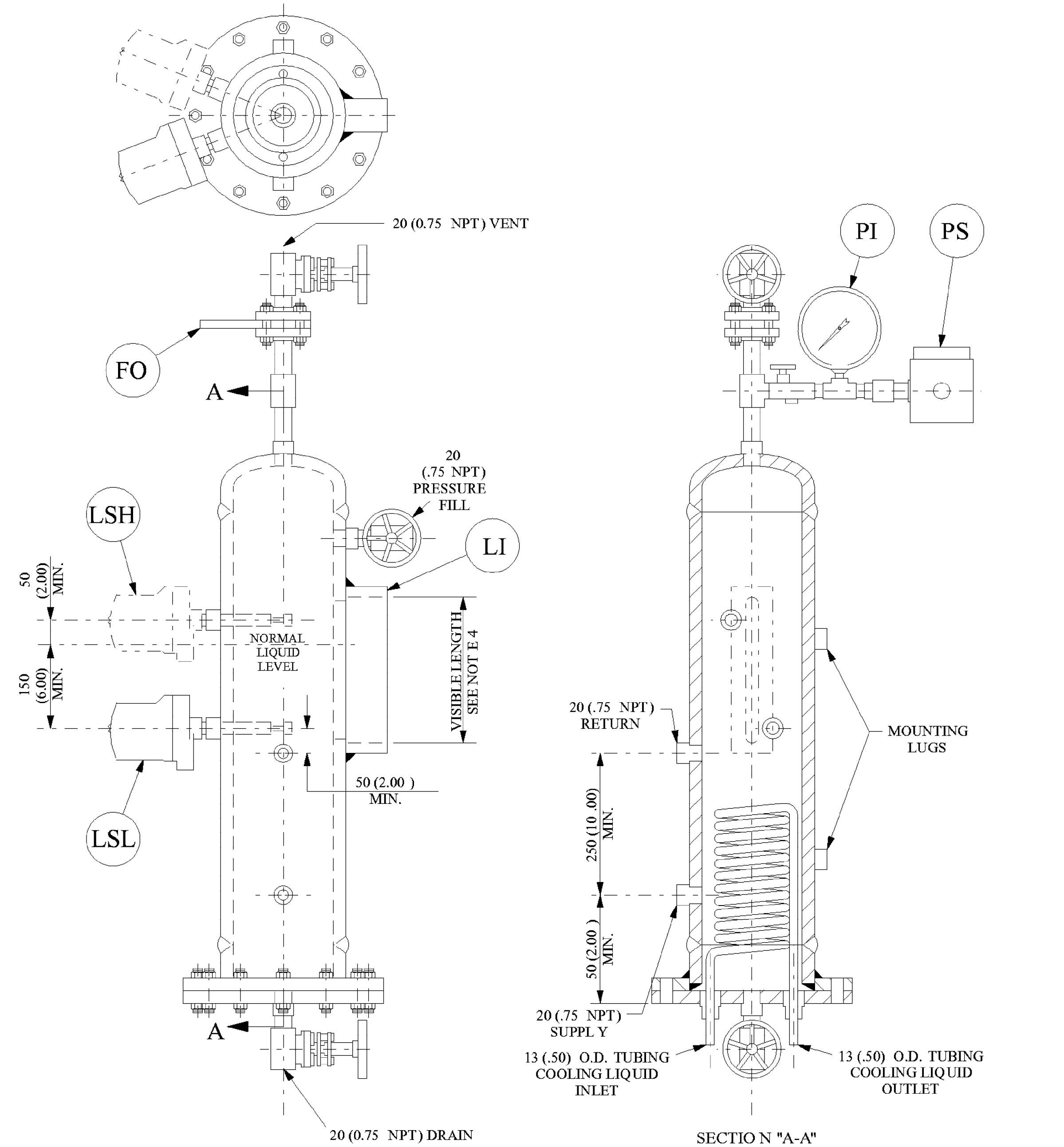
Notes:

1 Refer to data sheet for component definition
2 Dot-dash indicates supplied when specified
3 Dimensions shown are in millimeters (inches)
4 Visible length to extend from below LSL to the greater of 75 (3.0) above NLL or 25 (1.0) above LSH

FO = flow orifice
LSH = level switch low
LSL = level switch low
LI = level indicator

PI = pressure indicator
PSH = pressure switch high

Figure D.26 — Standard external barrier/buffer fluid reservoir



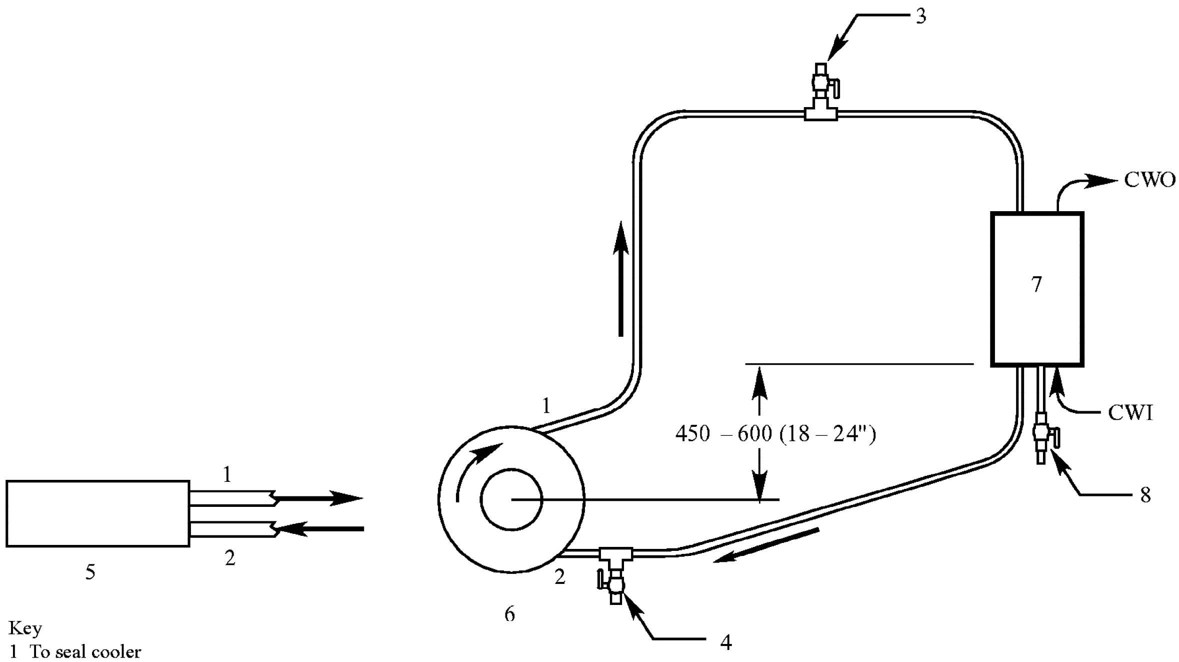
Notes:

1 Refer to data sheet for component definition
2 Dot-dash indicates supplied when specified
3 Dimensions shown are in millimeters (inches)
4 Visible length to extend from below LSL to the greater of 75 (3.0) above NLL or 25 (1.0) above LSH

FO = flow orifice
LSH = level switch low
LSL = level switch low
LI = level indicator

PI = pressure indicator
PSH = pressure switch high

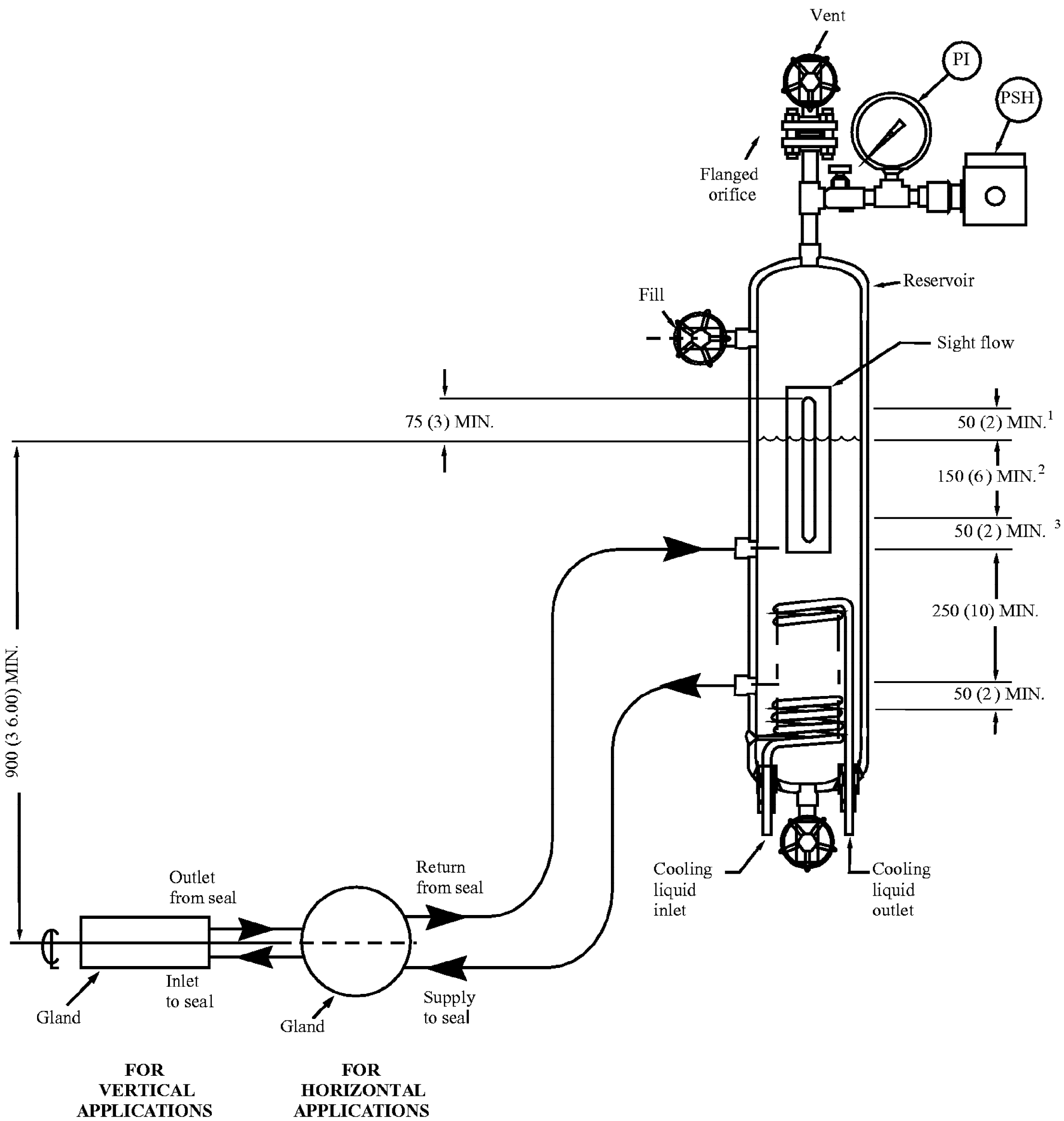
Figure D.27 — Alternative external barrier/buffer fluid reservoir



Key
1 To seal cooler
2 From seal cooler
3 High point vent in connecting tubing
4 Low point drain in connecting tubing if required
5 Arrangement for vertical pump applications
6 Arrangement for horizontal pump applications
7 Seal cooler
8 Cooling water service drain
CWI = cooling water inlet
CWO = cooling water outlet

Notes:
1. Cooling liquid is on the shell side. Process fluid is on the tube side.
2. Care should be taken to ensure that the mounting of the seal cooler, the arrangement of the piping and the location of the vent(s) provide complete venting of gas from system.
3. The cooler arrangement shall provide drainage for both cooling liquid and process fluids. It may not be possible to mount the seal cooler to provide both proper venting and proper draining. In this case, it is more important to mount the cooler so that proper venting can be achieved.
4. For tubing use smooth, long-radius bends. For piping, minimize the number of 90° elbows, although 45° elbows may be used.
5. All lines shall slope up from the gland to high point vent at a minimum of 40 millimeters per meter (0.5 inches per foot).
6. The seal flush cooler shall be located as close to the pump as possible while leaving sufficient room for operation and maintenance. It should not be located directly above the pump.

Figure D.28 — Typical installation of a Plan 23 circulation system

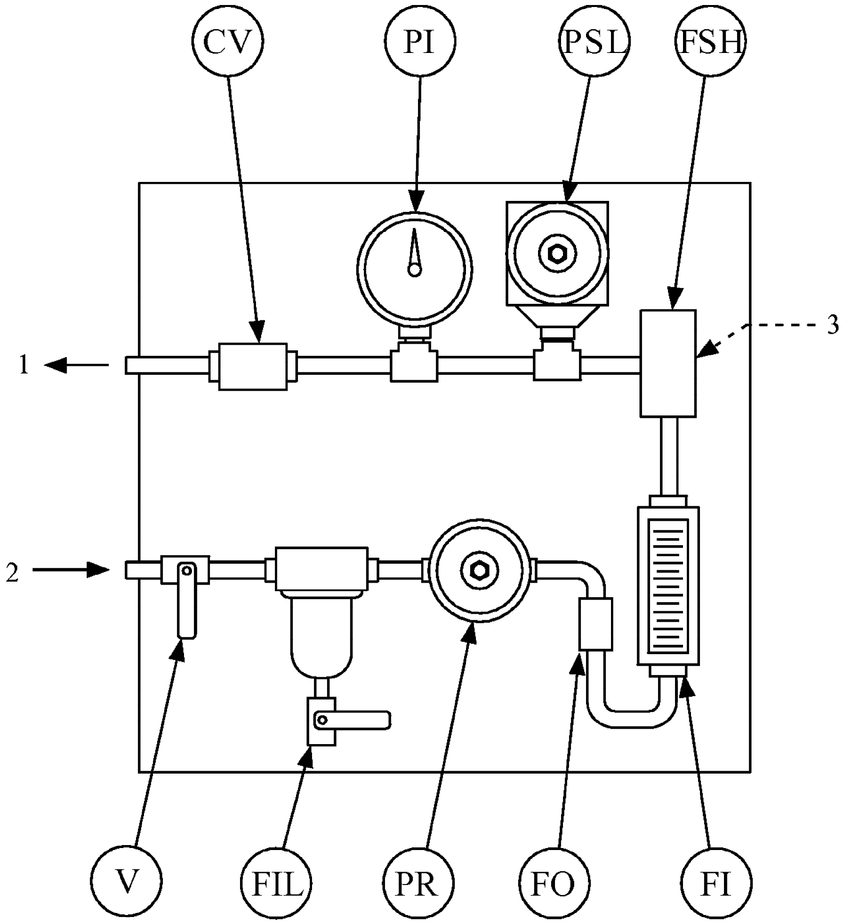


Key
1 High level alarm installed in this range
2 Normal liquid level
3 Low level alarm installed in this range

Notes

1. For tubing. use smooth, long-radius bends. For piping, minimize the number of 90° elbows, although 45° elbows may be used.
2. All lines shall slope up from the gland to the reservoir at a minimum of 40 millimeters per meter (0.5 inches per foot).
3. The reservoir shall be located as close to the pump as possible while leaving sufficient room for operation and maintenance. It should not be located directly above the pump. Hot lines should be insulated as necessary for safety.

Figure D.29 — Typical installation of a barrier/buffer fluid reservoir



Key

1 To seal
2 From gas supply
3 If specified

CV = check valve
FI = flow indicator
FIL = coalescing filter
FO = flow orifice 1.5mm (0.062"), if required
FSH = flow switch high
PI = pressure indicator
PR = pressure regulator
PSL = pressure switch low
V = shut-off valve

Notes

Figure shows general arrangement of components on gas supply panel. The physical layout of components may be different as long as all required components and the described flow sequence are present.

Figure D.30 — Standard external barrier/buffer gas supply panel

Annex E
(informative)

Inspector checklist

Item	Clause reference	Date inspected	Inspected by	Status
The following items apply to all seals:				
Gland connections marked	6.1.2.17			
No plastic plugs	6.1.2.18 10.4.3			
Weld procedures approved	6.1.6.10.1			
Repair procedures approved	6.1.6.10.2			
Wrought material inspections	6.1.6.10.4			
Welded connections	6.1.6.10.5			
Impact test results	6.1.6.11.3			
Adequate clearance and safe access	8.1.4			
Piping, fabrication, examination and inspection meet standards and weld procedures approved.	8.1.6			
Tags attached to coolers	8.2.3.2			
Orifice data	8.5.2.1.2			
Buffer/barrier fluid reservoir tag	8.5.4.4.4			
Thermal sizing criteria	8.5.4.5.1			
Relief valve list	9.8.1			
Compliance with inspectors checklist	10.1.7			
NDE inspection results	10.2.3			
Cleanliness inspection	10.2.13 10.4.3			
Hardness test results	10.2.14			
Qualification test results	10.3.1.5.1 11.2.2 11.2.4			

Test certificate	10.3.1.5.1			
Certified hydrostatic test results	10.3.2.1			
Seal supplied air test tag	10.3.3.2			
Seal leakage acceptance criteria	10.3.5.1.1			
Seal repair reports	10.3.5.1.2			
Site storage prcedures	10.4.2			
Preparation for shipment	10.4.3			
Auxiliary piping connections tagged or marked	10.4.4			
Installation instructions	10.4.5			
Contract data	11.3.1			

Annex F
(normative)

Mechanical seal data sheets

Category 1 & 2 Seals	
MECHANICAL SEAL DATA SHEET FOR CENTRIFUGAL & ROTARY PUMPS U.S. CUSTOMARY UNITS PAGE 1 OF 2	REQUIRED FOR: ____ SITE: ____ UNIT: ____ JOB/PROJECT NO. ____ ITEM NO. ____ REQUISITION / SPEC. NUMBER ____ / ____ INQUIRY NUMBER ____ BY ____ PURCH ORDER NUMBER ____ DATE ____ REVISION NO. 0 DATE

DEFAULT SELECTION	DATA SUPPLIED; ○ CUSTOMARY UNITS ○ SI UNITS
○ INDICATES DATA COMPLETED BY PURCHASER	HARDWARE SUPPLIED ○ CUSTOMARY UNITS ○ SI UNITS
☐ BY SEAL VENDOR	STANDARDS APPLICABLE; ○ PRIMARY REFERENCE (5.2)
BY SEAL VENDOR OR PURCHASER	○ SECONDARY REFERENCE (5.2)

SEAL SPECIFICATION - (REF CLAUSE 1.2, FIGURES 1 TO 6)

CATEGORY	SEAL CATEGORY 1 (1.2)	SEAL CATEGORY 2 (1.2)	SEAL CODE (ANNEX J)
TYPE	TYPE A (3.78)	TYPE B (3.79)	ALTERNATE STATIONARY (TYPE A & B)
(CODE-CW)	TYPE C (3.80)	ALTERNATE ROTATING (TYPE C)	SINGLE SPRING (TYPE A)

ARR'G'T		DEFAULT CONFIGURATION	ALTERNATE DESIGN	FLUSH PLANS (SEE ANNEX D)
1 (3.2)		1CW-FX	1CW-FL; DIST. FLUSH; ALTERNATE BUSH	01, 11, 14, 23, 32, 51, 62; 02, 13, 21, 31, 41, 61
2 (3.3)	BUFFER: LIQUID	2CW-CW	FX; DIST. FLUSH; TANGENTIAL LBO CONN'N	01, 13, 23, 41, 62, 75; 02, 14, 31, 52, 71, 76
	BUFFER: GAS	2CW-CS	2NC-CS; FX	11, 21, 32, 61, 72
3 (3.4)	BARRIER: LIQUID	3CW-FB	3CW-BB; FX; 3CW-FF; TANG. LBO	01, 13, 53B, 61; 02, 32, 53C, 62
	BARRIER: GAS	3NC-BB	3NC-FF; 3NC-FB	11, 53A, 54, 74
SLEEVE-SHAFT DRIVE		SET-SCREW ONTO SHAFT	ALTERNATE (6.1.3.13) - SPECIFY	

MATERIALS (REFERENCE 6.1.6 & ANNEX C)

SECONDARY SEALS	SEAL FACES	METAL BELLOWS	SPRINGS	METAL PARTS
FKM; FFKM	CARBON VS SIC	UNS N10276 (TYPE B)	UNS N10276 OR N06455	UNS S31600/ S31635
SPIRAL-W GASKET	SIC VS SIC	UNS N07718 (TYPE C)		UNS N10276
NBR; EPM/EPDM	SS-SIC; RB-SIC	UNS N08020	UNS S31600 OR S31635	UNS N08020
OTHER:	____ VS ____	OTHER:		OTHER:

MECHANICAL SEAL DATA

○ SEAL VENDOR ____	☐ ALTERNATE SEAL FOR PUMP PERFORMANCE TEST
○ DATA REQUIREMENTS FORM (ANNEX G)	☐ DYNAMIC SEALING PRESSURE RATING (3.19) ____ PSIG
☐ SIZE/TYPE ____	☐ STATIC SEALING PRESSURE RATING (3.74) ____ PSIG
☐ SEAL DRAWING NUMBER ____	☐ MAXIMUM ALLOWABLE TEMPERATURE (3.39) ____ °F
☐ VENDOR'S SEAL CODE ____	○ MINIMUM DESIGN METAL TEMPERATURE ____ °F
☐ MODIFIED FACES FOR PUMP PERFORMANCE TEST	

SEAL CHAMBER DATA (REFERENCE 6.1.2.4)

ASME B73.1 & 2 — CYLINDRICAL — TAPERED — ISO 13709 — ISO 3069-C — OTHER, SPECIFY ____

○ BOLT-ON CHAMBER (6.1.2.5) — SEAL CHAMBER FLUSH PORT REQ'D — SEAL CHAMBER VENT REQ'D

FLOATING THROAT BUSH — FIXED THROAT BUSH — CHAMBER HEATING/COOLING — H — C

PUMP DATA

PUMP DESIGN ○ MANUFACTURER ____ ○ MODEL ____ ○ FRAME/SIZE ____ ○ CASE MATERIAL ____

PUMP OPERATING PRESSURE ○ SUCTION PRESSURE (RATED) ____ PSIG ○ DISCHARGE PRESSURE ____ PSIG

SEAL CHAMBER ○ NORMAL ____ PSIG ○ MIN / MAX (MDSP, 3.41) ____ / ____ PSIG ○ MSSP (3.43) ____ PSIG

SHAFT ○ DIA. ____ IN ○ SHAFT SPEED ____ RPM SHAFT DIRECTION (FROM DRIVER): ○ CW ○ CCW

FLUID DATA - (FOR QUENCH, BUFFER AND BARRIER FLUID DATA, SEE PAGE 2)

PUMPED STREAM	○ HAZARDOUS ○ FLAMMABLE ○ ____
○ TYPE OR NAME ____ CONC'N ____ %	○ FLUID SOLID @ AMBIENT
○ DISSOLVED CONTAMINANT ○ H_2S ____ PPM ○ WET	○ SOLIDIFIES @ ____ °F POUR POINT ____ °F
○ Cl_2 ____ PPM ○ OTHER ____ @ ____ PPM	○ PUMPED STREAM SOLIDIFIES UNDER SHEAR
○ SOLID CONTAMINANT ____	○ PUMPED STREAM CONTAINS AGENTS THAT POLYMERIZE
○ CONCENTRATION (% BY WT, OR PPM) ____	SPECIFY AGENTS ____ @ TEMP ____ °F
○ PUMPING TEMPERATURE	○ PUMPED STREAM CAN PLATE OUT OR DECOMPOSE:
MIN ____ °F NORMAL ____ °F MAX ____ °F	SPECIFY CONDITIONS ____
○ SPECIFIC GRAVITY AT TEMPERATURE INDICATED	○ PUMPED STREAM IS REGULATED FOR FUGITIVE OR
@ NORMAL TEMP ____ @ MAX TEMP ____	OTHER EMISSIONS. REGULATION LEVEL ____ PPMV
○ VAPOR PRESSURE AT TEMPERATURE INDICATED	○ SPECIAL PUMP CLEANING PROCEDURES
NORMAL TEMP ____ PSIA MAX TEMP ____ PSIA	SPECIFY; ____
○ ATMOSPHERIC BOILING POINT. ____ °F	○ ALTERNATE PROCESS FLUIDS & CONCENTRATION
○ VISCOSITY @ NORMAL PUMPING TEMP. ____ Cp	(INCL. COMMISSIONING)
FLUSH FLUID If flush fluid is pumpage, then flush fluid data is not required.	
○ TYPE OR NAME ____ CONC'N ____ %	○ VAPOR PRESSURE AT TEMPERATURE INDICATED
○ SEAL VENDOR REVIEW REQUIRED	NORMAL TEMP ____ PSIA MAX TEMP ____ PSIA
○ FLUID TEMPERATURE	○ ATMOSPHERIC BOILING POINT. ____ °F
MIN ____ °F NORMAL ____ °F MAX ____ °F	○ VISCOSITY @ NORMAL PUMPING TEMP. ____ Cp
○ SPECIFIC GRAVITY AT TEMPERATURE INDICATED	☐ FLOW RATE REQ'D MAX/MIN ____ / ____ GPM
@ NORMAL TEMP ____ @ MAX TEMP ____	☐ PRESSURE REQ'D MAX/MIN ____ / ____ PSIG

Category 1 & 2 Seals	
MECHANICAL SEAL DATA SHEET **FOR CENTRIFUGAL & ROTARY PUMPS** **U.S. CUSTOMARY UNITS** **PAGE 2 OF 2** **(FLUID DATA, UTILITIES, ACCESSORIES, & INSP./TEST.)**	REQUIRED FOR: ______ SITE: ______ UNIT: ______ JOB/PROJECT NO. ______ ITEM NO. ______ REQUISITION / SPEC. NUMBER ______ / ______ INQUIRY NUMBER ______ BY ______ PURCH ORDER NUMBER ______ DATE ______ REVISION NO. 0 DATE

Line		
1	INDICATES DATA COMPLETED BY PURCHASER	BY SEAL VENDOR / BY SEAL VENDOR OR PURCHASER
2	DEFAULT SELECTION	
3	FLUID DATA - (QUENCH, BUFFER AND BARRIER FLUID DATA, LIQUID AND GAS)	
4	QUENCH MEDIUM	SUPPLY TEMPERATURE MAX/MIN ______ / ______ °F
5	TYPE OR NAME	FLOW RATE REQ'D MAX/MIN ______ / ______ GPM/SCFH
6	BUFFER/BARRIER MEDIUM	SPECIFIC GRAVITY AT TEMP. INDICATED (LIQUID)
7	TYPE OR NAME ______	@ NORMAL TEMP ______ @ MAX TEMP ______
8	PURCHASER SELEC'N / SEAL VENDOR SELEC'N	VAPOR PRESSURE AT TEMPERATURE INDICATED (LIQUID)
9	SEAL VENDOR REVIEW / PURCHASER REVIEW	NORMAL TEMP ______ PSIA MAX TEMP ______ PSIA
10	FLOW RATE REQ'D MAX/MIN. ______ / ______ GPM/SCFH	ATMOSPHERIC BOILING POINT (LIQUID) ______ °F
11	SUPPLY PRESSURE MAX/MIN. ______ / ______ PSIG	VISCOSITY @ NORMAL TEMP (LIQUID) ______ Cp
12	FLUID OPERATING TEMPERATURE	SPECIFIC HEAT @ NORMAL TEMP ______ BTU/HR FT °F
13	MIN ______ °F NORMAL ______ °F MAX ______ °F	COOLING/HEATING REQUIRED (+ OR -) ______ BTU/HR
14	SITE AND UTILITIES	
15	CONTROL VOLTAGE ______ V PHASE ______ HERTZ ______	COOLING H_20 SUPPLY TEMP. ______ °F Cl_2 ______ PPM
16	ELECTRICAL AREA CL ______ GR ______ DIV ______	COOLING H_2O PRESS. NORM./DES. ______ / ______ PSIG
17	DESIGN AMBIENT MIN./MAX. ______ / ______ °F	EXPLOSIVE AREA CLASS (DIRECTIVE 94/9/EC) ______
18	ACCESSORIES (CLAUSES 8 AND 9)	
19	GENERAL	PLAN 52 AND 53 SYSTEMS CONTINUED
20	JOINT USER/VENDOR LAYOUT OF EQUIPMENT (8.1.4)	EQUIPMENT SUPPORT SUPPLIER ______
21	SPECIAL REQUIREMENTS FOR HAZARDOUS SERVICE	FILLING SYSTEM SUPPLIER ______
22	______	ASME CODE STAMP REQUIRED
23	SPECIAL CLEANING AND DECONTAMINATION REQ'TS ______	RESERVOIR CAPACITY (8.5.4.3.1) ______ GA ______
27	THERMAL RELIEF VALVES REQUIRED (9.8.3)	SYSTEM HOLD-UP PERIOD (PLANS 53B & 53C) ______ DAYS
28	COOLING SYSTEM	PRESSURE SWITCH (8.5.4.2.7) TO ACTIVATE ON;
29	HEAT EXCHANGER SUPPLIER ______	RISING PRESSURE (ARR 2) SET @ ______ PSIG
30	WATER COOLED / AIR COOLED / ASME B31.3	FALLING PRESSURE (ARR 3) SET @ ______ PSIG
31	EQUIPMENT REFERENCE/CODE ______	HIGH LEVEL ALARM REQUIRED (8.5.4.2.8)
32	COOLING WATER LINES SUPPLIER ______	H/Q CURVE FOR INTERNAL CIRCULATING DEVICE (8.6.2.1)
33	TUBING / GALVANISED PIPING (8.4.2)	TEST BASED H/Q CURVE FOR INTERNAL CIRC. DEVICE
34	COOLING WATER FLOW RATE ______ GPM	EXTERNAL CIRCULATING PUMP (8.6.3.1)
35	SIGHT FLOW INDICATORS (8.4.3) OPEN / CLOSED	PLAN 72 AND 74 SYSTEM
36	PLAN 11, 12, 13, 31 AND 41 SYSTEMS	EQUIPMENT SUPPLIER ______
37	CONNECTING LINES SUPPLIER ______	HIGH FLOW ALARM SWITCH (8.6.6.5)
38	TUBING / PIPING (8.5.2.1)	PLAN 75 AND 76 SYSTEM
39	RESTRICTION ORIFICE NIPPLE IN FLUSH LINE (8.5.2.3)	EQUIPMENT SUPPLIER ______
40	CYCLONE SEPARATOR SUPPLIER ______	HIGH LEVEL ALARM SWITCH FOR PLAN 75 (8.6.5.3)
41	PLAN 52 AND 53 SYSTEMS	TEST CONNECTION (8.6.5.4)
42	STANDARD (FIG D.26) / ALTERNATE (FIG D.27)	INSTRUMENTATION
43	DIMENSIONAL VARIATIONS TO STANDARD (FIG D.26)	USER SPECIFICATION REFERENCE FOR
44	______	INSTRUMENTATION/CONTROLS ______
45	DIMENSIONAL VARIATIONS TO ALTERNATE (FIG D.27)	PRESSURE GAUGES (9.4);
46	______	OIL FILLED PRESSURE GAUGES (9.4.3)
47	ALTERNATE FABRICATION STANDARD ______	PRESSURE SWITCHES (9.5.2); TRANSMITTERS (9.5.2.3)
48	PRIMARY EQUIPMENT SUPPLIER ______	LEVEL SWITCHES (9.5.3);
49	SUPPLIER REFERENCE/CODE ______	HYDROSTATIC / CAPACITANCE / ULTRASONIC
50	CONNECTING LINES SUPPLIER ______	LEVEL INDICATORS (9.6) TRANSMITTER (9.5.3.2)
51	TUBING / PIPING (8.5.4.4.9)	WELD PAD / EXTERNAL, REMOVABLE (9.6.2)
52		FLOW INDICATORS (9.7); TRANSMITTER (9.7.2)
53	INSPECTION AND TESTING	
54	PURCHASER PARTICIPATION IN INSPECTION & TEST	100% INSPECTION OF ALL WELDS (6.1.6.10.5.1) USING;
55	SPECIFY; ______	MAGNETIC PARTICLE / LIQUID PENETRANT
56	INSPECTOR'S CHECK LIST (10.1.7 & ANNEX E)	RADIOGRAPHIC / ULTRASONIC
57	OPTIONAL QUALIFICATION TESTING REQ'D (10.3.1.1.2)	MODIFIED FACES FOR PUMP TEST (10.3.5.2.1)
58	PURCHASER APPROVAL REQUIRED FOR WELDED	(SEE PAGE 1, LINE 31)
59	CONNECTION DESIGNS, (6.1.6.10.5.4)	ALTERNATE SEAL PUMP TEST (10.3.5.2.2)
60	HARDNESS TEST (10.2.14) REQUIRED FOR;	(SEE PAGE 1, LINE 26)
61	______	

Category 1 & 2 Seals	REQUIRED FOR: SITE: UNIT:
MECHANICAL SEAL DATA SHEET FOR CENTRIFUGAL & ROTARY PUMPS S.I.UNITS PAGE 1 OF 2	JOB/PROJECT NO. ITEM NO.
	REQUISITION / SPEC. NUMBER /
	INQUIRY NUMBER BY
	PURCH ORDER NUMBER DATE
	REVISION NO. 0 DATE

◌ DEFAULT SELECTION	DATA SUPPLIED; ○ CUSTOMARY UNITS ○ SI UNITS
○ INDICATES DATA COMPLETED BY PURCHASER	HARDWARE SUPPLIED ○ CUSTOMARY UNITS ○ SI UNITS
☐ BY SEAL VENDOR	STANDARDS APPLICABLE; ○ PRIMARY REFERENCE (5.2)
☐ BY SEAL VENDOR OR PURCHASER	○ SECONDARY REFERENCE (5.2)

SEAL SPECIFICATION - (REF CLAUSE 1.2, FIGURES 1 TO 6)

CATEGORY	○ SEAL CATEGORY 1 (1.2)	○ SEAL CATEGORY 2 (1.2)	☐ SEAL CODE (ANNEX J)
TYPE	☐ TYPE A (3.78)	☐ TYPE B (3.79)	☐ ALTERNATE STATIONARY (TYPE A & B)
(CODE-CW)	☐ TYPE C (3.80)	☐ ALTERNATE ROTATING (TYPE C)	☐ SINGLE SPRING (TYPE A)

ARR'G'T		DEFAULT CONFIGURATION	ALTERNATE DESIGN	FLUSH PLANS (SEE ANNEX D)
1 (3.2)		☐ 1CW-FX	☐ 1CW-FL ☐ DIST. FLUSH	☐ 01 ☐ 11 ☐ 14 ☐ 23 ☐ 32 ☐ 51 ☐ 62
			☐ ALTERNATE BUSH	☐ 02 ☐ 13 ☐ 21 ☐ 31 ☐ 41 ☐ 61
2 (3.3)	BUFFER LIQUID	☐ 2CW-CW	☐ FX ☐ DIST. FLUSH	☐ 01 ☐ 13 ☐ 23 ☐ 41 ☐ 62 ☐ 75
			☐ TANGENTIAL LBO CONN'N	☐ 02 ☐ 14 ☐ 31 ☐ 52 ☐ 71 ☐ 76
	BUFFER GAS	☐ 2CW-CS	☐ 2NC-CS ☐ FX	☐ 11 ☐ 21 ☐ 32 ☐ 61 ☐ 72
3 (3.4)	BARRIER LIQUID	☐ 3CW-FB	☐ 3CW-BB ☐ FX	☐ 01 ☐ 13 ☐ 53B ☐ 61
			☐ 3CW-FF ☐ TANG. LBO	☐ 02 ☐ 32 ☐ 53C ☐ 62
	BARRIER GAS	☐ 3NC-BB	☐ 3NC-FF ☐ 3NC-FB	☐ 11 ☐ 53A ☐ 54 ☐ 74

SLEEVE-SHAFT DRIVE ☐ SET-SCREW ONTO SHAFT ☐ ALTERNATE (6.1.3.13) - SPECIFY

MATERIALS (REFERENCE 6.1.6 & ANNEX C)

SECONDARY SEALS	SEAL FACES	METAL BELLOWS	SPRINGS	METAL PARTS
☐ FKM ☐ FFKM	☐ CARBON VS SIC	☐ UNS N10276 (TYPE B)	☐ UNS N10276	☐ UNS S31600/ S31635
☐ SPIRAL-W GASKET	☐ SIC VS SIC	☐ UNS N07718 (TYPE C)	OR N06455	☐ UNS N10276
☐ NBR ☐ EPM/EPDM	☐ SS-SIC ☐ RB-SIC	☐ UNS N08020	☐ UNS S31600	☐ UNS N08020
☐ OTHER:	☐ VS	☐ OTHER:	OR S31635	☐ OTHER:

MECHANICAL SEAL DATA

○ SEAL VENDOR	☐ ALTERNATE SEAL FOR PUMP PERFORMANCE TEST
○ DATA REQUIREMENTS FORM (ANNEX G)	☐ DYNAMIC SEALING PRESSURE RATING (3.19) bar (ga)
☐ SIZE/TYPE	☐ STATIC SEALING PRESSURE RATING (3.74) bar (ga)
☐ SEAL DRAWING NUMBER	☐ MAXIMUM ALLOWABLE TEMPERATURE (3.39) °C
☐ VENDOR'S SEAL CODE	○ MINIMUM DESIGN METAL TEMPERATURE °C
☐ MODIFIED FACES FOR PUMP PERFORMANCE TEST	

SEAL CHAMBER DATA (REFERENCE 6.1.2.4)

ASME B73.1 & 2 ☐ CYLINDRICAL ☐ TAPERED ☐ ISO 13709 ☐ ISO 3069-C ☐ OTHER, SPECIFY

○ BOLT-ON CHAMBER (6.1.2.5) ☐ SEAL CHAMBER FLUSH PORT REQ'D ☐ SEAL CHAMBER VENT REQ'D

☐ FLOATING THROAT BUSH ☐ FIXED THROAT BUSH ☐ CHAMBER HEATING/COOLING ☐ H ☐ C

PUMP DATA

PUMP DESIGN ○ MANUFACTURER ○ MODEL ○ FRAME/SIZE ○ CASE MATERIAL

PUMP OPERATING PRESSURE ○ SUCTION PRESS. (RATED) bar (ga) ○ DISCHARGE PRESSURE bar (ga)

SEAL CHAMBER ○ NORMAL bar (ga) ○ MIN / MAX (3.41) / bar (ga) ○ MSSP (3.43) bar (ga)

SHAFT ○ DIA. mm ○ SHAFT SPEED r/min SHAFT DIRECTION (FROM DRIVER): ○ CW ○ CCW

FLUID DATA - (FOR QUENCH, BUFFER AND BARRIER FLUID DATA, SEE PAGE 2)

PUMPED STREAM	○ HAZARDOUS ○ FLAMMABLE ○
○ TYPE OR NAME CONC'N %	○ FLUID SOLID @ AMBIENT
○ DISSOLVED CONTAMINANT ○ H_2S ml/m³ ○ WET	○ SOLIDIFIES @ °C POUR POINT °C
○ Cl_2 ml/m³ ○ OTHER @ ml/m³	○ PUMPED STREAM SOLIDIFIES UNDER SHEAR
○ SOLID CONTAMINANT	○ PUMPED STREAM CONTAINS AGENTS THAT POLYMERIZE
○ CONCENTRATION (MASS FRACTION)	SPECIFY AGENTS @ TEMP °C
○ PUMPING TEMPERATURE	○ PUMPED STREAM CAN PLATE OUT OR DECOMPOSE:
MIN °C NORMAL °C MAX °C	SPECIFY CONDITIONS
○ RELATIVE DENSITY (TO WATER @ 25 °C) AT REF. TEMP.	○ PUMPED STREAM IS REGULATED FOR FUGITIVE OR
@ NORMAL TEMP @ MAX TEMP	OTHER EMISSIONS. REGULATION LEVEL ml/m³
○ ABSOLUTE VAPOR PRESSURE AT REFERENCE TEMP.	○ SPECIAL PUMP CLEANING PROCEDURES
NORMAL TEMP bar MAX TEMP bar	SPECIFY;
○ ATMOSPHERIC BOILING POINT. °C	○ ALTERNATE PROCESS FLUIDS & CONCENTRATION
○ VISCOSITY @ NORMAL PUMPING TEMP. Pa.s	(INCL. COMMISIONING)
FLUSH FLUID If flush fluid is pumpage, then flush fluid data is not required.	
○ TYPE OR NAME CONC'N %	○ ABSOLUTE VAPOR PRESSURE AT REFERENCE TEMP.
○ SEAL VENDOR REVIEW REQUIRED	NORMAL TEMP bar MAX TEMP bar
○ FLUID TEMPERATURE	○ ATMOSPHERIC BOILING POINT. °C
MIN °C NORMAL °C MAX °C	○ VISCOSITY @ NORMAL PUMPING TEMP. Pa.s
○ RELATIVE DENSITY (TO WATER @ 25 °C) AT REF. TEMP.	☐ FLOW RATE REQ'D MAX/MIN / l/min
@ NORMAL TEMP @ MAX TEMP	☐ PRESSURE REQ'D MAX/MIN / bar (ga)

Category 1 & 2 Seals	REQUIRED FOR: SITE: UNIT:
MECHANICAL SEAL DATA SHEET FOR CENTRIFUGAL & ROTARY PUMPS	JOB/PROJECT NO. ITEM NO. REQUISITION / SPEC. NUMBER /
S.I. UNITS	INQUIRY NUMBER BY
PAGE 2 OF 2	PURCHASE ORDER NUMBER DATE
(FLUID DATA, UTILITIES, ACCESSORIES, & INSP./TEST.)	REVISION NO. 0 DATE

Line		
1	INDICATES DATA COMPLETED BY PURCHASER	BY SEAL VENDOR — BY SEAL VENDOR OR PURCHASER
2	DEFAULT SELECTION	
3	FLUID DATA - (QUENCH, BUFFER AND BARRIER FLUID DATA, LIQUID AND GAS)	
4	QUENCH MEDIUM	SUPPLY TEMPERATURE MAX/MIN / °C
5	TYPE OR NAME	FLOW RATE REQ'D MAX/MIN / l/min
6	BUFFER/BARRIER MEDIUM	
7	TYPE OR NAME	RELATIVE DENSITY (TO WATER @ 25°C) AT REF. TEMP.
8	PURCHASER SELEC'N — SEAL VENDOR SELEC'N	@ NORMAL TEMP @ MAX TEMP
9	SEAL VENDOR REVIEW — PURCHASER REVIEW	ABSOLUTE VAPOR PRESSURE AT REFERENCE TEMP.
10	FLOW RATE REQ'D MAX/MIN. / l/min	NORMAL TEMP bar MAX TEMP bar
11	COOLING/HEATING REQUIRED (+ OR -) Kw	ATMOSPHERIC BOILING POINT (LIQUID) °C
12	SUPPLY PRESSURE MAX/MIN. / bar (ga)	VISCOSITY @ NORMAL TEMP (LIQUID) Pa.s
13	FLUID OPERATING TEMPERATURE	SPECIFIC HEAT CAPACITY @ CONSTANT PRESSURE
14	MIN °C NORMAL °C MAX °C	FOR LIQUID @ NORMAL TEMPERATURE J/Kg.K
15	SITE AND UTILITIES	
16	CONTROL VOLTAGE V PHASE HERTZ	COOLING H_2O SUPPLY TEMP. °C — Cl_2 ml/m^3
17	ELECTRICAL AREA CL GR DIV	COOLING H_2O PRESS. NORM./DES. / bar (ga)
18	DESIGN AMBIENT MIN./MAX. / °C	EXPLOSIVE AREA CLASS (DIRECTIVE 94/9/EC)
19	ACCESSORIES (CLAUSES 8 AND 9)	
20	GENERAL	PLAN 52 AND 53 SYSTEMS CONTINUED
21	JOINT USER/VENDOR LAYOUT OF EQUIPMENT (8.1.4)	EQUIPMENT SUPPORT SUPPLIER
22	SPECIAL REQUIREMENTS FOR HAZARDOUS SERVICE	FILLING SYSTEM SUPPLIER
23		ASME CODE STAMP REQUIRED
24	SPECIAL CLEANING AND DECONTAMINATION REQ'TS	RESERVOIR CAPACITY (8.5.4.3.1) l
25	UTILITY MANIFOLD CONNECTIONS REQUIRED (8.4.4)	NLL TO GLAND PLATE HEIGHT (8.5.4.2.3) m
26	TYPE AND SPEC. OF HEAT TRACING (8.6.5.8)	PRESSURE CASING MAWP (3.40) bar (ga) @ °C
27		SET PRESSURE RANGE, MAX/MIN / bar (ga)
28	THERMAL RELIEF VALVES REQUIRED (9.8.3)	SYSTEM HOLD-UP PERIOD (PLANS 53B & 53C) DAYS
29	COOLING SYSTEM	PRESSURE SWITCH (8.5.4.2.7) TO ACTIVATE ON;
30	HEAT EXCHANGER SUPPLIER	RISING PRESSURE (ARR 2) SET @ bar (ga)
31	WATER COOLED — AIR COOLED — ASME B31.3	FALLING PRESSURE (ARR 3) SET @ bar (ga)
32	EQUIPMENT REFERENCE/CODE	HIGH LEVEL ALARM REQUIRED (8.5.4.2.8)
33	COOLING WATER LINES SUPPLIER	H/Q CURVE FOR INTERNAL CIRCULATING DEVICE (8.6.2.1)
34	TUBING — GALVANISED PIPING (8.4.2)	TEST BASED H/Q CURVE FOR INTERNAL CIRC. DEVICE
35	COOLING WATER FLOW RATE l/min	EXTERNAL CIRCULATING PUMP (8.6.3.1)
36	SIGHT FLOW INDICATORS (8.4.3) — OPEN — CLOSED	PLAN 72 AND 74 SYSTEM
37	PLAN 11, 12, 13, 31 AND 41 SYSTEMS	EQUIPMENT SUPPLIER
38	CONNECTING LINES SUPPLIER	HIGH FLOW ALARM SWITCH (8.6.6.5)
39	TUBING — PIPING (8.5.2.1)	PLAN 75 AND 76 SYSTEM
40	RESTRICTION ORIFICE NIPPLE IN FLUSH LINE (8.5.2.3)	EQUIPMENT SUPPLIER
41	CYCLONE SEPARATOR SUPPLIER	HIGH LEVEL ALARM SWITCH FOR PLAN 75 (8.6.5.3)
42	PLAN 52 AND 53 SYSTEMS	TEST CONNECTION (8.6.5.4)
43	STANDARD (FIG D.26) — ALTERNATE (FIG D.27)	INSTRUMENTATION
44	DIMENSIONAL VARIATIONS TO STANDARD (FIG D.26)	USER SPECIFICATION REFERENCE FOR
45		INSTRUMENTATION/CONTROLS
46	DIMENSIONAL VARIATIONS TO ALTERNATE (FIG D.27)	PRESSURE GAUGES (9.4);
47		OIL FILLED PRESSURE GAUGES (9.4.3)
48	ALTERNATE FABRICATION STANDARD	PRESSURE SWITCHES (9.5.2); — TRANSMITTER (9.5.2.3)
49	PRIMARY EQUIPMENT SUPPLIER	LEVEL SWITCHES (9.5.3);
50	SUPPLIER REFERENCE/CODE	HYDROSTATIC — CAPACITANCE — ULTRASONIC
51	CONNECTING LINES SUPPLIER	LEVEL INDICATORS (9.6) — TRANSMITTER (9.5.3.2)
52	TUBING — PIPING (8.5.4.4.9)	WELD PAD — EXTERNAL, REMOVABLE (9.6.2)
53		FLOW INDICATORS (9.7); — TRANSMITTER (9.7.2)
54	INSPECTION AND TESTING	
55	PURCHASER PARTICIPATION IN INSPECTION & TEST	100% INSPECTION OF ALL WELDS (6.1.6.10.5.1) USING;
56	SPECIFY;	MAGNETIC PARTICLE — LIQUID PENETRANT
57	INSPECTOR'S CHECK LIST (10.1.7 & ANNEX E)	RADIOGRAPHIC — ULTRASONIC
58	OPTIONAL QUALIFICATION TESTING REQ'D (10.3.1.1.2)	MODIFIED FACES FOR PUMP TEST (10.3.5.2.1)
59	PURCHASER APPROVAL REQUIRED FOR WELDED	(SEE PAGE 1, LINE 31)
60	CONNECTION DESIGNS, (6.1.6.10.5.4)	ALTERNATE SEAL PUMP TEST (10.3.5.2.2)
61	HARDNESS TEST (10.2.14) REQUIRED FOR;	(SEE PAGE 1, LINE 26)
62		

Category 3 Seals	REQUIRED FOR: SITE: UNIT:
MECHANICAL SEAL DATA SHEET	JOB/PROJECT NO. ITEM NO.
FOR CENTRIFUGAL & ROTARY PUMPS	REQUISITION / SPEC. NUMBER /
U.S. CUSTOMARY UNITS	INQUIRY NUMBER BY
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DEFAULT SELECTION
INDICATES DATA COMPLETED BY PURCHASER
BY SEAL VENDOR
BY SEAL VENDOR OR PURCHASER

DATA SUPPLIED; CUSTOMARY UNITS SI UNITS
HARDWARE SUPPLIED CUSTOMARY UNITS SI UNITS
STANDARDS APPLICABLE; PRIMARY REFERENCE (5.2)
SECONDARY REFERENCE (5.2)

SEAL SPECIFICATION - (REF CLAUSE 1.2, FIGURES 1 TO 6)

TYPE (CODE-CW): TYPE A (3.78) TYPE B (3.79) ALTERNATE STATIONARY (TYPE A & B)
TYPE C (3.80) ALTERNATE ROTATING (TYPE C) SINGLE SPRING (TYPE A)

ARR'G'T		DEFAULT CONFIGURATION	ALTERNATE DESIGN	FLUSH PLANS (SEE ANNEX D)
1 (3.2)		1CW-FL	ALTERNATE BUSH	01 11 14 23 32 51 62 / 02 13 21 31 41 61
2 (3.3)	BUFFER LIQUID	2CW-CW	FX / DIST. FLUSH	01 13 23 41 62 75 / 02 14 31 52 71 76
	BUFFER GAS	2CW-CS	2NC-CS FX	11 21 32 61 72
3 (3.4)	BARRIER LIQUID	3CW-FB	3CW-BB 3CW-FF FX	01 11 32 53B 54 62
	BARRIER GAS	3NC-BB	3NC-FF 3NC-FB	02 13 53A 53C 61 74

SLEEVE-SHAFT DRIVE: SET-SCREW ONTO SHAFT ALTERNATE (6.1.3.13) - SPECIFY

MATERIALS (REFERENCE 6.1.6 & ANNEX C)

SECONDARY SEALS	SEAL FACES	METAL BELLOWS	SPRINGS	METAL PARTS
FKM FFKM	CARBON VS SIC	UNS N10276 (TYPE B)	UNS N10276	UNS S31600/ S31635
SPIRAL-W GASKET	SIC VS SIC	UNS N07718 (TYPE C)	OR N06455	UNS N10276
NBR EPM/EPDM	SS-SIC RB-SIC	UNS N08020	UNS S31600	UNS N08020
OTHER:	VS	OTHER:	OR S31635	OTHER:

MECHANICAL SEAL DATA

SEAL VENDOR	DYNAMIC SEALING PRESSURE RATING (3.19) ______ PSIG
DATA REQUIREMENTS FORM (ANNEX G)	STATIC SEALING PRESSURE RATING (3.74) ______ PSIG
SIZE/TYPE	MAXIMUM ALLOWABLE TEMPERATURE (3.39) ______ °F
SEAL DRAWING NUMBER	MINIMUM DESIGN METAL TEMPERATURE ______ °F
SEAL CODE (ANNEX J) C3	GENERATED HEAT @ NORM. CONDITIONS ______ BTU/HR
VENDOR'S SEAL CODE	HEAT SOAK @ NORM. CONDITIONS ______ BTU/HR
MODIFIED FACES FOR PUMP PERFORMANCE TEST	TOTAL SEAL AXIAL THRUST ON SHAFT ______ LBF
ALTERNATE SEAL FOR PUMP PERFORMANCE TEST	

SEAL CHAMBER DATA (REFERENCE 6.1.2.4)

ISO 13709 (ISO 3069-H) OTHER, SPECIFY BOLT-ON CHAMBER (6.1.2.5)
SEAL CHAMBER FLUSH PORT REQ'D SEAL CHAMBER VENT REQ'D CHAMBER HEATING/COOLING H C
FLOATING THROAT BUSH FIXED THROAT BUSH

PUMP DATA

PUMP DESIGN: MANUFACTURER ______ MODEL ______ FRAME/SIZE ______ CASE MATERIAL ______
PUMP OPERATING PRESSURE: SUCTION PRESSURE (RATED) ______ PSIG DISCHARGE PRESSURE ______ PSIG
SEAL CHAMBER: NORMAL ______ PSIG MIN / MAX (MDSP, 3.41) ______ / ______ PSIG MSSP (3.43) ______ PSIG
SHAFT: DIA. ______ IN SHAFT SPEED ______ RPM SHAFT DIRECTION (FROM DRIVER): CW CCW

FLUID DATA - (FOR QUENCH, BUFFER AND BARRIER FLUID DATA, SEE PAGE 2)

PUMPED STREAM	HAZARDOUS FLAMMABLE ______
TYPE OR NAME ______ CONC'N ______ %	FLUID SOLID @ AMBIENT
DISSOLVED CONTAMINANT H_2S ______ PPM WET	SOLIDIFIES @ ______ °F POUR POINT ______ °F
Cl_2 ______ PPM OTHER ______ @ ______ PPM	PUMPED STREAM SOLIDIFIES UNDER SHEAR
SOLID CONTAMINANT ______	PUMPED STREAM CONTAINS AGENTS THAT POLYMERIZE
CONCENTRATION (% BY WT, OR PPM) ______	SPECIFY AGENTS ______ @ TEMP ______ °F
PUMPING TEMPERATURE	PUMPED STREAM CAN PLATE OUT OR DECOMPOSE:
MIN ______ °F NORMAL ______ °F MAX ______ °F	SPECIFY CONDITIONS ______
SPECIFIC GRAVITY AT TEMPERATURE INDICATED	PUMPED STREAM IS REGULATED FOR FUGITIVE OR
@ NORMAL TEMP ______ @ MAX TEMP ______	OTHER EMISSIONS. REGULATION LEVEL ______ PPMV
VAPOR PRESSURE AT TEMPERATURE INDICATED	SPECIAL PUMP CLEANING PROCEDURES
NORMAL TEMP ______ PSIA MAX TEMP ______ PSIA	SPECIFY; ______
ATMOSPHERIC BOILING POINT. ______ °F	ALTERNATE PROCESS FLUIDS & CONCENTRATION
VISCOSITY @ NORMAL PUMPING TEMP. ______ Cp	(INCL. COMMISSIONING)
FLUSH FLUID If flush fluid is pumpage, then flush fluid data is not required.	
TYPE OR NAME ______ CONC'N ______ %	VAPOR PRESSURE AT TEMPERATURE INDICATED
SEAL VENDOR REVIEW REQUIRED	NORMAL TEMP ______ PSIA MAX TEMP ______ PSIA
FLUID TEMPERATURE	ATMOSPHERIC BOILING POINT. ______ °F
MIN ______ °F NORMAL ______ °F MAX ______ °F	VISCOSITY @ NORMAL PUMPING TEMP. ______ Cp
SPECIFIC GRAVITY AT TEMPERATURE INDICATED	FLOW RATE REQ'D MAX/MIN ______ / ______ GPM
@ NORMAL TEMP ______ @ MAX TEMP ______	PRESSURE REQ'D MAX/MIN ______ / ______ PSIG

Category 3 Seals	REQUIRED FOR: SITE: UNIT:
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U.S. CUSTOMARY UNITS	INQUIRY NUMBER BY
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1	○ INDICATES DATA COMPLETED BY PURCHASER	☐ BY SEAL VENDOR ◻ BY SEAL VENDOR OR PURCHASER
2	◻ ◌ DEFAULT SELECTION	
3	FLUID DATA - (QUENCH, BUFFER AND BARRIER FLUID DATA, LIQUID AND GAS)	
4	QUENCH MEDIUM	◻ SUPPLY TEMPERATURE MAX/MIN / °F
5	◻ TYPE OR NAME	☐ FLOW RATE REQ'D MAX/MIN / GPM/SCFH
6	BUFFER AND BARRIER LIQUID/GAS	
7	◻ TYPE OR NAME	◻ SPECIFIC GRAVITY AT TEMP. INDICATED (LIQUID)
8	○ PURCHASER SELEC'N ☐ SEAL VENDOR SELEC'N	@ NORMAL TEMP @ MAX TEMP
9	○ SEAL VENDOR REVIEW ☐ PURCHASER REVIEW	◻ VAPOR PRESSURE AT TEMPERATURE INDICATED (LIQUID)
10	☐ FLOW RATE REQ'D MAX/MIN. / GPM/SCFH	NORMAL TEMP PSIA MAX TEMP PSIA
11	☐ COOLING/HEATING REQUIRED (+ OR -) BTU/HR	◻ ATMOSPHERIC BOILING POINT (LIQUID) °F
12	◻ SUPPLY PRESSURE MAX/MIN. / PSIG	◻ VISCOSITY @ NORMAL TEMP (LIQUID) Cp
13	◻ FLUID OPERATING TEMPERATURE	◻ SPECIFIC HEAT @ NORMAL TEMP BTU/HR FT °F
14	MIN °F NORMAL °F MAX °F	
15	SITE AND UTILITIES	
16	○ CONTROL VOLTAGE V PHASE HERTZ	○ COOLING H_2O SUPPLY TEMP. °F ○ Cl_2 PPM
17	○ ELECTRICAL AREA CL GR DIV	○ COOLING H_2O PRESS. NORM./DES. / PSIG
18	○ DESIGN AMBIENT MIN./MAX. / °F	○ EXPLOSIVE AREA CLASS (DIRECTIVE 94/9/EC)
19	ACCESSORIES (CLAUSES 8 AND 9)	
20	GENERAL	PLAN 52 AND 53 SYSTEMS CONTINUED
21	○ JOINT USER/VENDOR LAYOUT OF EQUIPMENT (8.1.4)	○ EQUIPMENT SUPPORT SUPPLIER
22	○ SPECIAL REQUIREMENTS FOR HAZARDOUS SERVICE	○ FILLING SYSTEM SUPPLIER
23		○ ASME CODE STAMP REQUIRED
24	○ SPECIAL CLEANING AND DECONTAMINATION REQ'TS	◻ RESERVOIR CAPACITY (8.5.4.3.1) GA
25	○ UTILITY MANIFOLD CONNECTIONS REQUIRED (8.4.4)	◻ NLL TO GLAND PLATE HEIGHT (8.5.4.2.3) FT
26	○ TYPE AND SPEC. OF HEAT TRACING (8.6.5.8)	☐ PRESSURE CASING MAWP (3.40) PSIG @ °F
27		◻ SET PRESSURE RANGE, MAX/MIN / PSIG
28	○ THERMAL RELIEF VALVES REQUIRED (9.8.3)	◻ SYSTEM HOLD-UP PERIOD (PLANS 53B &53C) DAYS
29	COOLING SYSTEM	PRESSURE SWITCH (8.5.4.2.7) TO ACTIVATE ON;
30	○ HEAT EXCHANGER SUPPLIER	◻ RISING PRESSURE (ARR 2) SET @ PSIG
31	◻ WATER COOLED ◻ AIR COOLED ○ ASME B31.3	◻ FALLING PRESSURE (ARR 3) SET @ PSIG
32	◻ EQUIPMENT REFERENCE/CODE	◻ HIGH LEVEL ALARM REQUIRED (8.5.4.2.8)
33	○ COOLING WATER LINES SUPPLIER	○ H/Q CURVE FOR INTERNAL CIRCULATING DEVICE (8.6.2.1)
34	◌ TUBING ○ GALVANISED PIPING (8.4.2)	○ TEST BASED H/Q CURVE FOR INTERNAL CIRC. DEVICE
35	◻ COOLING WATER FLOW RATE GPM	○ EXTERNAL CIRCULATING PUMP (8.6.3.1)
36	○ SIGHT FLOW INDICATORS (8.4.3) ○ OPEN ○ CLOSED	PLAN 72 AND 74 SYSTEM
37	PLAN 11, 12, 13, 31 AND 41 SYSTEMS	○ EQUIPMENT SUPPLIER
38	○ CONNECTING LINES SUPPLIER	○ HIGH FLOW ALARM SWITCH (8.6.6.5)
39	○ TUBING ○ PIPING (8.5.2.1)	PLAN 75 AND 76 SYSTEM
40	○ RESTRICTION ORIFICE NIPPLE IN FLUSH LINE (8.5.2.3)	○ EQUIPMENT SUPPLIER
41	○ CYCLONE SEPARATOR SUPPLIER	○ HIGH LEVEL ALARM SWITCH FOR PLAN 75 (8.6.5.3)
42	PLAN 52 AND 53 SYSTEMS	○ TEST CONNECTION (8.6.5.4)
43	◻ STANDARD (FIG D.26) ◻ ALTERNATE (FIG D.27)	INSTRUMENTATION
44	☐ DIMENSIONAL VARIATIONS TO STANDARD (FIG D.26)	○ USER SPECIFICATION REFERENCE FOR
45		INSTRUMENTATION/CONTROLS
46	☐ DIMENSIONAL VARIATIONS TO ALTERNATE (FIG D.27)	PRESSURE GAUGES (9.4);
47		○ OIL FILLED PRESSURE GAUGES (9.4.3)
48	◻ ALTERNATE FABRICATION STANDARD	PRESSURE SWITSHES (9.5.2); ○ TRANSMITTER (9.5.2.3)
49	○ PRIMARY EQUIPMENT SUPPLIER	LEVEL SWITCHES (9.5.3);
50	◻ SUPPLIER REFERENCE/CODE	○ HYDROSTATIC ○ CAPACITANCE ○ ULTRASONIC
51	○ CONNECTING LINES SUPPLIER	LEVEL INDICATORS (9.6) ○ TRANSMITTER (9.5.3.2)
52	◌ TUBING ○ PIPING (8.5.4.4.9)	◌ WELD PAD ○ EXTERNAL, REMOVABLE (9.6.2)
53		FLOW INDICATORS (9.7); ○ TRANSMITTER (9.7.2)
54	INSPECTION AND TESTING	
55	○ PURCHASER PARTICIPATION IN INSPECTION & TEST	○ 100% INSPECTION OF ALL WELDS (6.1.6.10.5.1) USING;
56	SPECIFY;	○ MAGNETIC PARTICLE ○ LIQUID PENETRANT
57	○ INSPECTOR'S CHECK LIST (10.1.7 & ANNEX E)	○ RADIOGRAPHIC ○ ULTRASONIC
58	○ OPTIONAL QUALIFICATION TESTING REQ'D (10.3.1.1.2)	◻ MODIFIED FACES FOR PUMP TEST (10.3.5.2.1)
59	○ PURCHASER APPROVAL REQUIRED FOR WELDED	(SEE PAGE 1, LINE 30)
60	CONNECTION DESIGNS, (6.1.6.10.5.4)	◻ ALTERNATE SEAL PUMP TEST (10.3.5.2.2)
61	○ HARDNESS TEST (10.2.14) REQUIRED FOR;	(SEE PAGE 1, LINE 31)
62		

Category 3 Seals	REQUIRED FOR: _____ SITE: _____ UNIT: _____
MECHANICAL SEAL DATA SHEET **FOR CENTRIFUGAL & ROTARY PUMPS** **S.I.UNITS** **PAGE 1 of 2**	JOB/PROJECT NO. _____ ITEM NO. _____ REQUISITION / SPEC. NUMBER _____ / _____ INQUIRY NUMBER _____ BY _____ PURCH ORDER NUMBER _____ DATE _____ REVISION NO. 0 DATE

☐ ◌ DEFAULT SELECTION	DATA SUPPLIED; ○ CUSTOMARY UNITS ○ SI UNITS
○ INDICATES DATA COMPLETED BY PURCHASER	HARDWARE SUPPLIED ○ CUSTOMARY UNITS ○ SI UNITS
☐ BY SEAL VENDOR	STANDARDS APPLICABLE; ○ PRIMARY REFERENCE (5.2)
☐ BY SEAL VENDOR OR PURCHASER	○ SECONDARY REFERENCE (5.2)

SEAL SPECIFICATION - (REF CLAUSE 1.2, FIGURES 1 TO 6)

TYPE (CODE-CW)	☐ TYPE A (3.78)	☐ TYPE B (3.79)	☐ ALTERNATE STATIONARY (TYPE A & B)
	☐ TYPE C (3.80)	☐ ALTERNATE ROTATING (TYPE C)	☐ SINGLE SPRING (TYPE A)

ARR'G'T		DEFAULT CONFIGURATION	ALTERNATE DESIGN	FLUSH PLANS (SEE ANNEX D)
1 (3.2)		☐ 1CW-FL	☐ ALTERNATE BUSH	☐ 01 ☐ 11 ☐ 14 ☐ 23 ☐ 32 ☐ 51 ☐ 62 ☐ 02 ☐ 13 ☐ 21 ☐ 31 ☐ 41 ☐ 61
2 (3.3)	BUFFER LIQUID	☐ 2CW-CW	☐ FX ☐ DIST. FLUSH	☐ 01 ☐ 13 ☐ 23 ☐ 41 ☐ 62 ☐ 75 ☐ 02 ☐ 14 ☐ 31 ☐ 52 ☐ 71 ☐ 76
	BUFFER GAS	☐ 2CW-CS	☐ 2NC-CS ☐ FX	☐ 11 ☐ 21 ☐ 32 ☐ 61 ☐ 72
3 (3.4)	BARRIER LIQUID	☐ 3CW-FB	☐ 3CW-BB ☐ 3CW-FF ☐ FX	☐ 01 ☐ 11 ☐ 32 ☐ 53B ☐ 54 ☐ 62
	BARRIER GAS	☐ 3NC-BB	☐ 3NC-FF ☐ 3NC-FB	☐ 02 ☐ 13 ☐ 53A ☐ 53C ☐ 61 ☐ 74
SLEEVE-SHAFT DRIVE		☐ SET-SCREW ONTO SHAFT	☐ ALTERNATE (6.1.3.13) - SPECIFY	

MATERIALS (REFERENCE 6.1.6 & ANNEX C)

SECONDARY SEALS	SEAL FACES	METAL BELLOWS	SPRINGS	METAL PARTS
☐ FKM ☐ FFKM	☐ CARBON VS SIC	☐ UNS N10276 (TYPE B)	☐ UNS N10276	☐ UNS S31600/ S31635
☐ SPIRAL-W GASKET	☐ SIC VS SIC	☐ UNS N07718 (TYPE C)	OR N06455	☐ UNS N10276
☐ NBR ☐ EPM/EPDM	☐ SS-SIC ☐ RB-SIC	☐ UNS N08020	☐ UNS S31600	☐ UNS N08020
☐ OTHER:	☐ VS	☐ OTHER:	OR S31635	☐ OTHER:

MECHANICAL SEAL DATA

○ SEAL VENDOR	☐ DYNAMIC SEALING PRESSURE RATING (3.19) _____ bar (ga)
○ DATA REQUIREMENTS FORM (ANNEX G)	☐ STATIC SEALING PRESSURE RATING (3.74) _____ bar (ga)
☐ SIZE/TYPE	☐ MAXIMUM ALLOWABLE TEMPERATURE (3.39) _____ °C
☐ SEAL DRAWING NUMBER	○ MINIMUM DESIGN METAL TEMPERATURE _____ °C
☐ SEAL CODE (ANNEX J) C3	☐ GENERATED HEAT @ NORM. CONDITIONS _____ kW
☐ VENDOR'S SEAL CODE	☐ HEAT SOAK @ NORMAL CONDITIONS _____ kW
☐ MODIFIED FACES FOR PUMP PERFORMANCE TEST	☐ TOTAL SEAL AXIAL THRUST ON SHAFT _____ N
☐ ALTERNATE SEAL FOR PUMP PERFORMANCE TEST	

SEAL CHAMBER DATA (REFERENCE 6.1.2.4)

☐ ISO 13709 (ISO 3069-H)	☐ OTHER, SPECIFY _____	○ BOLT-ON CHAMBER (6.1.2.5)
☐ SEAL CHAMBER FLUSH PORT REQ'D	☐ SEAL CHAMBER VENT REQ'D	☐ CHAMBER HEATING/COOLING ☐ H ☐ C
☐ FLOATING THROAT BUSH	☐ FIXED THROAT BUSH	

PUMP DATA

PUMP DESIGN ○ MANUFACTURER _____ ○ MODEL _____ ○ FRAME/SIZE _____ ○ CASE MATERIAL _____

PUMP OPERATING PRESSURE ○ SUCTION PRESS. (RATED) _____ bar (ga) ○ DISCHARGE PRESSURE _____ bar (ga)

SEAL CHAMBER ○ NORMAL _____ bar (ga) ○ MIN / MAX (3.41) _____ / _____ bar (ga) ○ MSSP (3.43) _____ bar (ga)

SHAFT ○ DIA. _____ mm ○ SHAFT SPEED _____ r/min SHAFT DIRECTION (FROM DRIVER): ○ CW ○ CCW

FLUID DATA - (FOR QUENCH, BUFFER AND BARRIER FLUID DATA, SEE PAGE 2)

PUMPED STREAM	○ HAZARDOUS ○ FLAMMABLE ○ _____
○ TYPE OR NAME _____ CONC'N _____ %	○ FLUID SOLID @ AMBIENT
○ DISSOLVED CONTAMINANT ○ H_2S _____ ml/m³ ○ WET	○ SOLIDIFIES @ _____ °C POUR POINT _____ °C
○ Cl_2 _____ ml/m³ ○ OTHER _____ @ _____ ml/m³	○ PUMPED STREAM SOLIDIFIES UNDER SHEAR
○ SOLID CONTAMINANT _____	○ PUMPED STREAM CONTAINS AGENTS THAT POLYMERIZE
○ CONCENTRATION (MASS FRACTION) _____	SPECIFY AGENTS _____ @ TEMP _____ °C
○ PUMPING TEMPERATURE	○ PUMPED STREAM CAN PLATE OUT OR DECOMPOSE:
MIN _____ °C NORMAL _____ °C MAX _____ °C	SPECIFY CONDITIONS _____
○ RELATIVE DENSITY (TO WATER @ 25 °C) AT REF. TEMP.	○ PUMPED STREAM IS REGULATED FOR FUGITIVE OR
@ NORMAL TEMP _____ @ MAX TEMP _____	OTHER EMISSIONS. REGULATION LEVEL _____ ml/m³
○ ABSOLUTE VAPOR PRESSURE AT REFERENCE TEMP.	○ SPECIAL PUMP CLEANING PROCEDURES
NORMAL TEMP _____ bar MAX TEMP _____ bar	SPECIFY; _____
○ ATMOSPHERIC BOILING POINT. _____ °C	○ ALTERNATE PROCESS FLUIDS & CONCENTRATION
○ VISCOSITY @ NORMAL PUMPING TEMP. _____ Pa.s	(INCL. COMMISSIONING) _____
FLUSH FLUID If flush fluid is pumpage, then flush fluid data is not required.	
○ TYPE OR NAME _____ CONC'N _____ %	○ ABSOLUTE VAPOR PRESSURE AT REFERENCE TEMP.
○ SEAL VENDOR REVIEW REQUIRED	NORMAL TEMP _____ bar MAX TEMP _____ bar
○ FLUID TEMPERATURE	○ ATMOSPHERIC BOILING POINT. _____ °C
MIN _____ °C NORMAL _____ °C MAX _____ °C	○ VISCOSITY @ NORMAL PUMPING TEMP. _____ Pa.s
○ RELATIVE DENSITY (TO WATER @ 25 °C) AT REF. TEMP.	☐ FLOW RATE REQ'D MAX/MIN _____ / _____ l/min
@ NORMAL TEMP _____ @ MAX TEMP _____	☐ PRESSURE REQ'D MAX/MIN _____ / _____ bar (ga)

Category 3 Seals	REQUIRED FOR: ______ SITE: ______ UNIT: ______
MECHANICAL SEAL DATA SHEET	JOB/PROJECT NO. ______ ITEM NO. ______
FOR CENTRIFUGAL & ROTARY PUMPS	REQUISITION /SPEC. NUMBER ______ / ______
S.I.UNITS	INQUIRY NUMBER ______ BY ______
PAGE 2 OF 2	PURCH ORDER NUMBER ______ DATE ______
(FLUID DATA, UTILITIES, ACCESSORIES, & INSP./TEST.)	REVISION NO. 0 DATE

Line		
1	○ INDICATES DATA COMPLETED BY PURCHASER	☐ BY SEAL VENDOR ▢ BY SEAL VENDOR OR PURCHASER
2	▢ ◌ DEFAULT SELECTION	
3	FLUID DATA - (QUENCH, BUFFER, AND BARRIER FLUID DATA, LIQUID AND GAS)	
4	QUENCH MEDIUM	▢ SUPPLY TEMPERATURE MAX/MIN ______ / ______ °C
5	▢ TYPE OR NAME	☐ FLOW RATE REQ'D MAX/MIN ______ / ______ l/min
6	BUFFER AND BARRIER LIQUID/GAS	
7	▢ TYPE OR NAME ______	▢ RELATIVE DENSITY (TO WATER @ 25°C) AT REF. TEMP.
8	○ PURCHASER SELEC'N ☐ SEAL VENDOR SELEC'N	@ NORMAL TEMP ______ @ MAX TEMP ______
9	○ SEAL VENDOR REVIEW ☐ PURCHASER REVIEW	▢ ABSOLUTE VAPOR PRESSURE AT REFERENCE TEMP.
10	☐ FLOW RATE REQ'D MAX/MIN. ______ / ______ l/min	NORMAL TEMP ______ bar MAX TEMP ______ bar
11	☐ COOLING/HEATING REQUIRED (+ OR -) ______ kW	▢ ATMOSPHERIC BOILING POINT (LIQUID) ______ °C
12	▢ SUPPLY PRESSURE MAX/MIN. ______ / ______ bar (ga)	▢ VISCOSITY @ NORMAL TEMP (LIQUID) ______ Pa.s
13	▢ FLUID OPERATING TEMPERATURE	▢ SPECIFIC HEAT CAPACITY @ CONSTANT PRESSURE
14	MIN ______ °C NORMAL ______ °C MAX ______ °C	FOR LIQUID @ NORMAL TEMPERATURE ______ J/Kg.K
15	SITE AND UTILITIES	
16	○ CONTROL VOLTAGE ______ V PHASE ______ HERTZ ______	○ COOLING H2O SUPPLY TEMP. ______ °C ○ Cl_2 ______ ml/m³
17	○ ELECTRICAL AREA CL ______ GR ______ DIV ______	○ COOLING H_2O PRESS. NORM./DES. ______ / ______ bar (ga)
18	○ DESIGN AMBIENT MIN./MAX. ______ / ______ °C	○ EXPLOSIVE AREA CLASS (DIRECTIVE 94/9/EC) ______
19	ACCESSORIES (CLAUSES 8 AND 9)	
20	GENERAL	PLAN 52 AND 53 SYSTEMS CONTINUED
21	○ JOINT USER/VENDOR LAYOUT OF EQUIPMENT (8.1.4)	○ EQUIPMENT SUPPORT SUPPLIER ______
22	○ SPECIAL REQUIREMENTS FOR HAZARDOUS SERVICE	○ FILLING SYSTEM SUPPLIER ______
23	______	○ ASME CODE STAMP REQUIRED
24	○ SPECIAL CLEANING AND DECONTAMINATION REQ'TS	▢ RESERVOIR CAPACITY (8.5.4.3.1) ______ l
25	○ UTILITY MANIFOLD CONNECTIONS REQUIRED (8.4.4)	▢ NLL TO GLAND PLATE HEIGHT (8.5.4.2.3) ______ m
26	○ TYPE AND SPEC. OF HEAT TRACING (8.6.5.8)	☐ PRESSURE CASING MAWP (3.40) ______ bar (ga) @ ______ °C
27	______	▢ SET PRESSURE RANGE, MAX/MIN ______ / ______ bar (ga)
28	○ THERMAL RELIEF VALVES REQUIRED (9.8.3)	▢ SYSTEM HOLD-UP PERIOD (PLANS 53B &53C) ______ DAYS
29	COOLING SYSTEM	PRESSURE SWITCH (8.5.4.2.7) TO ACTIVATE ON;
30	○ HEAT EXCHANGER SUPPLIER ______	▢ RISING PRESSURE (ARR 2) SET @ ______ bar (ga)
31	▢ WATER COOLED ▢ AIR COOLED ○ ASME B31.3	▢ FALLING PRESSURE (ARR 3) SET @ ______ bar (ga)
32	▢ EQUIPMENT REFERENCE/CODE ______	▢ HIGH LEVEL ALARM REQUIRED (8.5.4.2.8)
33	○ COOLING WATER LINES SUPPLIER ______	○ H/Q CURVE FOR INTERNAL CIRCULATING DEVICE (8.6.2.1)
34	◌ TUBING ○ GALVANISED PIPING (8.4.2)	○ TEST BASED H/Q CURVE FOR INTERNAL CIRC. DEVICE
35	▢ COOLING WATER FLOW RATE ______ l/min	○ EXTERNAL CIRCULATING PUMP (8.6.3.1)
36	○ SIGHT FLOW INDICATORS (8.4.3) ○ OPEN ○ CLOSED	PLAN 72 AND 74 SYSTEM
37	PLAN 11, 12, 13, 31 AND 41 SYSTEMS	○ EQUIPMENT SUPPLIER ______
38	○ CONNECTING LINES SUPPLIER ______	○ HIGH FLOW ALARM SWITCH (8.6.6.5)
39	○ TUBING ○ PIPING (8.5.2.1)	PLAN 75 AND 76 SYSTEM
40	○ RESTRICTION ORIFICE NIPPLE IN FLUSH LINE (8.5.2.3)	○ EQUIPMENT SUPPLIER ______
41	○ CYCLONE SEPARATOR SUPPLIER ______	○ HIGH LEVEL ALARM SWITCH FOR PLAN 75 (8.6.5.3)
42	PLAN 52 AND 53 SYSTEMS	○ TEST CONNECTION (8.6.5.4)
43	▢ STANDARD (FIG D.26) ▢ ALTERNATE (FIG D.27)	INSTRUMENTATION
44	☐ DIMENSIONAL VARIATIONS TO STANDARD (FIG D.26)	○ USER SPECIFICATION REFERENCE FOR
45	______	INSTRUMENTATION/CONTROLS ______
46	☐ DIMENSIONAL VARIATIONS TO ALTERNATE (FIG D.27)	PRESSURE GAUGES (9.4);
47	______	○ OIL FILLED PRESSURE GAUGES (9.4.3)
48	▢ ALTERNATE FABRICATION STANDARD ______	PRESSURE SWITCHES (9.5.2); ○ TRANSMITTER (9.5.2.3)
49	○ PRIMARY EQUIPMENT SUPPLIER ______	LEVEL SWITCHES (9.5.3);
50	▢ SUPPLIER REFERENCE/CODE ______	○ HYDROSTATIC ○ CAPACITANCE ○ ULTRASONIC
51	○ CONNECTING LINES SUPPLIER ______	LEVEL INDICATORS (9.6) ○ TRANSMITTER (9.5.3.2)
52	◌ TUBING ○ PIPING (8.5.4.4.9)	◌ WELD PAD ○ EXTERNAL, REMOVABLE (9.6.2)
53		FLOW INDICATORS (9.7); ○ TRANSMITTER (9.7.2)
54	INSPECTION AND TESTING	
55	○ PURCHASER PARTICIPATION IN INSPECTION & TEST	○ 100% INSPECTION OF ALL WELDS (6.1.6.10.5.1) USING;
56	SPECIFY; ______	○ MAGNETIC PARTICLE ○ LIQUID PENETRANT
57	○ INSPECTOR'S CHECK LIST (10.1.7 & ANNEX E)	○ RADIOGRAPHIC ○ ULTRASONIC
58	○ OPTIONAL QUALIFICATION TESTING REQ'D (10.3.1.1.2)	▢ MODIFIED FACES FOR PUMP TEST (10.3.5.2.1)
59	○ PURCHASER APPROVAL REQUIRED FOR WELDED	(SEE PAGE 1, LINE 30)
60	CONNECTION DESIGNS, (6.1.6.10.5.4)	▢ ALTERNATE SEAL PUMP TEST (10.3.5.2.2)
61	○ HARDNESS TEST (10.2.14) REQUIRED FOR;	(SEE PAGE 1, LINE 31)
62	______	

Annex G
(normative)

Mechanical seals data requirements form

Category III Seals	REQUIRED FOR:	SITE:	UNIT:		
MECHANICAL SEALS DATA REQUIREMENTS FORM	JOB/PROJECT NO.	ITEM NO.			
	REQUISITION / SPEC. NUMBER	/			
	INQUIRY NUMBER	BY			
	PURCH ORDER NUMBER	DATE			
	REVISION NO. 0	DATE			

NOMENCLATURE:

.......S = NUMBER OF WEEKS PRIOR TO SHIPMENT
.......F = NUMBER OF WEEKS AFTER FIRM ORDER
......D = NUMBER OF WEEKS AFTER RECEIPT OF APPROVED DRAWINGS

	DATA REQUIRED	PROPOSAL NO. OF COPIES	CONTRACT NO. OF COPIES	CONTRACT DATE DUE	CONTRACT DATE RECEIVED
1	CROSS SECTIONAL DRAWING (TYPICAL) - REFERENCE 11.2.2	○			
2	AUXILIARY SYSTEM SCHEMATIC - REFERENCE 11.3.3	○	○		
3	APPROPRIATELY COMPLETED DATA SHEETS - REFERENCE ANNEX F	○	○		
4	ALTERNATIVES PROPOSED	○			
5	EXCEPTIONS TO THIS INTERNATIONAL STANDARD	○			
6	DETAILED BILL OF MATERIALS FOR SEAL AND AUXILIARY SYSTEM	○	○		
7	ESTIMATED SEAL LEAKAGE OF 2NC-CS (IF APPLICABLE)	○			
8	SEAL QUALIFICATION TEST RESULTS - REFERENCE 11.2.4, FIG I.I1 & I.I2	○			
9	SEAL DESIGN PERFORMANCE PARAMETERS - REFERENCE 11.2.3	○			
10	SEAL AXIAL THRUST ON THE SHAFT (SEE DATA SHEET, ANNEX F)	○	○		
11	CROSS SECTIONAL DRAWING (SPECIFIC) - REFERENCE 11.3.2		○		
12	DETAILED DRAWING OF AUXILIARY SYSTEM - REF 11.3.4		○		
13	SEAL ENERGY AND HEAT SOAK CALCULATIONS (SEE ANNEX B)		○		
14	INTERNAL CIRCULATING DEVICE PERFORMANCE - REF 8.6.2.1 & 8.6.2.2		○		
15	SYSTEM RESISTANCE CURVE - REFERENCE 8.6.2.1		○		
16	INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTIONS (SPECIFIC) - REFERENCE 11.3.6* & 11.3.7*		○		
17	HYDROSTATIC TEST CERTIFICATION - REFERENCE 10.3.2.1		○		
18	MATERIAL SAFETY DATA SHEETS - REFERENCE 11.3.8		○		
19	ADDITIONAL PROPOSAL DATA - SPECIFY	○			
20	ADDITIONAL CONTRACT DATA - SPECIFY		○		

* NOTE: A copy will be supplied with the seal and Auxiliary System

ADDRESS FOR FORWARDING DATA ______________________

VENDOR SIGNATURE
(SIGNATURE CONFIRMS RECEIPT OF APPROVED DRAWINGS) ______________ **DATE** ______________

Annex H
(normative)

Seal and pump vendor interface paragraphs

CATEGORY 1, 2 and 3 SEALS		
Clause	**Topic**	**Responsibility**
4	Define who has unit responsibility	Joint
6.1.1.8	Provide axial movement capability of the seal	Seal Vendor
6.1.2.2	Define who shall supply seal chamber	Joint
6.1.2.4	Define seal chamber type	Seal Vendor
6.1.2.5	Define who shall supply seal chamber	Joint
6.1.2.8.2	Advise if register fit is outside or inside	Pump Vendor
6.1.2.9	Provide max allowable working pressure of pump	Pump Vendor
6.1.2.12	Provide gland or seal chamber bolting size	Pump Vendor
6.1.2.14	Provide seal chamber pressure	Pump Vendor
6.1.2.17	Define size and location of tapped connections in gland	Joint
6.1.2.17	Advise pump vendor if connections are required on the pump seal chamber	Seal Vendor
6.1.2.20	Define how seal chamber shall be vented	Joint
6.1.2.24	Define heating or cooling requirements for pump	Seal Vendor
6.1.2.25	Define who shall provide flush tap and port connections	Joint
6.1.2.26	Define who shall provide flush tap and port connections	Joint
6.1.3.2	Provide shaft diameter for seal mounting	Pump Vendor
6.1.3.5	Define impeller end of shaft and any threads requiring clearance for O-rings, etc.	Pump Vendor
6.1.3.11	Provide shaft hardness ensure set screws will imbed in shaft	Pump Vendor

6.1.3.12	Advise if drive collar requires greater than nine set screws	Seal Vendor
6.1.3.13	Advise if key drive or split collars are required to drive and locate the seal	Seal Vendor
6.1.6.2.4	Advise if seal cannot be operated during pump test	Seal Vender
6.1.6.7.1	Advise pump construction if higher alloy than AISI Type 316 stainless steel	Pump Vendor
6.1.6.7.2	Advise if spiral wound gasket is required on Non ISO 13709 pumps	Seal Vendor
6.1.6.8.1	Advise pump construction if higher alloy than AISI Type 316 stainless steel	Pump Vendor
6.1.6.8.2	Advise if spiral wound gasket is required on Non ISO 13709 pumps	Seal Vendor
6.2.1.2.2	Provide mating dimensions for seal chamber face	Pump Vendor

CATEGORY 2 and 3 SEALS		
6.2.2.2.2	Provide mating dimensions for seal chamber face	Pump Vendor
6.2.2.3.1	Supply shaft dimensions for seal mounting	Pump Vendor
6.2.2.3.2	Key drive requirements to be defined	Seal Vendor

SPECIFIC SEAL CONFIGURATIONS		
7.2.5.1.1	Provide shaft diameter to size throttle bushing	Pump Vendor
7.2.6.1	Provide shaft diameter to size throttle bushing	Pump Vendor

ACCESSORIES		
8.1.1	Define seal flush, quench and cooling systems required	Seal Vendor
8.1.4	Develop arrangement of equipment, piping and auxiliaries	Joint
8.1.11	Provide max allowable working pressure of pump casing	Pump Vendor
8.1.12	Provide pump construction for alloy pumps	Pump Vendor
8.6.1	Define means of circulating barrier/buffer fluid	Seal Vendor

8.6.2.3	Provide seal chamber bore diameter	Pump Vendor
8.6.2.4	Provide location of seal chamber port(s)	Pump Vendor

INSPECTION, TESTING, AND PREPARATION FOR SHIPMENT		
10.3.5.1.1	Advise if seal shall have modified seal faces for pump test	Seal Vendor
10.3.5.1.2	Advise if seal cannot be operated during pump test	Seal Vendor

DATA TRANSFER		
11.1.1	Provide completed seal data sheet to pump manufacturer	Seal Vendor
11.1.4	Define data requirements for seal	Seal Vendor
11.2	Provide seal cross sectional drawing to pump manufacturer	Seal Vendor
11.3	Define who is supplying what data	Joint

Annex I
(normative)

Mechanical seal test qualification form

MECHANICAL SEAL TEST QUALIFICATION FORM

Manufacturer: ______________________ Seal Model / Type: ______________________

API 682 Seal Type: ________ A ________ B ________ C ________ ES

Matl. of construction: Rotating Face ________________ Stationary Face ________________

Secondary Seals ________________ Metal Hardware ________________

Seal Size: ________ API Code: ________ API Plan: ________ Shaft Speed: ________

Rotating Face Matl.: ________________ Stationary Face Matl.: ________________

Application Group (Table 8) ______ Non-Hydrocarbon (water, caustic, acid) ______ Non-Flashing Hydrocarbon ______ Flashing Hydrocarbon

Shaft Run Out (Fig 18) ______ Sleeve Run Out (Fig 18) ______ Seal Chamber Concentricity (Fig 13) ______ Seal Chamber Face Runout (Fig 15) ______

Fluid: ________ Base Point Temp °F/ °C _____/_____ Base Point Pressure PSIG/bar ____ / ____

SG ______ V. Pressure ________ Solids ______ Particle Size ______ * Dual Seals

DYNAMIC TEST 100 hr. minimum — Date	Time — Start	Time — Stop	Pressure (PSIG)	Process Temp (°C)	Flush Temp IN (°C)	Flush Temp OUT (°C)	Flush Flow Rate (GPM)	Seal Chamber Temp (°C)	Barrier Fluid Press. (PSIG)*	Barrier Fluid Temp IN (°C)*	Barrier Fluid Temp OUT (°C)*	Sleeve to Box Concentricity	Horse Power Consumption	Hydrocarbon Leakage (gm/day)	Non-Hydrocarbon Leakage (cc/min)	Circulating Device (GPM)
STATIC TEST 4 hr. minimum																
CYCLIC TEST 5 Cycle minimum																

Figure I.1 — Mechanical seal test qualification form

MECHANICAL SEAL TEST QUALIFICATION FORM

2CW-CS, 2NC-CS, 3NC-FF, 3NC-BB, 3NC-FB

Manufacturer ____________________ Seal Type/Model ____________________

Arrangement _______ 2CW-CS _______ 2NC-CS _______ 3NC-FF _______ 3NC-BB _______ 3NC-FB

Material of Construction Rotating Face ________________ Stationary Face ________________

Fluid Service ____Non-Hydrocarbon (water, caustic, acid) ____Non-Flashing Hydrocarbon ___Flashing Hydrocarbon

Shaft Run Out ____________ Sleeve Run Out __________ Face to Sleeve Concentricity __________

Test Fluid ________________ Base Point Temperature ________________ Base Point Pressure ______________

SG ___________ Vapor Pressure ________________ Solids ____________ Particle Size ______________

Test Procedure ________ 10.3.1.2.8 (for 2CW-CS, 2NC-CS Arrangements)
________ 10.3.1.2.9 (for 3NC-FF, 3NC-BB, 3NC-FB Arrangements)

Data Point	Date	Time	Inner Seal		Buffer/Barrier			Speed RPM	Seal Leakage			
			Pressure Bar (PSI)	Temp °C (°F)	Medium	Pressure Bar (PSI)	Temp °C (°F)		Inner	Outer		
									cc/Hr	PPM	cc/Hr	Nl/Hr

Outer Seal Face Wear Stationary Face____________ Rotating Face____________ mm (in.)

Inner Seal Face Wear Stationary Face____________ Rotating Face____________ mm (in.) (10.3.1.2.9 only)

Figure I.2 — Mechanical seal test qualification form (2CW-CS, 2NC-CS, 3NC-FF, 3NC-BB, 3NC-FB)

Annex J
(informative)

Mechanical seal codes

J.1 Mechanical seals

In accordance with this Standard, mechanical seals can be described in a general manner by using the following simplified coding system:

J.2 First letter: seal category (1, 2, 3)

The category number is prefixed with a "C" for clarity.

NOTE Historical codes for Balanced (B) or Unbalanced (U) are unnecessary because all API 682 seals are balanced. See clause 1.2 and annex A, Sheet 2 for seal category descriptions.

J.3 Second letter: seal arrangement (1, 2, 3)

The arrangement number is prefixed with an "A" for clarity.

NOTE Historical codes for Single (S), Tandem (T) or Double (D) are obsolete and may be misinterpreted. See clauses 1.2, 3.2, 3.3, 3.4 and annex A, Sheet 2 for seal arrangement descriptions.

J.4 Third letter: seal type (A, B, C)

There is no prefix with the seal type letter.

NOTE Historical codes for Plain (P), Throttle bushing with quench, leakage and/or drain connections (T), or Auxiliary (A) sealing devices are obsolete as each seal type contains specific seal gland plate features. See clauses 1.2, 3.78, 3.79, 3.80 and annex A, Sheet 2 for seal type descriptions.

J.5 Fourth number(s): flush arrangement

One or more arrangement number from annex D. The letter "X" may be used in any position but shall always be explained.

J.6 Non-standard reference

NOTE 1 Historical codes for gasket material have been eliminated as it is not seen as major cost issue at the time of early project development.

NOTE 2 If a category or arrangement code is used in a seal code, then this Standard is assumed to be invoked. Where there are conflicts in seal codes, the category and arrangement codes take precedence.

J.7 Summary

This coding system is a variation of the five character code that has been used for many years to describe seals in ISO 13709. Seal codes are especially useful when working with new projects which may have many pumps and seals. This coding system is not intended to provide information about the details of the seal; always check the seal data sheet for details.

EXAMPLE 1 C1A1A11 is a Category 1, Arrangement 1 (single seal), Type A (pusher seal) seal which uses a Plan 11 flush. According to this Standard, this seal has:

a) a fixed, carbon throttle bushing in the seal gland (clause 7, 7.1.2.1);

b) fluoroelastomer secondary seals (clause 6, 6.1.6.5.1);

c) multiple springs (clause 6, 6.1.5.1);

d) carbon vs. self sintered silicon carbide faces (clause 6, 6.1.6.2.3); and

e) A single inlet (non-distributed) flush port (clause 6, 6.2.1.2.2).

EXAMPLE 2 C3A2C1152 is a Category 3, Arrangement 2 (unpressurized), Type C (stationary metal bellows) seal which utilizes Plans 11 and Plan 52 flush. By definition in this Standard the seal has:

a) two flexible metal bellows mounted in series (clause 1.3, 3.3);

b) a contacting, wet inner seal with a reverse balance capability;

● c) a liquid buffer fluid and contacting containment seal (clause 7, 7.2.1.3);

● d) flexible graphite for secondary sealing elements (clause 3, 3.86);

e) carbon vs. reaction bonded silicon carbide faces (clause 6, 6.1.6.2.2 and 6.1.6.2.3);

f) a distributed inlet flush system (clause 6, 6.2.3.2.1);

● g) a tangential buffer fluid outlet (clause 7, 7.2.4.2.1); and

● h) $^{3}/4$ in. buffer fluid connections if the sleeve bore is over 63,5 mm (2,5 in.), where practical.

Bibliography

[1] ISO 2858, *End-suction centrifugal pumps (rating 16 bar) — Designation, nominal duty point and dimensions.*

[2] ISO 3448, *Standard industrial liquid lubricants — ISO viscosity classification.*

[3] API RP 750, *Management of Process Hazards.*

[4] API Std 610, *Centrifugal Pumps for Refinery Service.*

[5] API Std 676, *Positive displacement pumps — Rotary.*

[6] ASME PTC 19.1, *Test uncertainty instruments and apparatus.*

[7] ASME PTC 19.2, *Pressure measurement instruments and apparatus.*

[8] ASME PTC 19.3, *Temperature measurement instruments and apparatus.*

[9] ASME PTC 19.5, *Application Part II of fluid meters.*

[10] ASME PTC 19.5.1, *Weighing scales.*

[11] ASME PTC 19.7, *Measurement of shaft power.*

[12] ASME PTC 19.8, *Measurement of indicated power.*

[13] ASME PTC 19.10, *Flue and exhaust gas analyses.*

[14] ASME PTC 19.11, *Water and steam in the power cycle (purity and quality, leak detection and measurement).*

[15] ASME PTC 19.22, *Digital systems techniques instruments and apparatus.*

[16] ASME PTC 19.23, *Guidance manual for model testing.*

[17] ASTM A 216, *Carbon-Steel Castings Suitable for Fusion Welding for High-Temperature Service.*

[18] ASTM A 217, *Martensitic Stainless and Alloy Steel Castings for Pressure-Containing Parts Suitable for High Temperature Service.*

[19] ASTM A 351, *Austenitic Steel Castings for High-Temperature Service.*

[20] ASTM A 436, *Austenitic Gray Iron Castings.*

[21] ASTM A 439, *Austenitic Ductile Iron Castings.*

[22] ASTM A 494, *Nickel and Nickel Alloy Castings.*

[23] ASTM A 564, *Hot-Rolled and Cold-Finished Age-Hardening Stainless and Heat-Resisting Steel Bars, Wire, and Shapes.*

[24] ASTM A 576, *Special Quality Hot-Wrought Carbon Steel Bars.*

[25] ASTM A 744, *Iron-Chromium-Nickel and Nickel-Base Corrosion Resistant Castings for Severe Service.*

[26] ASTM A 747, *Precipitation Hardening Stainless Steel Castings.*

[27] ASTM B 127, *Specification for Nickel-Copper Alloy (UNS N04400) Plate Sheet and Strip.*

[28] ASTM B 164, *Specification for Nickel-Copper Alloy Rod, Bar, and Wire.*

[29] ASTM B 473, *Chromium-Nickel-Iron-Molybdenum-Copper-Columbium Stabilized Alloy (UNS N08020) Bar and Wire.*

[30] ASTM B 564, *Specification for Nickel Alloy Forgings.*

[31] ASTM B 574, *Specification for Low-Carbon Nickel-Molybdenum-Chromium and Low-Carbon Nickel-Chromium-Molybdenum Alloy Rod.*

[32] ASTM B 575, *Specification for Low-Carbon Nickel-Molybdenum-Chromium and Low-Carbon Nickel-Chromium-Molybdenum Alloy Plate, Sheet and Strip.*

[33] ASTM B 637, *Specification for Precipitation Hardening Nickel Alloy Bars, Forgings, and Forging Stock for High-Temperature Service.*

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