This document is the first draft of the body of API 682 5th Ed. It is for comment ballot. The task force intention is to circulate this body for comment because many of the Annex's depend on content within the body of the standard. We'd like to resolve as many issues as possible in hopes to expedite revision of the annexes.

While there are many small technical changes throughout this document, we highlighted what the task force felt were significant changes in teal. Other highlights are for task force use and will mean nothing to a document reviewer.

Thanks,
API 682 Task Force

Pumps-Shaft Sealing Systems for Centrifugal and Rotary Pumps

API STANDARD 682
FIFTH EDITION DRAFT, MARCH 2024
(ANNEXES NOT INCLUDED)

Pumps—Shaft Sealing Systems for Centrifugal and Rotary Pumps

1 Scope

This standard specifies requirements and gives recommendations for sealing systems for centrifugal and rotary pumps used in the petroleum, natural gas, and chemical industries. See A.1.1 and A.1.2. It is the responsibility of the purchaser or seal vendor to ensure that the selected seal and auxiliaries are suitable for the intended service condition. It is applicable mainly for hazardous, flammable, and/or toxic services where a greater degree of reliability is required for the improvement of equipment availability and the reduction of both emissions to the atmosphere and life-cycle sealing costs. It covers seals for pump shaft diameters from 0.75 in. (20 mm) to 6.0 in. (150 mm).

This standard is also applicable to seal spare parts and can be referred to for the upgrading of existing equipment. A classification system for the seal configurations covered by this standard into categories, types, arrangements, and orientations is provided.

This standard is referenced normatively in API 610. It can be applicable to retrofitted pumps and to pumps other than API 610 pumps (e.g. ASME B73.1, ASME B73.2, and API 676 pumps).

This standard might also be referenced by other machinery standards such as other pumps, compressors, and agitators. Users are cautioned that this standard is not specifically written to address all of the potential applications that a purchaser may specify. This is especially true for the size envelope specified for API 682 seals. The purchaser and seal vendor shall mutually agree on the features taken from this standard and used in the application.

The seals used in the figures are also intended to show the generic location of the seals relative to the piping plans. Other seal designs detailed in this standard (e.g. types, configurations, categories, rotating vs stationary options) as well as designs from different manufacturers may have a different appearance than the generic seals used in the figures. The seals illustrated are not an endorsement of a specific design or configuration.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Recommended Practice 520 (all parts), *Sizing, Selection, and Installation of Pressure-relieving Devices in Refineries*

API Standard 526, *Flanged Steel Pressure Relief Valves*

API Standard 610, *Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries*

API Standard 614 *Lubrication, Shaft-sealing and Control-oil Systems and Auxiliaries for Petroleum, Chemical, and Gas Industry Services*

ASME V [1], *ASME Boiler and Pressure Vessel Code, Section V, Non-destructive Examination*

[1] ASME International, 3 Park Avenue, New York, New York 10016-5990, www.asme.org.

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*

ASME B16.11*, Forged Fittings, Socket-welding and Threaded*

ASME B16.20, *Metallic Gaskets for Pipe Flanges—Ring Joint, Spiral-wound, and Jacketed*

ASME B18.18.2M, Inspection and Quality Assurance for High-Volume Machine Assembly Fasteners

ASME B31.3, *Process Piping*

ASME B73.1, *Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process*

ASME B73.2, *Specification for Vertical In-line Centrifugal Pumps for Chemical Process*

ASME PTC 8.2, *Centrifugal Pumps, Performance Test Codes*

AWS D1.1 [2], *Structural Welding Code—Steel*

EN 287 (all parts) [3], *Approval testing of welders—fusion welding*

EN 288 (all parts), *Specification and approval of welding procedures for metallic materials*

EN 13445 (all parts), *Unfired pressure vessels*

EPA Method 21 [4], Appendix A of Title 40, Part 60 of the U.S. *Code of Federal Regulations*, *Environmental Protection Agency, United States, Determination of Volatile Organic Compound Leaks*

IEC 60079 (all parts) [5], *Electrical apparatus for explosive gas atmospheres*

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

ISO 7 (all parts) [6], *Pipe threads where pressure-tight joints are made on the threads*

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

ISO 262, *ISO general-purpose metric screw threads—Selected sizes for screws, bolts, and nuts*

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

ISO 724, *ISO general-purpose metric screw threads—basic dimensions*

[2] American Welding Society, 550 NW LeJeune Road, Miami, Florida 33126, www.aws.org.
[3] European Committee for Standardization, Avenue Marnix 17, B-1000 Brussels, Belgium, www.cen.eu.
[4] U.S. Environmental Protection Agency, Ariel Rios Building, 1200 Pennsylvania Avenue, Washington, DC 20460, www.epa.gov.
[5] International Electrotechnical Commission, 3, rue de Varembé, P.O. Box 131, CH-1211 Geneva 20, Switzerland, www.iec.ch.
[6] International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland, www.iso.org.

ISO 965 (all parts), *ISO general-purpose metric screw threads—Tolerances*

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

ISO 15649, *Petroleum and natural gas industries—Piping*

NEMA 250 [7], *Enclosures for Electrical Equipment (1,000 Volts Maximum)*

NFPA 70 [8], *National Electrical Code*

Title 1, Part A, Section 112, *U.S. National Emission Standards for Hazardous Air Pollutants (NESHAPs) (Clean Air Act Amendment, Air Pollution Prevention and Control, Air Quality and Emissions Limitations, Hazardous Air Pollutants)*

3 Terms, Definitions, and Symbols

For the purposes of this document, the following terms and definitions apply.

3.1 Terms and Definitions

3.1.1
Anti-rotation device
Device used to prevent rotation of one component relative to an adjacent component in a seal assembly.

EXAMPLES: Key, pin.

3.1.2
Arrangement 1 seal
See 4.1.4.

3.1.3
Arrangement 2 seal
See 4.1.4.

3.1.4
Arrangement 3 seal
See 4.1.4.

3.1.5
atmospheric leakage collector
External reservoir arranged to capture liquid seal leakage from an Arrangement 1 seal.

3.1.6
auxiliary sleeve
Separate sleeve mounted on the outer diameter of the seal shaft sleeve that facilitates assembly of seal components.

[7] National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1752, Rosslyn, Virginia 22209, www.nema.org.

[8] National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-7471, www.nfpa.org.

3.1.7
back-to-back configuration
Dual seal in which both of the flexible elements are mounted between the mating rings and the barrier fluid is on the OD of both the inner seal and outer seal.

3.1.8
balanced seal
Mechanical seal in which the fluid closing forces have been modified through seal design.

NOTE In this standard the seal balance ratio is less than 1 (see balance ratio calculation in Annex F).

3.1.9
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.

3.1.10
barrier/buffer seal chamber
Component or aggregate of components that form the cavity into which the outer seal of a pressurized or unpressurized dual seal is installed and in which a barrier or buffer fluid is circulated.

3.1.11
bellows seal
Type of mechanical seal that uses a flexible metal bellows to provide secondary sealing and spring loading.

3.1.12
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.

3.1.13
cartridge seal
Completely self-contained unit (including seal/rings, mating ring/s, flexible elements, secondary seal, seal gland plate, and sleeve) that is preassembled and preset before installation. The cartridge may be mounted within the boundaries of the seal chamber or containment seal chamber or gland plate.

3.1.14
Category 1 seal
See 4.1.2.

3.1.15
Category 2 seal
See 4.1.2.

3.1.16
Category 3 seal
See 4.1.2.

3.1.17
Category 4 seal
See 4.1.2.

3.1.18
connection
Threaded or flanged joint that mates a port to a pipe or to a piece of tubing.

3.1.19
contacting seal
Seal design in which the mating faces are not designed to intentionally create aerodynamic or hydrodynamic forces to sustain a specific separation gap.

NOTE Contacting seals can 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.

3.1.20
containment device
Seal or bushing that is intended to manage leakage from the inner or outer seal and divert it to a location determined by the user.

See Annex F for further description.

3.1.21
containment seal
Special version of an outer seal used in Arrangement 2 and that normally operates in a vapor (gas buffer or no buffer) but will seal the process fluid for a limited time in the event of an inner seal failure. See 4.1.4.

3.1.22
containment seal chamber
Component or aggregate of components that form the cavity into which the containment seal is installed.

3.1.23
containment seal chamber leakage collector
Reservoir connected by pipework to the containment seal chamber for the purpose of collecting condensed leakage from the inner seal of an Arrangement 2.

3.1.24
crystallizing fluid
Fluid that is in the process of forming solids or that may form solids because of dehydration or chemical reaction and can also be caused by a change of state such as CO2.

3.1.25
dead-leg
A length of piping with no flow

3.1.26
distributed flush system
Arrangement of holes, passages, baffles, etc. designed to promote an even distribution of flush fluid around the circumference of the seal faces.

NOTE These are normally required when piping plans provide flush into the seal chamber.

3.1.27
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.

3.1.28
dual mechanical seal
Arrangement 2 or Arrangement 3 seal of any type.

3.1.29
dynamic sealing pressure rating
Highest pressure differential the seal assembly can continuously withstand at the minimum and maximum allowable temperature while the shaft is rotating.

NOTE This is the highest differential pressure the seal assembly can be exposed to while the shaft is rotating (through start-up and normal operating conditions) and still retain its static sealing pressure rating. Any shaft rotation at pressures above this rating could lead to major seal damage and/or failure.

3.1.30
dynamic secondary seal
Secondary seal that is designed to slide or move relative to other components to allow axial movement of the flexible element.

3.1.31
engineered seal
Mechanical seal for applications with service conditions outside the scope of this standard.

NOTE See A.1.2.

3.1.32
external circulating device
Device located outside of the seal/buffer/barrier chamber to circulate seal chamber fluid through a cooler or through a dual mechanical seal.

3.1.33
face-to-back configuration
Dual seal in which one mating ring between the two flexible elements and one flexible element is mounted between the two mating rings and the barrier or buffer fluid is on the ID of the inner seal and OD of the outer seal.

3.1.34
face-to-face configuration
Dual seal in which both mating rings are mounted between the flexible elements and the barrier fluid is on the OD of both the inner seal and outer seal.

3.1.35
fixed bushing
Cylindrical device with a close clearance to the shaft or sleeve that restricts flow between two regions and that does not have a clearance on the outer diameter relative to the housing in which it is mounted.

3.1.36
fixed throttle bushing
One-piece cylindrical device that is fitted to the stationary part of the containment seal chamber and has a radial clearance to a rotating component; it is used to help isolate one region from another and assist in channeling liquid leakage to an exit port, and the design is intended to maintain a fixed radial clearance over the operating life of the seal, these devices have a low L/D ratio 0.2 or lower.

3.1.37
flashing
Rapid change in 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 seal faces, or when fluid pressure is reduced below the fluid's vapor pressure because of a pressure drop across the seal faces.

3.1.38
flashing hydrocarbon
flashing fluid
Liquid hydrocarbon or other fluid with an absolute vapor pressure greater than 14.7 psi (0.1 MPa) (1 bar) at the pumping temperature, or a fluid that will readily boil at ambient conditions.

3.1.39
flexible element
Combination of elements that accommodate axial movement between rotating and stationary parts.

3.1.40
flexible graphite
Exfoliated and recompressed graphite material used for static (secondary seal) gaskets in mechanical seal design, from cryogenic to hot service.

3.1.41
floating bushing
Cylindrical device with a close clearance to the shaft or sleeve that restricts flow between two regions and that has a clearance on the outer diameter relative to the housing in which it is mounted to allow radial motion ("floating") of the bushing should it come in contact with the rotating shaft or sleeve.

3.1.42
fluoroelastomer
FKM
Saturated polymer in which hydrogen atoms have been replaced with fluorine; it is characterized by excellent hydrocarbon and general chemical resistance.

3.1.43
flush, noun
Fluid that is introduced into the seal chamber on the process fluid side in close proximity to the seal faces and typically used for cooling and lubricating the seal faces and/or to keep them clean.

3.1.44
gland plate
gland end plate
Pressure-retaining component(s) similar to a flange, which connects the stationary assembly of a mechanical seal to the seal chamber.

NOTE A gland plate may consist of more than one pressure-containing components, for example the two gland plates often used in a dual seal.

3.1.45
hook sleeve
Sleeve, with a step or hook at the product end, placed over the shaft to protect it from wear and corrosion.

NOTE The step is usually abutted against the impeller to hold it in place with a gasket between the shaft and the step (hook).

3.1.46
inner seal
(Arrangement 2 and Arrangement 3) The seal closest to the pump impeller or process fluid.

3.1.47
internal circulating device
Device located in the seal/buffer/barrier chamber to circulate fluid through a cooler or through a dual mechanical seal.

NOTE There are various designs to achieve radial or axial flow. The internal circulating device can be integral with other seal parts or a separate part. (This device was formerly known as a “pumping ring.”)

3.1.48
leakage concentration
Measure of the concentration of a volatile organic compound or other regulated emission in the environment immediately surrounding the seal.

3.1.49
leakage rate
Volume or mass of fluid passing through a seal in a given length of time.

3.1.50
light hydrocarbon
Hydrocarbon liquid that will readily boil at ambient conditions.

NOTE Typically this definition includes pure and mixed streams of pentane (C_5) and lighter liquids.

3.1.51
mating ring
Disk- or toroidal-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 on or in which it is mounted and that provides the mating seal face for the seal ring face, the mating seal face is perpendicular to the axis of the shaft.

3.1.52
maximum allowable temperature
MAT
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.

3.1.53
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 [cf. **static sealing pressure rating** (3.1.91), **dynamic sealing pressure rating** (3.1.29)].

3.1.54
maximum barrier fluid pressure
Highest expected barrier fluid pressure between the inner and outer seal of Arrangement 3 seals.

3.1.55
maximum dynamic sealing pressure
MDSP
Highest pressure expected at the seal (or seals) during any specified operating condition while the shaft is rotating. This includes transient conditions while starting and stopping of the pump.

NOTE Both static and dynamic sealing pressures play an important part in the selection of a mechanical seal. They are dependent on the pump system design, suction pressure, suction temperature, operating point, and pump clearances. They are also directly affected by the mechanical seal piping plan.

3.1.56
maximum operating temperature
Maximum temperature to which the seal (or seals) can be subjected.

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

3.1.57
maximum static sealing pressure
MSSP
Highest pressure, excluding pressures encountered during hydrostatic testing to which the seal (or seals) can be subjected while the shaft is not rotating.

NOTE Both static and dynamic sealing pressures play an important part in the selection of a mechanical seal. They are dependent on the pump system design, suction pressure, suction temperature, operating point, and pump clearances. They are also directly affected by the mechanical seal piping arrangement.

3.1.58
noncontacting seal
self-acting seal
Seal design in which the faces are designed to intentionally create aerodynamic or hydrodynamic separating forces to sustain a specific separation gap between the seal ring and the mating ring.

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

3.1.59
Non-flashing hydrocarbon
Non-flashing fluid
Liquid hydrocarbon or other fluid whose vapor pressure at any specified operating temperature is less than an absolute pressure of 14.7 psi (0.1 MPa) (1 bar), or a fluid that will not readily boil at ambient conditions.

3.1.60
nonhydrocarbon service
Service in which the fluid, such as sour water, boiler feed water, sodium hydroxide, acids, and amines, contains no hydrocarbons or the fluid has relatively small quantities of entrained hydrocarbons.

3.1.61
NPS
Value approximately equal to a diameter in inches

EXAMPLE: NPS 3/4

NOTE 1 Refer to ASME B31.3

NOTE 2 The letters NPS are followed by a value which is related to an approximate diameter of the bore, in inches, for piping up to and including 12 in. diameter. For piping over 12 in. (NPS 12), the NPS value is the nominal OD.

3.1.62
NPT
American National Standard Pipe Taper
thread form designation for pipe threads

EXAMPLE: 3/4-14 NPT

NOTE Proper designation is comprised of a number representing nominal pipe size followed by the number of threads per inch and the letters NPT representing the thread series.

3.1.63
observed test
Product test that is observed at the discretion of the purchaser, who has been given notice of the test by the manufacturer, but does not constitute a manufacturing hold point.

3.1.64
orifice nipple
Pipe nipple made of solid bar stock with an orifice hole drilled through it to restrict leakage in the event of an auxiliary system pipe or component failure.

NOTE Orifice nipples are commonly found on Piping Plan 11 systems.

3.1.65
O-ring
Elastomeric sealing ring with an O-shaped (circular) cross-section, which may be used as either a static or dynamic secondary seal.

3.1.66
outer seal
(Arrangement 2 and Arrangement 3) The seal located farthest from the pump impeller or process fluid.

3.1.67
perfluoroelastomer
FFKM
Fully fluorinated fluorocarbon elastomer commonly used as a secondary seal in high-temperature and/or corrosive service.

3.1.68
piping plan
Configuration of accessories, instruments, controls, and/or fluids designed to manage or control the environment around the seal.

NOTE Auxiliary piping plans vary with the application, seal type, and arrangement.

3.1.69
polymerizing fluid
Fluid that is in the process of changing, or is capable of changing, from one chemical composition to another with longer-chain components and different properties, usually becoming significantly more viscous and/or tacky.

3.1.70
port
Fluid passageway, typically located in the gland plate.

3.1.71
pressure casing
Composite of all the stationary pressure-containing parts of the seal, including seal chamber, barrier or buffer fluid chamber, containment seal chamber, and seal gland plate, and excluding seal ring, mating ring, bellows, sleeves, miscellaneous internal seal parts, and atmospheric side gland connections, which cannot be isolated from atmospheric pressure.

NOTE 1 The MAWP of the auxiliary system is specified in Section 8.

NOTE 2 The atmospheric side of the seal gland, the seal flush (piping) plan, auxiliary piping, and valves are not part of the pressure casing.

3.1.72
product temperature margin
Difference between the vaporization temperature of the fluid at the seal chamber pressure and the actual temperature of the fluid.

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.

3.1.73
pump manufacturer
Agency that designs, manufactures, tests, and provides service support for the pump.

NOTE The pump manufacturer may also purchase the sealing system and perform the installation.

3.1.74
pumped fluid
process fluid
The process stream designated in the datasheet for the pump service.

3.1.75
purchaser
Agency that issues the order and specifications to the vendor.

3.1.76
pusher seal
Seal that incorporates a dynamic secondary seal to allow axial movement of the flexible element; the axial movement is driven (pushed) by mechanical and/or hydraulic force.

3.1.77
quench,
Neutral fluid, usually water, steam, or nitrogen, introduced on the atmospheric side of the seal to retard formation of solids that may interfere with seal movement, or for other purposes such as prevention of coking, crystallization, or icing.

3.1.78
reservoir
A storage vessel that can contain pressurized or non-pressurized fluids.

3.1.79
seal
end face mechanical seal
Device that prevents the leakage of fluids between a shaft and housing in relative motion.

NOTE Sealing is accomplished by a stationary seal face bearing against a rotating seal face; the sealing faces are mounted perpendicular to the shaft axis.

3.1.80
seal balance ratio
Ratio of seal face area exposed to closing force by hydraulic differential pressure across the seal face to the total seal face area (see Annex F).

NOTE It is sometimes expressed as a percentage.

3.1.81
seal chamber
Component, either integral with or separate from the pump case (housing), which forms the region between the shaft and casing into which the seal is installed.

3.1.82
seal face
The lapped surface of a mating ring or seal ring that comes in contact or close proximity to the other ring and provides the relative rotary motion sealing surface(s).

3.1.83
seal manufacturer
Agency that designs, manufactures, tests, and provides service support for seals and associated support sealing systems.

3.1.84
seal ring
Disk- or toroidal-shaped member, mounted either on a sleeve or in a housing such that it is able to move axially relative to the sleeve or the housing on or in which it is mounted and that provides the mating seal face for the mating ring face, the seal ring face is perpendicular to the axis of the shaft.

3.1.85
seal sleeve
Hollow cylindrical component that fits on the outer diameter of the shaft with a close tolerance fit, incorporates a static secondary seal with the shaft and extends beyond the seal gland plate, it is used in the assembly of the seal components and ensures they rotate with the shaft.

3.1.86
sealing system
Pump seal that includes the seal cartridge, seal chamber and accessories.

3.1.87
secondary seal
Device (such as an O-ring, flexible graphite ring, flexible graphite filled spiral wound gasket, or bellows) that prevents leakage of the sealed fluid, barrier fluid, buffer fluid, or quench medium through paths other than the inner or outer seal faces, the containment device, or designated drain.

3.1.88
segmented floating bushing
Throat or throttle bushing that is composed of circumferential segments retained by a tensioning device.

3.1.89
service condition
Maximum or minimum temperature or pressure under static or dynamic conditions.

3.1.90
spark resistant material
A material that is not prone to generate impact sparks under conditions of an application.

3.1.91
static sealing pressure rating
Highest pressure differential the seal assembly can continuously withstand at the minimum and maximum allowable temperature while the shaft is not rotating and still retain its dynamic sealing pressure rating without disassembly and repair.

3.1.92
static secondary seal
Secondary seal between two surfaces that have no relative motion.

3.1.93
strainer
A relatively low pressure drop device designed to remove solid particles from the flush or other fluid.

3.1.94
throat bushing
Device that forms a restrictive close clearance around the sleeve (or shaft) between the seal chamber and the impeller.

3.1.95
throttle bushing
Containment device that forms a restrictively close clearance around the sleeve at the atmospheric end of a gland plate.

3.1.96
total indicator reading
total indicated runout
TIR
Difference between the maximum and minimum readings of a dial indicator or similar device when 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.

3.1.97
Type A seal
See 4.1.3.

3.1.98
Type B seal
See 4.1.3.

3.1.99
Type C seal
See 4.1.3.

3.1.100
vapor pressure margin

VPM

The seal chamber pressure minus the fluid vapor pressure.

3.1.101
vendor
Manufacturer of the equipment, or his/her agent, normally responsible for service support.

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

3.1.102
volatile hazardous air pollutant
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)*.

3.1.103
witnessed inspection
witnessed test
Inspection or test for which the purchaser is notified of the timing and a hold is placed on production until the purchaser or his/her representative is in attendance.

3.2 Symbols

For the purposes of this document, the following symbols apply.

A the area of the seal face, expressed in square millimeters

F_O the opening force, expressed in Newtons

f the effective coefficient of friction

K the pressure drop coefficient, dimensionless

$V\%_{AB}$ volume percentage of component A in mixture B

Δp the differential pressure, expressed in megapascals

ρ_A density (specific gravity) of fluid A

ρ_B density (specific gravity) of fluid B

ω_{AB} mass percentage of component A in mixture B

4 Sealing Systems

4.1 Seal Categories, Types, and Arrangements

4.1.1 General

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).

See Figure 1 through Figure 9 for typical representations.

NOTE The seals used in the figures are intended to be generic representations of seal configurations. The appearance of a seal may differ between manufactures. These figures are not an endorsement of a specific design.

4.1.2 Seal Categories

4.1.2.1 There are four seal categories, as follows.

— *Category 1* seals are intended for use in non-API 610 pump seal chambers, meeting the dimensional requirements of ASME B73.1, and ASME B73.2 seal chamber dimensions and Their application is limited to seal chamber temperatures from –40 °F (–40 °C) to 500 °F (260 °C) and dynamic sealing gauge pressures up to 300 psi (20 bar).

— *Category 2* seals are intended for use in seal chambers meeting the seal chamber envelope dimensional requirements of API 610. Their application is limited to seal chamber temperatures from –40 °F (–40 °C) to 750 °F (400 °C) and dynamic sealing gauge pressures up to 600 psi (40 bar).

— Category 3 provides the most exact testing and documentation requirements. They meet the seal chamber envelope requirements of API 610 (or equal). Their application is limited to seal chamber temperatures from –40 °F (–40 °C) to 750 °F (400 °C) and dynamic sealing gauge pressures up to 600 psi (40 bar).

— Category 4 seals are intended for use in seal chambers meeting the chamber envelope dimensional requirements of API 610. Their application is limited to seal chamber temperatures from -40 °F (-40 °C) to 350 °F (176 °C) and dynamic sealing gauge pressures up to and including 1480 psi (102 bar).

Further differences in the details of seal categories are given in Annex A.

Note 1 Temperatures and pressures outside the ranges of these categories, or which involve fluids not included in Annex A, may require engineering and seal selection guidance other than provided in this standard.

Note 2 Typically, Category 1 seals will be applied to ASME B73.1 and ASME B73.2 pumps. Most of Category 2, Category 3 and Category 4 seals will be installed in API 610 applications. There is a recognized possibility that Category 1 seals may be installed in API 610 applications, and Category 2 or Category 3 seals may be installed in ASME B73.1 and ASME B73.2 pumps.

4.1.3 **Seal Types**

There are three seal types, as follows.

— *Type A* seal is a balanced, cartridge design, pusher seal with multiple springs. Secondary sealing elements are elastomeric O-rings. Figure 7 depicts a Type A seal.

— *Type B* seal is a balanced, cartridge design (metal bellows) seal. Secondary sealing elements are elastomeric O-rings. Figure 8 depicts a Type B seal.

— *Type C* seal is a balanced, cartridge design (metal bellows) seal. Secondary sealing elements are flexible graphite. Figure 9 depicts a Type C seal.

NOTE 1 Further difference in the detail of seal types is given in Annex A.

NOTE 2 Materials are specified in Section 6. Guidance on equivalent material standards is in Annex B.

4.1.4 **Seal Arrangements**

4.1.4.1 **Arrangement 1, 2, and 3 Seals**

There are three seal arrangements, as follows.

— *Arrangement 1*—Seal configurations having one seal per cartridge assembly with process fluid on the outside diameter (OD) of the seal faces.

— *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.

— *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.

NOTE 1 The principal difference between Arrangement 2 and Arrangement 3 configurations is the concept of containment of leakage versus the elimination of process fluid leakage. Refer to the associated definitions and Annex G piping plan descriptions.

NOTE 2 In Arrangement 2, the outer seal can be a wet seal or a dry-running seal. The inner seal utilizes a piping plan typical of Arrangement 1 seals. If the outer seal is a wet seal design, an unpressurized liquid buffer fluid is supplied to the outer seal chamber. If the outer seal is a dry-running seal it is defined as a containment seal (3.1.21); it may use a gas buffer.

NOTE 3 For Seal Arrangement 2 and Arrangement 3 the seal types can be mixed across configurations.

4.1.4.2 Alternate Technology Designs and Sealing Methods

Alternative technology designs and sealing methods are also considered, as follows.

— *Contacting wet (CW) seals*—Seal design where the seal faces are not designed to intentionally create aerodynamic or hydrodynamic forces to sustain a specific separation gap (refer to 3.1.19).

— *Noncontacting (NC) seals (whether wet or dry)*—Seal design where the seal faces are designed to intentionally create aerodynamic or hydrodynamic separating forces to sustain a specific separation gap (refer to 3.1.58).

— *Containment seals (CS), whether contacting or noncontacting*—Seal design with one flexible element, seal ring and mating ring mounted in the containment seal chamber (refer to 3.1.21).

Figure 1 places all these concepts in one diagram, providing a comprehensive way to look at their interrelationships.

4.1.5 Seal Configurations

Dual seals can be in the following three configurations:

— face-to-back: refer to 3.1.33;

— back-to-back: refer to 3.1.7;

— face-to-face: refer to 3.1.34;

Refer to Figure 1.

Other configuration such as concentric seals may be agreed by the purchaser and vendor.

4.2 Equipment Reliability

4.2.1 Only equipment that is field proven is acceptable. The purchaser shall specify the TRL level from API 691 for qualified equipment.

NOTE Purchasers can use their engineering judgement in determining what equipment is field proven.

• 4.2.2 If specified, the vendor shall provide the documentation to demonstrate that all equipment proposed qualifies as field proven.

4.2.3 In the event that no such equipment is available, the vender shall submit an explanation of how their proposed equipment can be considered field proven.

NOTE A possible explanation can be that all components comprising the assembled machine satisfy the field proven definition.

4.3 Specifying and/or Purchasing a Sealing System

The datasheet (Annex C) 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 datasheet to obtain budgetary pricing on a sealing system is expressed in the seal code. Typical seal codes that can be used are given in Annex D. This assumes all standard defaults (construction features and materials). The minimum information required on the datasheet is the pump data, fluid data, and seal specification.

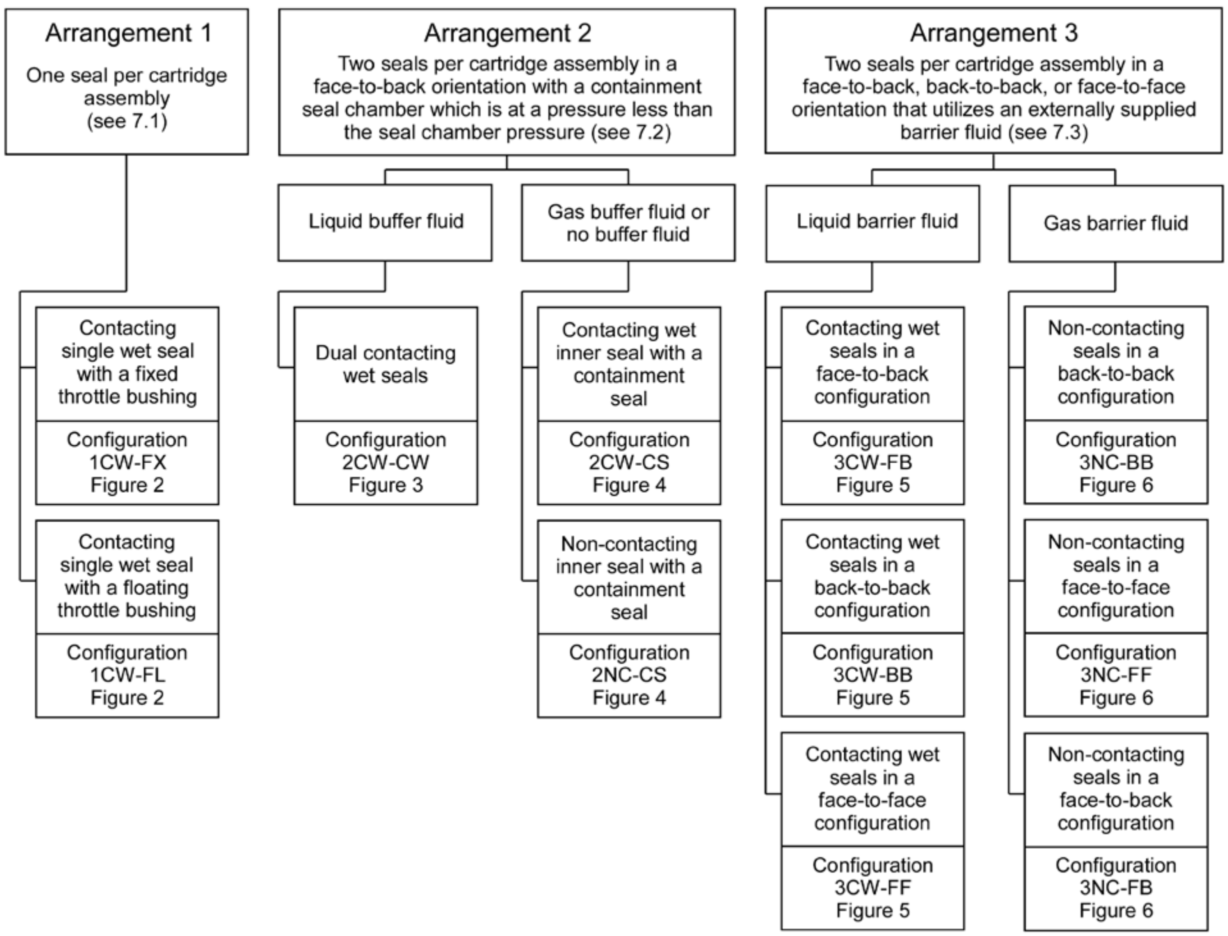
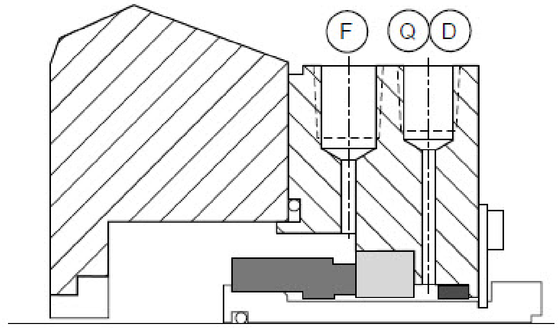
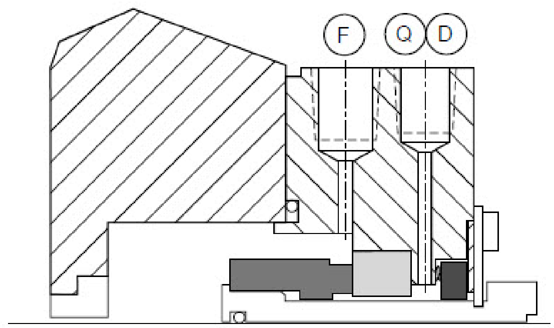


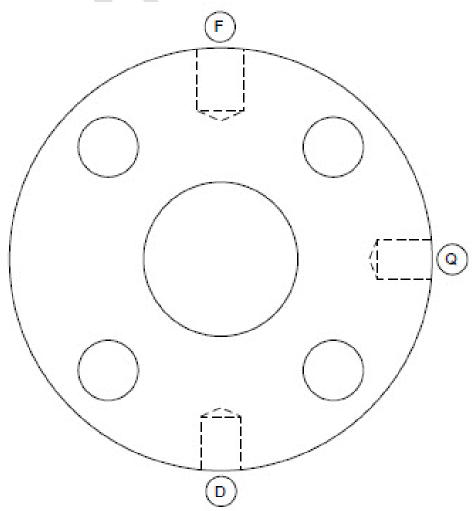
Figure 1—Seal Configurations



a) 1CW-FX, Contacting Single Wet Seal with a Fixed Throttle Bushing



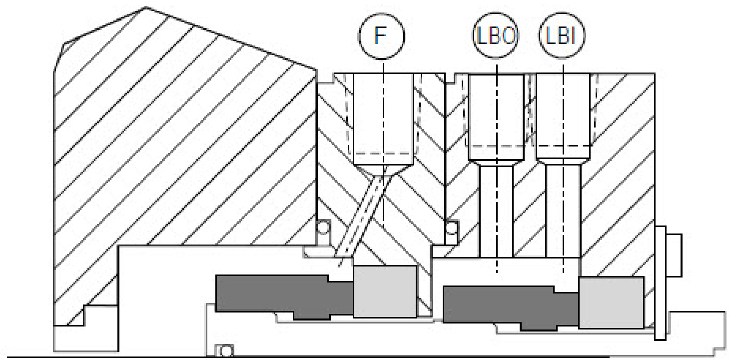
b) 1CW-FL, Contacting Single Wet Seal with a Floating Throttle Bushing



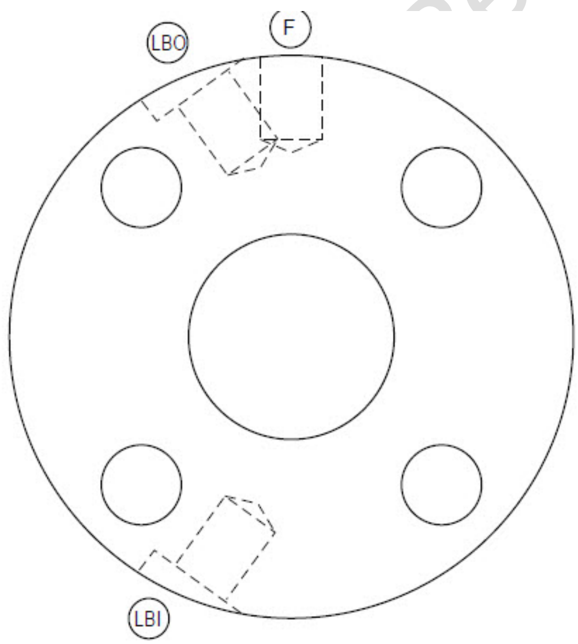
c) Typical Gland Plate Connection Orientation

NOTE For connection designations, see Table 2.

Figure 2—Arrangement 1: One Seal per Cartridge Assembly



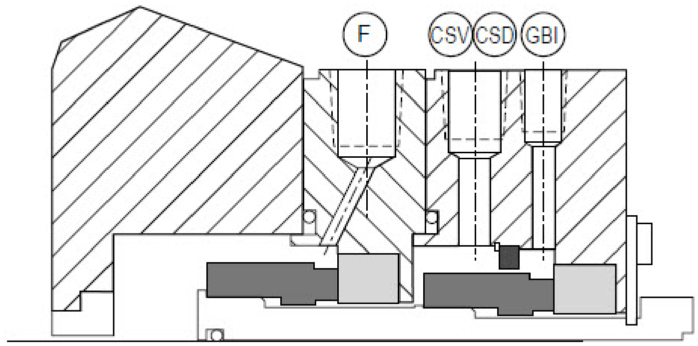
a) 2CW-CW, Dual Contacting Wet Seal



b) Typical Gland Plate Connection Orientation

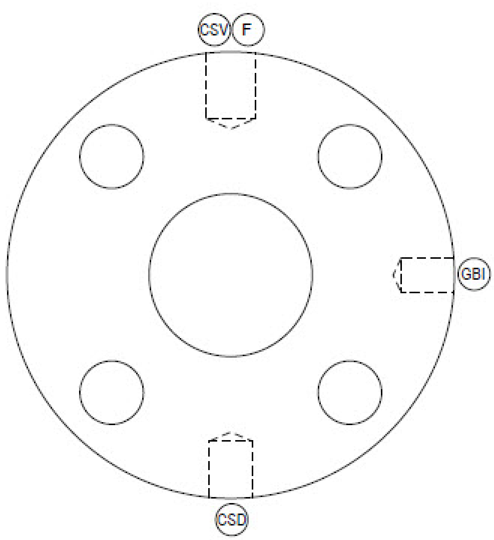
NOTE For connection designations, see Table 2.

Figure 3—Arrangement 2: Two Seals per Cartridge Assembly with a Liquid Buffer Fluid

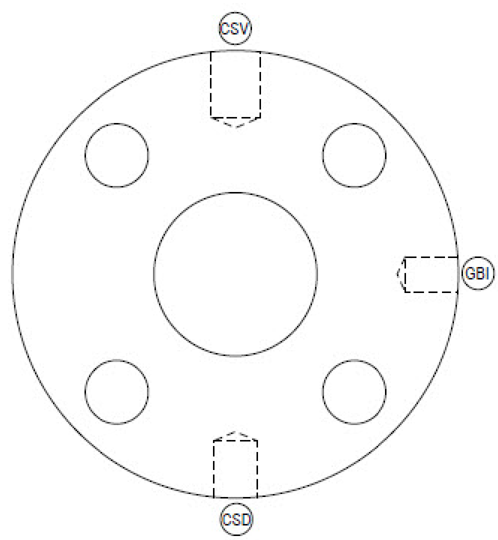


a) 2CW-CS, Contacting Wet Inner Seal with a Containment Seal

b) 2NC-CS, Noncontacting Inner Seal with a Containment Seal



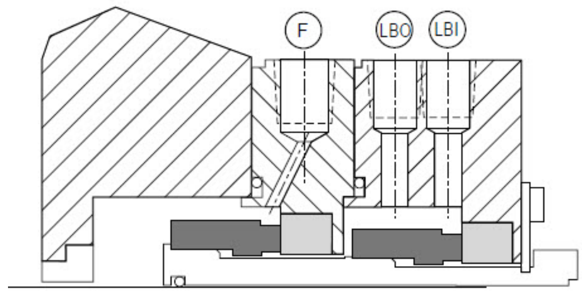
c) Typical Gland Plate Connection Orientation for 2CW-CS



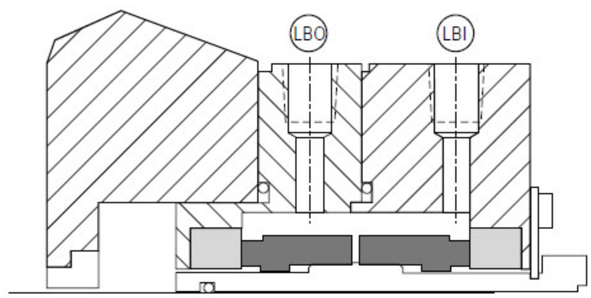
d) Typical Gland Plate Connection Orientation for 2NC-CS

NOTE For connection designations, see Table 2.

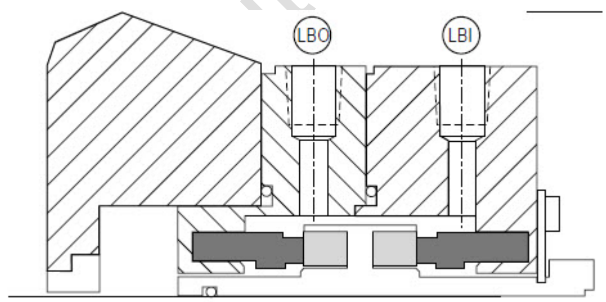
Figure 4—Arrangement 2: Two Seals per Cartridge Assembly with or Without a Gas Buffer Fluid



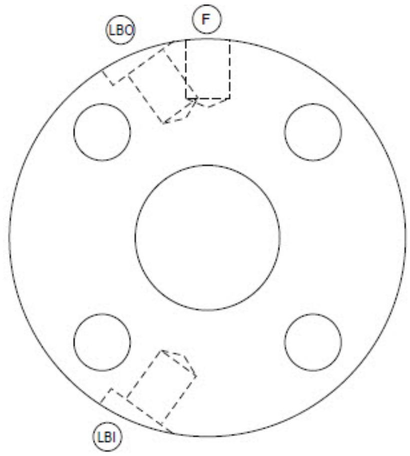
a) 3CW-FB, Contacting Wet Seals in a Face-to-Back Configuration



b) 3CW-BB, Contacting Wet Seals in a Back-to-Back Configuration



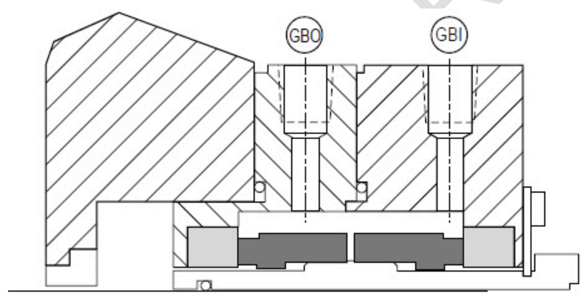
c) 3CW-FF, Contacting Wet Seals in a Face-to-Face Configuration



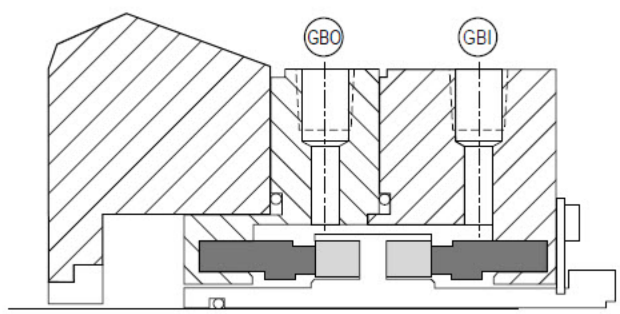
d) Typical Gland Plate Connection Orientation

NOTE For connection designations, see Table 2.

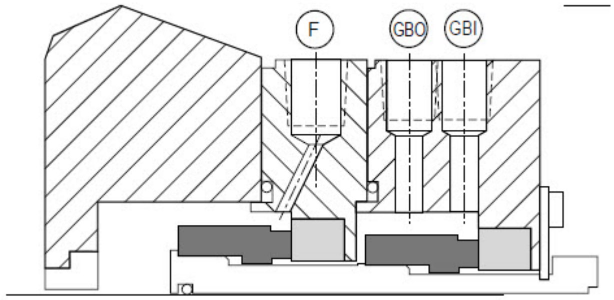
Figure 5—Arrangement 3: Two Seals per Cartridge Assembly with a Liquid Barrier Fluid



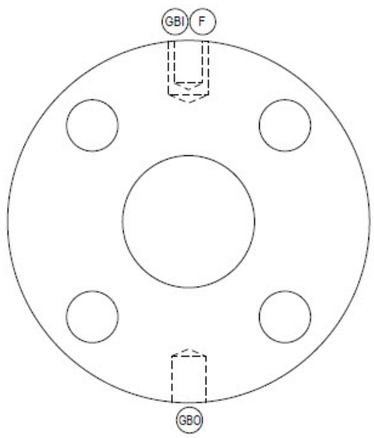
a) 3NC-BB, Noncontacting Seals in a Back-to-Back Configuration



b) 3NC-FF, Noncontacting Seals in a Face-to-Face Configuration



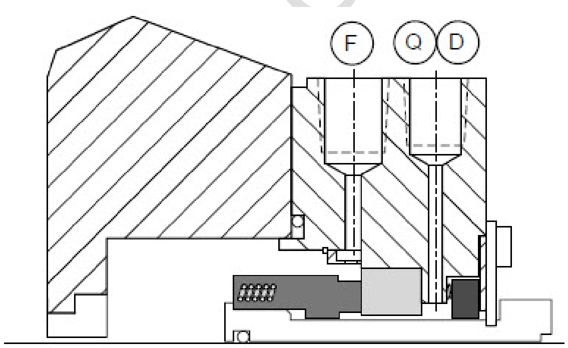
c) 3NC-FB, Noncontacting Seals in a Face-to-Back Configuration



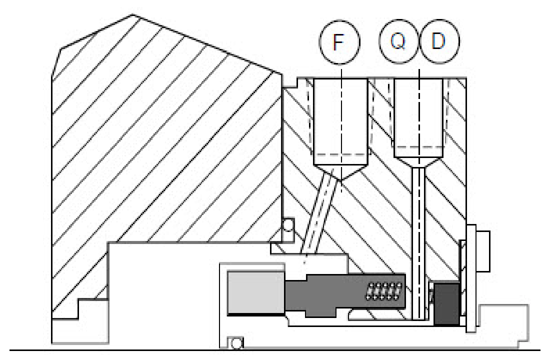
d) Typical Gland Plate Connection Orientation

NOTE For connection designations, see Table 2.

Figure 6—Arrangement 3: Two Seals per Cartridge Assembly with a Gas Barrier Fluid

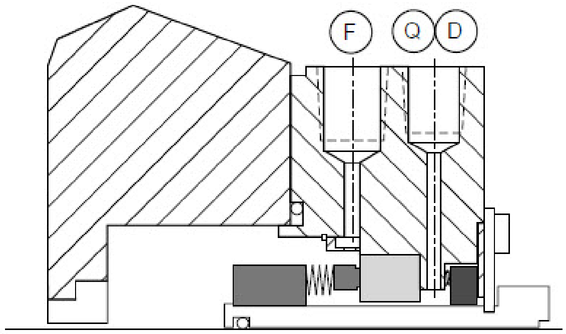


a) Rotating Flexible Element

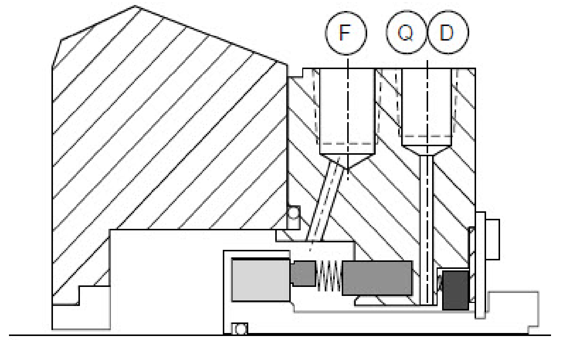


b) Stationary Flexible Element

Figure 7—Arrangement 1 Type A Seals

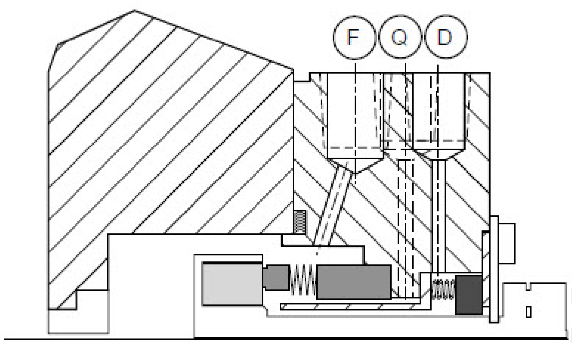


a) Rotating Bellows Assembly

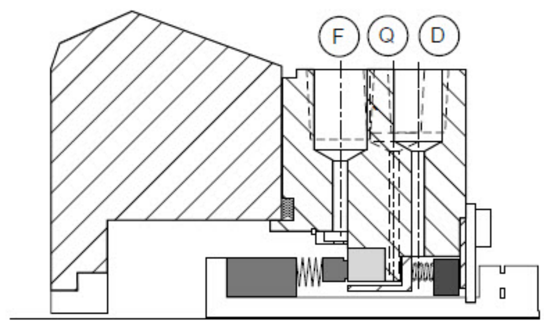


b) Stationary Bellows Assembly

Figure 8—Arrangement 1 Type B Seals



a) Stationary Bellows Assembly



b) Rotating Bellows Assembly

Figure 9—Arrangement 1 Type C Seals

5 General

5.1 Unit Responsibility

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. Annex E specifies the interface responsibilities of the pump and seal vendors.

5.2 Dimensions

- The purchaser shall specify whether data, drawings, hardware (including fasteners), and equipment supplied to this standard shall use SI units (or U.S. Customary units).

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, without hook sleeves.

NOTE API 610 requires that pumps be designed to enable seal removal without disturbing the driver.

6.1.1.2 Rotating or stationary flexible elements are acceptable for Type A, Type B and Type C seals.

NOTE There are several factors related to the design, manufacture, installation, and repair of the equipment that are considered when making the selection of a rotating or stationary flexible element. The relative merits of rotary and stationary flexible element seals and the factors influencing the choice are addressed in other subsections in this section, Annex A and Annex F.

6.1.1.3 Cartridge seals weighing more the 50 lb (25 kg) shall include lifting points to allow removal from packaging and installation on the equipment.

6.1.1.4 The cartridge seal shall incorporate a setting device 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 should be provided if seal-face surface speed at the mean diameter of the seal face exceeds 4500 ft/min (23 m/s).

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

a) nominal balance diameter exceeds 4.5 in. (115 mm);

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

c) the perpendicularity of the seal chamber mounting surface to the shaft is a problem, aggravated by high rotational speed; or

d) the seal chamber face runout requirements described in 6.1.3.13 cannot be met

NOTE As speed increases, the flexible element of a rotating seal flexes 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.

6.1.1.6 The pump and seal manufacturer shall jointly confirm that the seal is capable of handling normal and transient differential axial movement between the rotor and stator seal components.

NOTE 1 For pumps above 330F (165C), during start-up conditions, it is not unusual for a large amount of differential thermal growth to occur between the shaft and casing. Pump Temperature Equalization guidance is available in API 697 Pump Repairs.

NOTE 2 Axial movement is also a concern in some vertical pump designs that rely on the motor bearing for thrust positioning (i.e. OH4, OH5 and VS6 pumps). In certain conditions, process pressure can result in an upward thrust. Shaft axial movement is only limited by motor bearing axial float in these cases.

6.1.1.7 O-ring sealing surfaces, including all grooves and bores, shall have a maximum surface roughness (Ra) of 63 µin. (1.6 µm) for static O-rings. The surface against which dynamic O-ring slide shall have a maximum surface roughness of 32 µin. (0.8 µm).

Seal to pump interface sealing diameters shall have a minimum 0.12 in. (3 mm) radius or a minimum 0.06 in. (1.5 mm) chamfered lead-in for static O-rings. Chamfers shall have an angle of between 15° and 30°.

Chamfers or radii internal to the cartridge seal shall be adequate to prevent O-ring damage during assembly and shall be identical to the specification used in the qualification test.

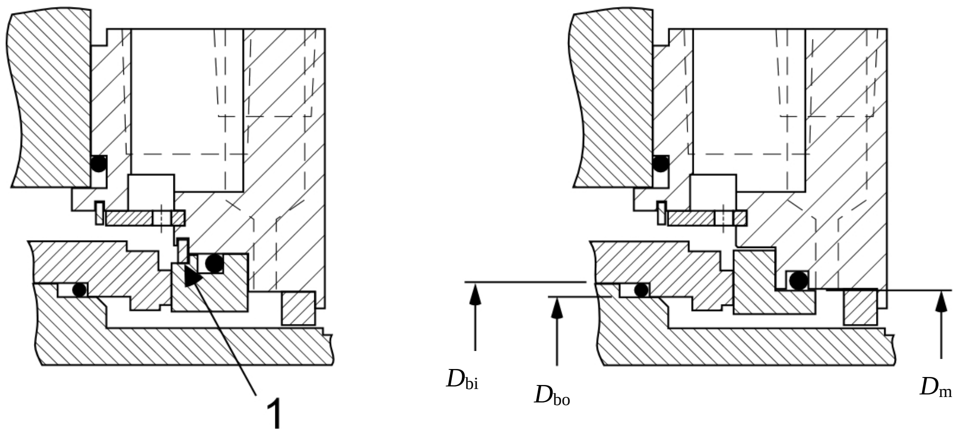
NOTE Lead-in chamfers internal to the cartridge seal can vary from the values specified in this section.

6.1.1.8 O-ring grooves shall be sized to accommodate perfluoroelastomer (FFKM) O-rings.

NOTE 1 Some FFKMs have a greater thermal expansion than most other O-ring materials, such as fluoroelastomer (FKM). Installing a FFKM in a groove designed for FKM can lead to damage to the O-ring. On the other hand, FKM O-rings function properly in the larger FFKM grooves. Choosing the wider groove as a standard eliminates this potential cause of O-ring failure and reduces the number of necessary spares.

NOTE 2 The thermal expansion damage in FFKM O-rings is often confused with damage due to chemical-induced swelling of the O-rings and vice versa.

6.1.1.9 For services where the seal chamber pressure can be below atmospheric or for Arrangement 3 inner seal, all seal components shall be designed with a means of retaining the sealing components to prevent them from being dislodged by atmospheric or barrier pressure (see Figure 10 for examples of such designs). The seal design shall be adequate to seal under vacuum conditions when the pump is not operating (see 6.1.3.15.1 for recommended operating conditions).



Key

1 retaining feature

$D_{bi} \geq D_m \geq D_{bo}$

a) Positive Retention **b) Pressure Retention (with L-shaped Mating Ring)**

Figure 10—Examples of Seal Retention Components in Vacuum Services and Arrangement 3 Inner Seal

6.1.2 Pressure and Temperature Ratings

6.1.2.1 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 MAWP and MAT 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 MAWP and MAT of the pressure casing in which they are installed.

● 6.1.2.2 The purchaser shall specify all process conditions on the seal datasheet.

6.1.2.3 Seal selection shall be based on the seal chamber conditions observed at pump normal conditions and function across all pressure and temperature ranges specified on the pump or seal datasheet.

NOTE Optimal mechanical seal selection entails designing the seal for normal process conditions, while ensuring the seal will survive when exposed to the MSSP and MDSP requirements. Good alignment between pump vendor, seal manufacturer and purchaser is important to prevent a compromised seal selection. This does acknowledge that although the seal will function at specified extreme pressure and temperature conditions, leakage rates may be higher and service hours may be lower than those at normal conditions.

6.1.2.4 Pump vendor shall define the minimum and maximum expected seal chamber pressure and temperature conditions when the pump shaft is rotating (through start-up and normal operating conditions). These pressures shall consider pump type / arrangement, pump internal clearances, and pump minimum / maximum suction and discharge pressures.

6.1.2.5 Seal manufacturer shall define the minimum and maximum pressure and temperature conditions at the seal faces when the pump shaft is rotating (through start-up and normal operating conditions). These pressures shall consider expected piping plans, flushing rates, and seal chamber pressure and temperature.

6.1.2.6 The static seal pressure rating shall be equal to or greater than the MSSP.

6.1.2.6.1 For Arrangement 1 seals, the MSSP shall be the highest discharge pressure for any of the respective operating case (normal, rated or alternate) on the pump or seal data sheet.

6.1.2.6.2 For Arrangement 2 seals, the inner seal MSSP shall be the highest discharge pressure for any of the respective operating case (normal, rated or alternate) on the pump or seal data sheet.

6.1.2.6.3 For Arrangement 2 seals, the outer seal MSSP shall be the maximum expected seal chamber pressure for any process condition specified on the pump data sheet.

6.1.2.6.4 For Arrangement 3 seals, the inner seal MSSP shall be the differential between maximum barrier fluid pressure and minimum static seal chamber pressure.

NOTE The maximum differential pressure the inner seal is exposed to is typically the differential between maximum barrier fluid pressure and atmospheric pressure for positive pressure pump applications. For sub-atmospheric pump applications it is important to consider the sub-atmospheric pressure conditions when defining the maximum differential pressure the inner seal will be exposed to.

6.1.2.6.5 For Arrangement 3 seals, the outer seal MSSP shall be the greater of maximum barrier fluid pressure or the highest discharge pressure for any of the respective operating case (normal, rated or alternate) on the pump or seal data sheet.

NOTE Depending on the inner and outer seal arrangements, it may be acceptable to have the inner and outer seal ratings equivalent.

● 6.1.2.6.6 If specified by Purchaser, vendor shall use alternative maximum static sealing pressure (MSSP) requirements specified for the specific application.

NOTE 1 The primary premise for the default MSSP requirements are parallel pump configurations where one of the pumps is a stand-by pump. If the suction valve on the stand-by pump is closed, the pump casing can be pressurized up to discharge header pressure due to discharge check-valve leakage or bypass.

NOTE 2 For stand-alone pump configurations, high discharge pressure pump applications or in applications where specific pressure and temperature conditions may limit the use of available seal designs, it may be advantageous for the Purchaser to consider specifying a lower MSSP by leveraging alternative engineering solutions or administrative controls.

NOTE 3 For applications where the seals will normally operate at discharge pressure, the Purchaser may default to an MSSP that is greater than the pump normal/rated discharge pressure. This may also be the case for applications where maximum suction pressure and pump shut-off pressure can occur from a single initiating event.

6.1.2.7 The dynamic seal pressure rating shall be equal to or greater than the MDSP.

6.1.2.7.1 For Arrangement 1 seals, the MDSP shall be as specified in Paragraphs 6.1.2.4 and 6.1.2.5.

6.1.2.7.2 For Arrangement 2 seals, the inner and outer seal MDSP shall be as specified in Paragraphs 6.1.2.4 and 6.1.2.5.

NOTE In the case of Arrangement 2 seals (wet or dry), the outer seal will normally be exposed to different fluid, pressure and temperature conditions than the inner seal. When exposed to the inner seal conditions, it is acknowledged the outer seal leakage rates may be higher and service hours may be lower than those at the outer seal normal sealing conditions.

6.1.2.7.3 For Arrangement 3 seals, the inner seal MDSP shall be the differential between the maximum barrier fluid pressure and minimum dynamic seal chamber pressure (through start-up and normal operating conditions).

6.1.2.7.4 For Arrangement 3 seals, the outer seal MDSP shall be the maximum expected barrier fluid pressure.

6.1.2.8 Seal manufacturer shall advise if it would be advantageous for Purchaser to consider alternative engineering / administrative controls to reduce the required sealing pressure.

NOTE: In certain pump applications, selecting the seal to meet the maximum static and dynamic sealing pressure requirements may result in compromised seal operation at normal operating conditions. In such cases it may be advantageous to leverage alternative administrative or engineering controls to lower the maximum required sealing pressure. Such alternatives may include: suction pressure relief valves, suction and discharge MOV permissives, administratively locking suction valves opened, etc.

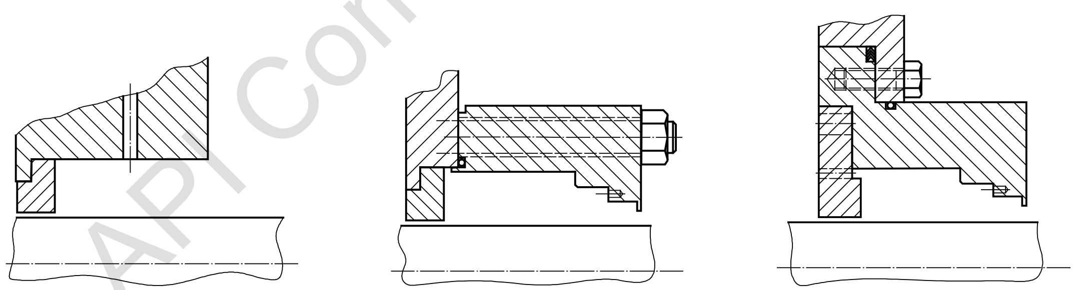
6.1.2.9 The MSSP and MDSP, along with the static and dynamic seal pressure ratings, shall be stated on the API-682 mechanical seal drawing.

6.1.3 Seal Chambers and Gland Plates

6.1.3.1 Gland plates shall be provided by the seal manufacturer.

6.1.3.2 Seal chambers shall be provided by the pump manufacturer unless otherwise specified.

6.1.3.3 Seal chambers are one of three types: traditional (cylindrical or taper), externally mounted, or internally mounted. Seal chambers are not required to accommodate packing. Figure 11 shows the three types of seal chamber.



a) Traditional **b) Externally Mounted** **c) Internally Mounted**

NOTE Type B, the externally mounted seal chamber, offers the most flexibility in terms of its ability to accommodate Arrangement 2 and 3 seals. The seal chamber can be optimized for the axial placement of flush, barrier, and buffer porting facilitating unrestricted flow paths.

Figure 11—Seal Chamber Types

6.1.3.4 The default seal chamber is the traditional type (cylindrical chamber, integral to the casing of the pump) supplied by the pump manufacturer.

• 6.1.3.5 If specified, a traditional (taper), internally mounted or externally mounted bolt-on seal chamber shall be provided by the seal manufacturer (Figure 11).

6.1.3.5.1 Category 1 seal chambers shall be designed to the dimensional envelope defined by ASME B73.1 and ASME B73.2.

6.1.3.5.2 Other than Category 1 seal chambers shall be designed to the dimensional envelope of API 610.

NOTE The reliability of a mechanical seal 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 used in some chemical industry pumps, 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.

6.1.3.6 The minimum diametral clearance between rotary and stationary components shall be sufficient to prevent contact between parts in relative motion and shall conform to the values in this section and Table 1.

a) For contacting seals (CW), the minimum diametral clearance between the rotating components of the seal and the stationary surfaces of the seal chamber and gland plate shall be 0.25 in. (6 mm) in order to promote fluid circulation and cooling around the seal faces.

b) For Arrangement 2 or 3 seals, where the inner seal is a non-contacting type (2 NC-CS or 3 NC-XX), the minimum diametral clearance between the rotating components of the seal and the stationary surfaces of the seal chamber and gland plate shall be 0.125 in. (3 mm). Non-contacting seals generate minimal amount of heat, only that resulting from the viscous shear of the sealed fluid.

c) The first point of radial contact by a metal component of the seal shall not be at the seal ring or mating ring (see NOTE 2).

NOTE 1 The intent of setting minimal clearances should in no way be construed as implying that any seal component can be used to restrict shaft movement in the event of bearing failure or other machinery or operation problem.

NOTE 2 The requirement in 6.1.3.6 c) is to minimize potential leakage levels and/or a friction generated ignition source in the rare fault event where the relative radial position of the rotating components to the stationary components would be beyond the minimum diametral clearances in Table 1. The importance of having sufficient design clearance to ensure adequate reliability and personal safety in hazardous, toxic and flammable services is paramount. Diametral clearances may be compromised in the event of the following scenarios:

— wear of shaft bearings beyond their design limits;

— operation of the pump beyond its allowable operating range;

— existing pumps that have damaged, corroded, or worn parts that control the radial location of the shaft to the casing.

It is important to ensure pump installation to the appropriate standards on hazardous services. Operational condition monitoring and controlled maintenance and reconditioning procedures are always applied.

NOTE 3 These minimal clearances will be adequate in equipment that is built and/or maintained to the specifications of API 610 and ANSI B73. For other equipment built, repaired, or operated to different specifications these clearances might not be sufficient. Larger clearances should be considered for:

— pump designs unable to conform to the shaft, casing and seal design limits in API 610, API 682, and the shaft/casing limits in ANSI B73.1 and ANSI B73.2. Potentially vulnerable pump designs are discussed in API 610.

— pumps installed with mounting and flange strain, from connecting pipe work, are beyond the recommended limits of API 610 and ANSI B73.1 and ANSI B73.2.

NOTE 4 These minimal clearances are to prevent contact between rotary and stationary parts, but internal clearances in Arrangement 2 and Arrangement 3 CW seals also need to be sufficient to insure proper circulation of the barrier/buffer fluid and cooling of the seal faces. This is particularly important in face-to-back configuration where barrier/buffer fluid circulation to the inner seal is inherently physically remote from the connections. Inadequate cooling of the inner seal can result in reduced seal reliability. Selection of 3CW-BB or 3CW-FF configuration or use of process fluid seal chamber cooling may resolve an inner seal cooling problem.

Table 1—Clearances between Rotary and Stationary Components

Inside Diameter (ID)	Outside Diameter (OD)		Minimum Diametral Clearance [a]	Reference
ID seal chamber bore and gland plate	OD rotating seal part	CW seal type	6 mm (0.25 in.)	6.1.3.6.a)
		NC seal type	3 mm (0.125 in.)	6.1.3.6 b)
ID stationary seal part	OD rotating seal part	shaft ≤ 60 mm	1 mm (0.039 in.)	6.1.3.6 c)
		60 mm < shaft ≤ 110 mm	2 mm (0.079 in.)	
		shaft > 110 mm	3 mm (0.125 in.)	
ID stationary gland part	OD internal circulation device	shaft ≤ 60 mm	1 mm (0.039 in.)	7.1.2.6
		shaft > 60 mm	2 mm (0.079 in.)	
ID containment fixed bushing 2CW-CS, 2NC-CS	OD rotating seal part	shaft ≤ 60 mm	1 mm (0.039 in.)	7.2.4.1
		shaft > 60 mm	2 mm (0.079 in.)	7.2.5.1
a. The minimum diametral clearances are calculated by subtracting the maximum outside diameter (of the internal part) from the minimum inside diameter (of the external part).				
Inside Diameter (ID)	**Outside Diameter (OD)**		**Maximum Diametral Clearance [b]**	**Reference**

ID floating carbon bushing	OD rotating sleeve	20 mm to 50 mm 51 mm to 80 mm 81 mm to 125 mm 126 mm to 150 mm 151 mm to 175 mm	0.18 mm (0.007 in.) 0.225 mm (0.009 in.) 0.28 mm (0.011 in.) 0.33 mm (0.013 in.) 0.38 mm (0.015 in.)	6.1.3.24
ID fixed throttle bushing	OD rotating sleeve	20 mm to 50 mm 51 mm to 75 mm 76 mm to 100 mm 101 mm to 125 mm 126 mm to 150 mm 151 mm to 175 mm	0.635 mm (0.025 in.) 0.762 mm (0.030 in.) 0.889 mm (0.035 in.) 1.016 mm (0.040 in.) 1.143 mm (0.045 in.) 1.270 mm (0.050 in.)	6.1.3.23

b. The maximum diametric clearances are calculated by subtracting the minimum outside diameter (of the internal part) from the maximum inside diameter (of the external part).

6.1.3.7 For Category 1 seals, all bolt and stud stresses shall be in accordance with ASME B73.1 or 73.2. For Category 2, Category 3 and Category 4 seals, all bolting and stud stresses shall be in accordance with API 610 clause on mechanical shaft seals.

6.1.3.8 The MAWP and MAT of the seal chamber and gland plates shall be equal to or greater than that of the pump pressure casing on which it is installed. This value shall be provided by the pump manufacturer.

6.1.3.8.1 The seal chamber and gland plates shall be manufactured from a corrosion resistant material that matches or exceeds the corrosion resistance of the pump casing material.

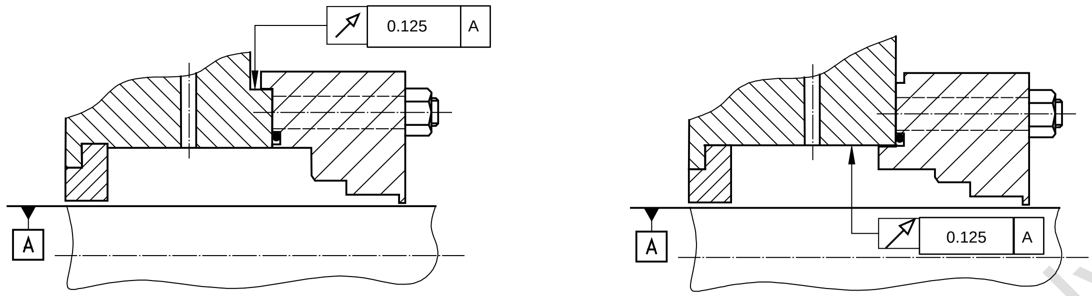
6.1.3.8.2 The seal chamber and gland plates shall have sufficient rigidity to avoid any distortion that would impair seal operation, including distortion that may occur during tightening of the bolts.

6.1.3.8.3 Seal gland plates shall be provided with holes (not slots) for attachment studs. If slots are specified, hardened washers shall be supplied for the seal gland plate.

NOTE In some applications, seal gland plates are provided with vertical slots.

6.1.3.8.4 Gland plate stud holes shall be sized according to ASME B18.2.8 LOOSE fit class or ISO 273 COARSE fit class.

6.1.3.8.5 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 (TIR) of not more than 0.125 mm (0.005 in.), see Figure 12. The rabbet diametrical clearance shall be H7/f7 in accordance with ISO 286-2.



a) Outside Diameter Fit **b) Inside Diameter Fit**

Figure 12—Seal Chamber Register Concentricity

6.1.3.8.6 A shoulder shall be provided integral to the seal gland plate to support the axial load generated by the seal chamber pressure.

6.1.3.9 Stress values used in the design of the seal gland shall be in accordance with the design factors for pressure casings as stated in API 610.

6.1.3.10 Manufacturing data report forms, third party inspections, and stamping, such as those specified in codes such as ASME VIII, are not required.

6.1.3.11 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 any corrosion allowance, shall be left around and below the bottom of drilled and tapped holes.

6.1.3.12 Threading details for bolting for pressure casings shall be in accordance with ISO 261, ISO 262, ISO 724, and ISO 965, or with ASME B1.1. Metric fine and UNF threads shall not be used.

Studs in accordance with API 610 Table H.1 shall be used, rather than other fasteners such as cap screws for connection of seal chamber to pump and seal gland plate to pump or seal chamber.

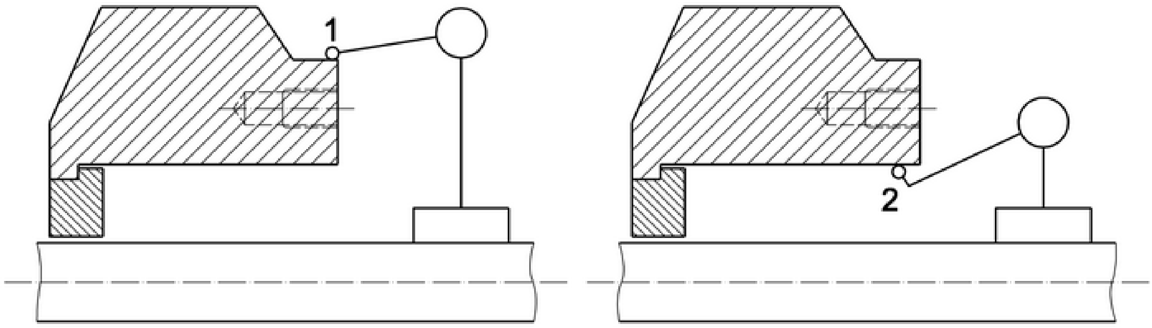
Adequate clearance shall be provided at bolting locations to permit the use of socket or box wrenches.

Manufacturers marking shall be located on all fasteners 0.25 in. (6 mm) and larger (excluding washers and headless set screws). For studs, the marking shall be on the nut end of the exposed stud end.

NOTE 1 A set screw is a headless screw with an internal hex opening on one end.

NOTE 2 Adequate clearance to use socket or box wrenches at gland plate bolting locations might not be feasible on small pumps.

6.1.3.13 The seal manufacturer shall design for seal chamber inside or outside diameter runout (TIR) up to 0.005 in. (125 µm/mm), see Figure 13a.



Key

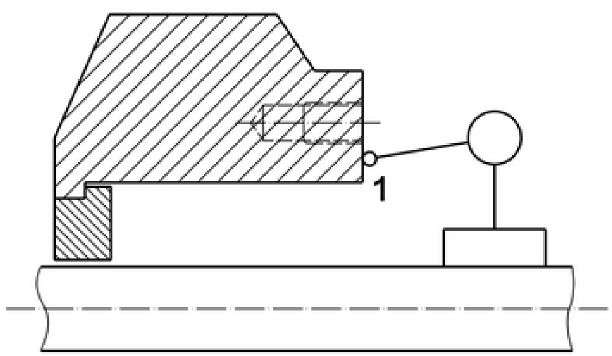
1 location of outside diameter measurement

2 location of inside diameter measurement

Figure 13a – Seal Chamber Diameter Runout

6.1.3.14 The seal manufacturer shall design for seal chamber face runout (TIR) as defined by the applicable pump standard, see Figure 13b.

NOTE Mechanical seal performance can be adversely affected by excessive runout 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.



Key

1 location of face runout measurement

Figure 13b—Seal Chamber Face Runout

6.1.3.15 For Arrangement 1 and Arrangement 2, seal chamber pressure and support systems for contacting wet seals (excluding containment seals) shall be designed for proper seal operation. Pumps that develop low differential pressure and pumps that handle high vapor pressure fluids may not achieve the required margins specified in 6.1.3.15.1 and 6.1.3.15.2. If the seal chamber conditions do not meet the specified margins, the seal manufacturer shall:

a) confirm the adequacy of the seal selection and piping plan based on the specified fluid;

b) recommend the seal chamber operating conditions (minimum pressure and maximum temperature)

c) consider furnishing the seal gland plate or seal chamber with a second flush connection to permit measurement of seal chamber pressure directly; and

d) consider furnishing a distributed flush system unless space limitations preclude its use.

e) consider using hydrodynamic seal face features to allow for operation with lower vapor pressure margins.

NOTE Refer to F.1.4 for specific recommendations.

6.1.3.15.1 During operation, the seal chamber pressure shall be at least 5 psi (0.035 MPa) (0.35 bar) above atmospheric pressure. This is particularly important if the inlet pressure to the pump is below atmospheric.

6.1.3.15.2 During operation, a vapor pressure margin (VPM) (i.e. the difference between the seal chamber pressure minus the maximum fluid vapor pressure) shall be maintained as required in 6.1.3.15.2 a). If it is not possible to achieve this margin the criteria in 6.1.3.15.2 b) shall be met.

a) Not less 50 psi (0.35 MPa) (3.5 bar).

b) A minimum ratio of 1.3 between the absolute pressure in the seal chamber and the absolute vapor pressure of the pumped fluid at pumping temperature.

NOTE 1 For high vapor pressure fluids, (e.g. NGL's like ethane or olefins like ethylene), it is recommended that the user consult the seal vendor for seal design and appropriate VPM.

NOTE 2 For additional guidance on VPM, the user should consult Annex F.

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

● 6.1.3.17 If specified, or if recommended by the seal manufacturer, close-clearance floating throat bushings shall be used to improve seal performance. The bushing materials, configuration and clearances shall be suitable for the service and approved by the purchaser.

NOTE 1 Close-clearance throat bushings can be used for any or all of the following purposes along with the appropriate piping 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.

See Annex F.5.3 for additional guidance concerning the use of throat bushings.

NOTE 2 The effectiveness of the close-clearance floating bushing may be compromised by existing internal vents and drains in the seal chamber. The effectiveness of the bushing may be improved by plugging these holes.

6.1.3.18 Datasheet-specified gland plate and seal chamber connections shall be identified by symbols permanently marked (e.g. stamped or cast) on the component.

6.1.3.19 The symbol, size, and location in Table 2 shall be used to locate ports and tapped holes in the seal chamber and gland plate. (See Figure 1 through Figure 9 for the relative axial position of the process and atmospheric connections)

6.1.3.19.1 Where appropriate, the letters “I” and “O” (marking In and Out) shall be used in conjunction with these markings.

6.1.3.19.2 For horizontal pumps, 0° is vertical on top.

6.1.3.19.3 For vertical pumps, the location of the flush (marked with letter “F”) connection defines 0° (see Figure 2 to Figure 6).

6.1.3.19.4 If tangential porting is used, the location of the drilled port into the seal chamber shall comply with Table 2. Tapped connections can be located at a different angle than the seal gland ports.

6.1.3.19.5 If the specified connection size or location cannot comply with Table 2, the seal supplier and purchaser shall agree on tapped connections, porting sizes and locations. These connections could be on the pump and in the pump manufacturer’s scope of supply. The dimension from the face of the seal chamber to the port centerline will be noted on the seal drawing.

NOTE Annex E specifies the interface responsibilities of the pump and seal vendors.

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

6.1.3.21 Gland plates and/or seal chambers for contacting wet seals including the barrier or buffer chamber, and containment seal chambers 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 Piping Plan 23, requiring manual seal chamber venting shall be approved by the purchaser. The following shall apply.

a) On small horizontal pumps where the elevation of the discharge nozzle is not high enough to achieve a continuously rising Piping Plan 11 flush line, then the connection may be located in the process piping upstream of the check valve if approved by the purchaser.

b) The seal chamber or gland plate shall have a port no less than 0.125 in. (3 mm) 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 14). 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 when they are vertically oriented.

c) Horizontal or vertical pumps having a Piping Plan 23 or vertical pumps having Piping Plans 11, 21, 31, and 41 shall be provided with a separate vent connection in the piping. Vertical pumps having Piping Plan 02 shall have a vent connection in the gland plate. Designs, other than these, requiring manual seal chamber venting require purchaser’s approval.

d) 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 Piping Plan 11 or Piping Plan 13 on a small pump). Entrained gas will quickly purge from the piping and seal chamber upon start-up of the pump.

Table 2—Symbols and Size for Seal Chamber and Gland Plate Connections

Seal	Symbol	Connection		Type	Minimum Size [a]	

Config.			Port Location [h]		Cat. 1,2	Cat. 3,4 [i]	Connection Required [f]
1CW-FX 1CW-FL	F	Flush	0	process	1/2 [c]	1/2	required
	FI	flush in (Plan 14 & 23 only)	180	process	1/2 [c]	1/2 [d]	WS
	FO	flush out (Plan 14 & 23 only)	0	process	1/2 [c]	1/2 [d]	WS
	D	drain	180	atmospheric	3/8 [e]	3/8	required
	Q	quench	90	atmospheric	3/8 [e]	3/8	required
	H	heating	—	utility	1/2 [c]	1/2	WS
	C	cooling	—	utility	1/2 [c]	1/2	WS
	PIT	pressure sensing port	90	instrumentation	3/8	3/8	WS [g]
2CW-CW	F	flush (inner seal)	0	process	1/2 [c]	1/2	required
	LBI	liquid buffer fluid in	180	process	1/2 [d]	1/2 [d]	required
	LBO	liquid buffer fluid out	0	process	1/2 [d]	1/2 [d]	required
	D	drain (outer seal)	180	atmospheric [b]	3/8 [e]	3/8	WS
	Q	quench (outer seal)	90	atmospheric [b]	3/8 [e]	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 [c]	1/2 [d]	WS
	FO	flush out (Plan 23 only)	0	process	1/2 [c]	1/2 [d]	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 [b]	3/8 [e]	3/8	WS
	Q	quench (outer seal)	90	atmospheric [b]	3/8 [e]	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 [b]	3/8 [e]	3/8	WS
	Q	quench (outer seal)	90	atmospheric [b]	3/8 [e]	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 [d]	1/2 [d]	required
	LBO	liquid barrier fluid out	0	barrier	1/2 [d]	1/2 [d]	required
	D	drain (outer seal)	180	atmospheric [b]	3/8 [e]	3/8	WS
	Q	quench (outer seal)	90	atmospheric [b]	3/8 [e]	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	WS
	D	drain (outer seal)	180	atmospheric [b]	3/8 [e]	3/8	WS
	Q	quench (outer seal)	90	atmospheric [b]	3/8 [e]	3/8	WS
	V	process vent	0	process	1/2	1/2	WS

a. All sizes listed in this table are NPT tapered thread connections.
b. 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.
c. A 0.375 NPT connection may be used if 0.5 NPT is not possible because of space constraints.
d. 0.5 NPT required for shaft diameters 2.5 in. (60 mm) or smaller, 0.75 NPT for larger shaft sizes.
e. A 0.25 NPT connection may be used if 0.375 NPT is not possible because of space constraints.
f. WS = Connection is provided only when the appropriate piping plan is specified.
g. PIT port for indicating pressure transmitter required for Piping Plan 66A and Piping Plan 66B.
h. With purchaser approval, the port location may be relocated to a different angle when necessitated by restriction in the pump or piping plan. (reference 6.1.3.19.5)
i. Ports may be larger than noted in this table on some Category 4 applications. These require engineering assessment.

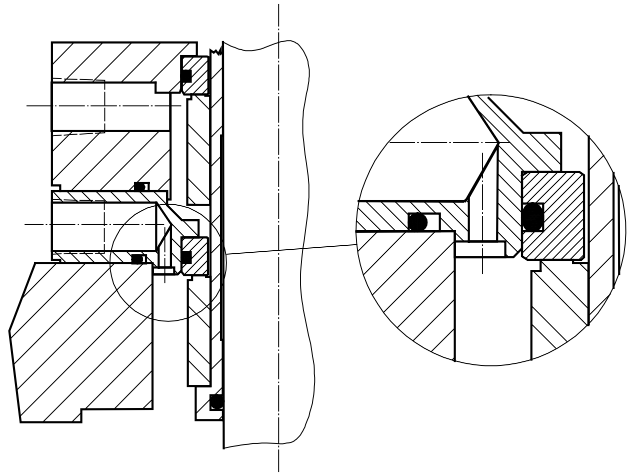


Figure 14—Seal Chamber/Gland Plate for Vertical Pumps

e) 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.

NOTE Drilling of throat bushing wall at top dead center, for horizontal shaft pumps, will allow natural venting of the seal chamber inside the pump. This can be a practical alternative when venting through the piping is either impractical or not possible.

6.1.3.22 Drilled passages shall be sized for the application and shall have a minimum diameter of 0.188 in. (5 mm).

6.1.3.23 The diametrical clearance at a fixed throttle bushing (see 3.1.35) bore shall not be more than specified in Table 1.

6.1.3.24 Floating throttle bushings made of carbon shall have a sleeve clearance as shown in Table 1.

NOTE If the bushing is designed to have the maximum diametrical clearance at a given pumping temperature, but the operation is below this temperature, the clearance will be greater than the one indicated in Table 1. If the purchaser wishes to minimize the clearance over a range of operating conditions, and therefore leakage past the bushing, consult the seal manufacturer for recommendation on material or a restriction device such as a segmented floating carbon bushing that can maintain a given clearance over a range of temperatures.

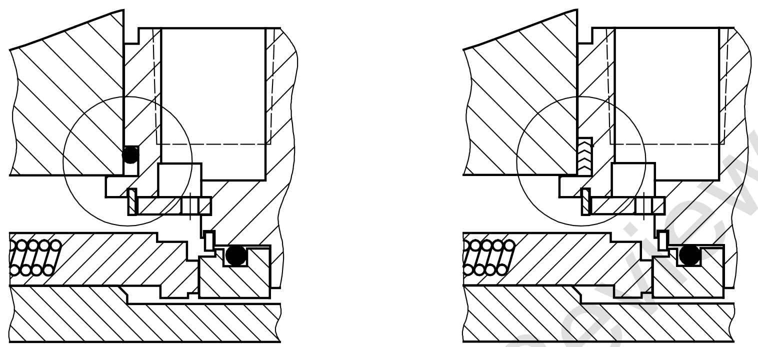
● 6.1.3.25 If specified, heating jackets or inserts shall be provided on seal chambers. Heating requirements shall be agreed between the purchaser, vendor and seal manufacturer.

NOTE The jacket can be used for temperature control, and this includes cooling as well as heating. Use of the jacket for cooling purposes is not recommended because of the relative inefficiency of the method and the tendency of plugging and fouling. Steam has been used effectively for cooling purposes on hot pumps and can prevent solidification of the process medium when idle. When a jacket is used, caution shall be exercised if skim cutting of the seal chamber bore is done, to insure that minimum wall thickness is maintained.

6.1.3.26 Gaskets for the gland plate or plates shall be designed for the maximum operating pressure and temperature and the following requirements.

6.1.3.26.1 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 (see Figure 15).

6.1.3.26.2 Controlled compression of the gasket (e.g. 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.



a) O-ring b) Spiral-wound Gasket

Figure 15—Mating Joint Gasket

NOTE To minimize runout, metal-to-metal contact is needed to keep faces and the shaft perpendicular for seals with rotating flexible elements.

6.1.3.26.3 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.

6.1.3.26.4 Where space or design limitations make this requirement impractical, an alternative seal gland plate design shall be submitted to the purchaser for approval.

6.1.3.26.5 The gland shall be designed such that torqueing to manufactures specifications will not adversely affect seal performance.

6.1.3.26.6 The pump manufacturer shall provide gland bolt torque specification to the user.

NOTE API RP 697 Pump Repairs Annexes include recommended torque values for metal to metal joints.

6.1.4 **Cartridge Seal Sleeves**

6.1.4.1 Seal sleeves shall be furnished by the seal manufacturer. The sleeve shall be made of one piece. (See 6.1.4.10 concerning auxiliary sleeves.) The seal sleeve assembly shall extend beyond the outer face of the seal gland plate.

NOTE Leakage between the shaft and the sleeve cannot be confused with leakage through the mechanical seal.

6.1.4.2 The seal manufacturer shall obtain the shaft diameter and tolerance from the pump manufacturer.

6.1.4.2.1 The seal manufacturer shall ensure a shaft-to-sleeve fit in accordance with ISO 286-2 as detailed Table 3. The intent of this requirement is to minimize sleeve runout (see Figure 16), while allowing for ease of installation and removal.

NOTE Other methods to achieve the same level of concentricity are available. The purchaser may wish to discuss these alternatives with the pump and seal vendor.

Table 3: Shaft to Seal Sleeve Fits

Shaft Diameter		**Sleeve**
mm	in.	
20 to 110	0.750 to 4.312	F7
>110 to 150	>4.312 to 6.000	F8

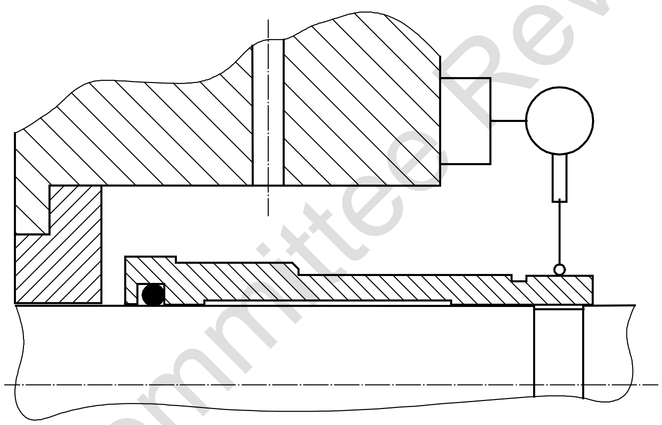


Figure 16—Seal Sleeve Runout

6.1.4.2.2 If the shaft diametric tolerance differs from h6, the seal manufacturer shall agree to the shaft to seal sleeve fit tolerance with the purchaser.

NOTE API 682 standard shaft to sleeve fit is based on a shaft diameter tolerance of h6; however, special cases may exist in which pumps are supplied with different shaft diameter tolerances.

6.1.4.2.3 Shrink disks typically require tighter clearances for seal face surface speeds greater than 4500 ft/min (23 m/s). Shrink-disk fits shall be per the shrink disk manufacturer's design criteria (see paragraph 6.1.4.16).

6.1.4.3 A clear means of guidance for setting the proper axial positioning of rotating elements on sleeves shall be provided.

NOTE This provision is intended to help the assembler of the seal properly locate seal components axially so that the correct spring load is attained. Features such as shoulders, or holes to receive dog points or pins, are examples of such clear means. This minimizes the possibility of error during assembly due to imprecise measurements or similar mistake. The intent is not to limit the seal designer to only one method.

6.1.4.4 Shaft-to-sleeve sealing devices shall be elastomeric O-rings or flexible graphite rings. Metallic sealing devices are often unreliable, damage the shaft, and make disassembly difficult. Sealing devices should be softer than the shaft.

6.1.4.5 Shaft-to-sleeve O-ring seals shall be located as close as practicable to the impeller end of the sleeve.

6.1.4.5.1 For shafts that require the O-ring to pass over the threads, at least 0.063 in. (1.6 mm) radial clearance shall be provided between the threads and the internal diameter of the O-ring.

6.1.4.5.2 The diameter transition shall be radiused or chamfered (see 6.1.1.7) to avoid damage to the O-ring.

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

6.1.4.6 Non-elastomeric 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.

6.1.4.7 Sleeves shall have a minimum radial thickness of 0.10 in. (2.5 mm) at their thinnest section, excluding a local feature such as a setting device groove or a hole which does not compromise the dimensional integrity of the sleeve. The sleeve thickness in the area of component drive set screws shall be in accordance with Table 4.

NOTE The sleeve thickness in the proximity of set-screw locations prevents sleeve distortion due to tightening of the set screws.

Table 4—Minimum Sleeve Thickness in the Area of Component-drive Set Screws

Shaft Diameter		**Minimum Sleeve Radial Thickness**	
mm	in.	mm	in.
20 to 60	0.750 - 2.375	2.5	0.100
> 60 to 80	> 2.375 to 3.250	3.8	0.150
> 80 to 110	> 3.250 to 4.312	5.0	0.200
> 110 to 150	> 4.312 to 6.000	6.0	0.250

6.1.4.8 The seal sleeve shall be machined and finished throughout its length such that the total runout between the bore and outside diameter does not exceed 0.001 in. (25 µm) TIR.

6.1.4.9 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.

6.1.4.10 Where possible seal sleeves shall be designed as one piece.

6.1.4.10.1 Cartridge designs for Arrangement 2 and 3 seals that incorporate an auxiliary sleeve to facilitate the assembly of the inner or outer seal components are acceptable.

6.1.4.10.2 The auxiliary sleeve shall be axially located on the seal sleeve by positive means as specified in 6.1.4.3.

6.1.4.10.3 Auxiliary sleeves shall not extend beyond the seal sleeve. See Figure 17 for an illustration of an auxiliary sleeve.

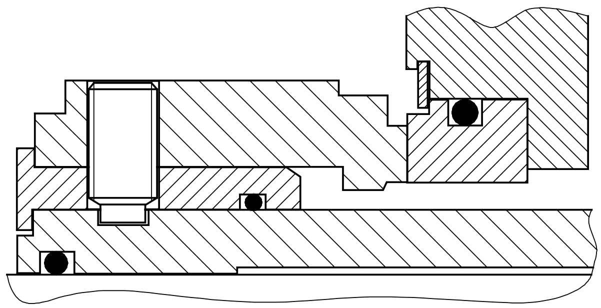


Figure 17 - Example Auxiliary Sleeve Arrangement

6.1.4.11 Drive-collar set screws shall not pass through clearance holes unless the sleeve bore has a relief groove. For between-bearing pumps, the shaft shall be relieved in the set screw area. This relieved area should be chamfered appropriately to avoid O-ring damage during seal installation.

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 will then need to 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.

6.1.4.12 Drive-collar set screws shall be harder than the shaft. See Table F.2 and Table F.3.

6.1.4.13 It is the responsibility of the seal vendor to ensure that the drive-collar set screws shall be of adequate quantity and size to ensure that rotational drive and axial positioning are adequate for the service conditions. For purposes of determining what is adequate the collar and set screw arrangement shall be able to statically maintain axial positioning under the axial load generated by a minimum of 150% of the maximum seal chamber pressure according to 6.1.2.6 and 6.1.2.7. The axial load is calculated by multiplying the pressure by the annular surface area defined by the shaft and the seal balance diameter. See F.4 for calculation details.

6.1.4.14 Drive collar and set screw arrangement shall be able to statically maintain axial positioning under the axial load generated by a minimum of 150% of the maximum seal chamber pressure rating according to 6.1.2.6 and 6.1.2.7.

NOTE 1 The axial load is calculated by multiplying the pressure by the annular surface area defined by the shaft and the seal balance diameter. See F.4 for calculation details.

NOTE 2 A seal could have internal clearances that may result in some minor deflection under loads.

6.1.4.15 Designs using more than 12 set screws to drive and/or axially position the sleeve require purchaser approval.

● 6.1.4.16 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 shrink disk (see Figure 18) or a split ring engaging a groove in the shaft (see Figure 19).

NOTE Use of these designs avoids shaft damage by dimpling the shaft for dog-point set screws when high thrust loads exist on the sleeve.

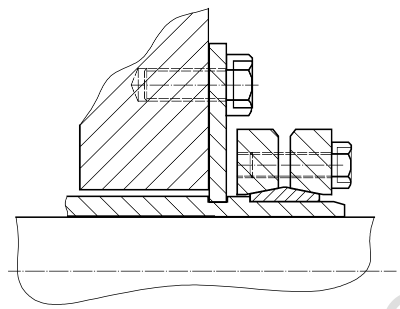


Figure 18—Seal Sleeve Attachment by Shrink Disk

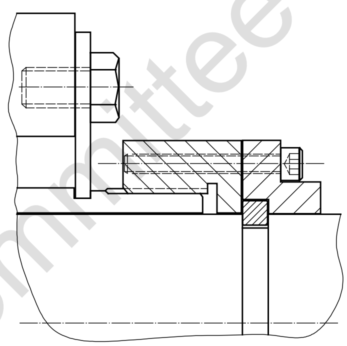


Figure 19—Seal Sleeve Attachment by Split Ring

6.1.5 **Mating Rings**

6.1.5.1 Anti-rotation devices shall be designed to minimize distortion of the seal faces. Clamped faces shall not be used unless approved by the purchaser (see Figure 20).

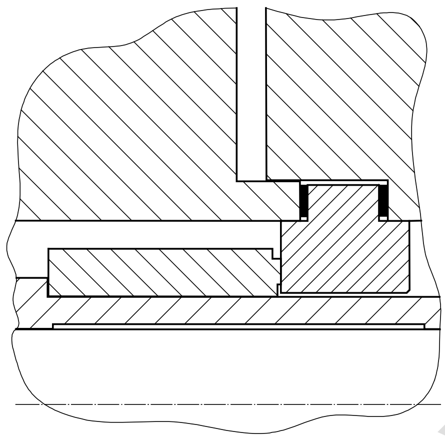


Figure 20—Clamped Faces

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

6.1.5.2 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.

6.1.6 **Flexible Elements**

● 6.1.6.1 The flexible element of a Type A seal shall be a multiple spring design. If specified, a single-spring Type A seal can be furnished by the seal manufacturer.

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 more even loading.

NOTE 2 Single-spring seals generally add 0.25 in. (6 mm) to 0.5 in. (13 mm) 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 resulting from changes in the relative axial location of the shaft with respect to the seal chamber (such as in case of differential thermal expansion.) The use of cartridge seals has largely eliminated errors in axial setting of the seal.

NOTE 3 For corrosive services, the wire in single springs is significantly greater in cross-section, providing a greater corrosion allowance. Multiple springs can more easily be located outside the process, thus eliminating immersion of the spring in the corrosive media.

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

NOTE This requirement means that designs such as lapped-joint rotating seal rings are prohibited, 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.

6.1.7 **Materials**

6.1.7.1 **General**

6.1.7.1.1 Seal components shall be furnished with the materials referenced in 6.1.7.2 to 6.1.7.9.

NOTE 1 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. See *NACE Corrosion Engineer's Reference Book* for one source of suitable materials.

NOTE 2 Material selection can vary depending on the function of the part and its proximity to, or contact with, the process fluid. Thus, it is not uncommon in corrosive services for dual seals to have different material used for components in the outer part of the seal that are not wetted by the process fluid.

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

6.1.7.1.3 Materials identified in the proposal other than those specified in this standard shall be identified with their applicable specification numbers (e.g. ISO, EN, ASTM, 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.

6.1.7.2 **Seal Faces**

6.1.7.2.1 Seal face materials shall be in accordance with 6.1.7.2.2 through 6.1.7.2.6.

NOTE There are many face materials available, each having relative benefits and disadvantages. No material or material combination is excluded simply from the fact that it is not specifically mentioned, consult the seal manufacturer for the best face combination in a specific service.

6.1.7.2.2 Each seal shall be comprised of a seal ring and a mating ring that have passed the relevant qualification testing per Section 10.

NOTE This standard does not apply to split mechanical seals where ring segments are used.

6.1.7.2.3 Except as required by 6.1.7.2.4, one of the rings shall be carbon graphite.

● 6.1.7.2.4 For all seal categories the material for one of the rings shall be reaction-bonded silicon carbide (RBSiC) or self-sintered silicon carbide (SSSiC), depending on the chemical compatibility and recommendation by the seal vendor. The manufacturer shall state the type of silicon carbide offered for each service.

NOTE See B.2.3 for guidance related to manufacture and use of RBSiC versus SSSiC.

6.1.7.2.5 Abrasive, viscous, and high-pressure services may require two hard materials. For such services, the default material for both the seal ring and the mating rings shall be silicon carbide. Other hard face combinations of SSSiC, RBSiC, and graphite loaded SSSiC, graphite loaded RBSiC, or tungsten carbide are widely used and are acceptable with purchaser approval.

NOTE See B.2.4 for guidance regarding the selection of optimum hard face-material combinations.

6.1.7.2.6 Seal and mating rings shall be of homogeneous material, except that inherently wear-resistant materials such as silicon carbide or tungsten carbide may be enhanced by applying a coating. Overlays or coatings shall not be used as the sole means of providing wear resistance.

NOTE Temperature limitations for seal-face materials are listed in B.2.

6.1.7.2.7 The seal manufacturer shall advise if the specified face material combination may not be suitable for performance testing of the pump on water. If so, the seal manufacturer shall recommend alternative materials for use during pump performance testing.

6.1.7.3 **Seal Sleeves**

Seal sleeves shall be stainless steel [Austenitic Stainless Steel Type 316, 316L, or 316Ti, or equivalent (see B.1)]. Sleeves for alloy pumps in corrosive services shall be of the same alloy as the casing, or one with superior corrosion resistance.

6.1.7.4 **Springs**

Seals with multiple coil-springs shall have Alloy C-276 or Alloy C4 spring material or springs with superior corrosion resistance for the specified application. Single coil-springs shall have Austenitic stainless steel Type 316 stainless steel spring material or one with superior corrosion resistance for the specified application.

NOTE Cross-section thickness of the spring is 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 Austenitic stainless steel Type 316 stainless steel may be just as suitable in the same service using a single spring.

6.1.7.5 **Secondary Seals**

6.1.7.5.1 The default O-ring material shall be FKM.

NOTE Temperature limitations, chemical and mechanical compatibility for elastomers are discussed in Annex B.

6.1.7.5.2 If operating temperatures or chemical compatibility preclude the use of FKMs, the purchaser and vendor shall agree on secondary seal material selections for the specified process conditions.

NOTE See Annex B for additional details.

6.1.7.5.3 Seal manufacturers shall use elastomer material type and grade selections based on successful prior use in the refining, chemical, or pipeline industry. Similar grades and types as used in qualification testing, with the same nominal durometer in the dynamic secondary seal location may be substituted without additional qualification testing as specified in Annex I.

6.1.7.5.4 If the temperature, chemical or mechanical limitations of elastomers have been exceeded, secondary seals shall be flexible graphite.

6.1.7.5.5 If used as a core component per Annex I, a mechanically energized polymeric secondary seal can be provided if agreed to by the vendor and purchaser.

6.1.7.6 **Metal Bellows**

Metal bellows shall be Alloy C-276 for Type B seals and Alloy 718 for Type C seals. If recommended by the seal vendor and agreed to by the purchaser, Alloy 718 may also be used for Type B seals.

NOTE This requirement only applies to the bellows core (the flexible diaphragms).

6.1.7.7 **Gland Plates**

6.1.7.7.1 Gland plates shall be stainless steel [Austenitic Stainless Steel Type 316, 316L, or 316Ti, or equivalent (see B.1)]. Gland plates for alloy pumps in corrosive services shall be of the same alloy as the casing, or one with superior corrosion resistance.

● 6.1.7.7.2 The gland plate to seal chamber gasket shall be an O-ring for services below 350 °F (175 °C) of the same material required by 6.1.7.5.1 and 6.1.7.5.2. For temperatures over 350 °F (175 °C) or if specified, graphite-filled type Austenitic Stainless Steel Type 304 or Austenitic Stainless Steel Type 316 stainless steel spiral-wound gaskets shall be used.

NOTE Spiral-wound gaskets have bolt torque requirements for full compression. See 6.1.3.7 for bolting requirements for spiral-wound gaskets.

6.1.7.7.3 Nameplates and rotation arrows (if attached) shall be of austenitic stainless steel or nickel-copper (UNS N04400) alloy. Stamp top of seal gland with rotation arrow for between bearing pumps that have unidirectional seals. Attachment pins shall be of the same material. Welding shall not be permitted.

6.1.7.8 **Bolt-on Seal Chambers**

6.1.7.8.1 Bolt-on seal chambers for alloy pumps shall be of the same alloy as the casing, or one with superior corrosion resistance and mechanical properties. Unless otherwise specified, seal chambers for other pumps shall be stainless steel [Austenitic Stainless Steel Type 316, 316L, or 316Ti, or equivalent (see B.1)].

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.

6.1.7.8.2 Chamber-to-casing gasket material requirements shall conform to 6.1.7.7.2.

6.1.7.9 **Miscellaneous Parts**

6.1.7.9.1 Spring-retaining components, drive pins, anti-rotation pins, and internal set screws shall have strength and corrosion resistance equal to or better than AISI Type 316 stainless steel (see B.1).

6.1.7.9.2 The pump and seal vendors shall ensure that outside drive components have suitable corrosion resistance for the service (see F.3). See also 6.1.4.12 and 6.1.4.13.

6.1.7.10 **Welding**

6.1.7.10.1 If required, welding shall comply with the Welding Section requirements of API 610.

6.1.7.10.2 Metal bellows used are exempted from welding requirements because they are manufactured using a proprietary welding process that is not covered by general welding codes or industry standards.

6.1.7.11 **Low Temperature Service**

6.1.7.11.1 For operating temperatures below –20 °F (–29 °C) or, if specified, for other low ambient temperatures, steels shall comply with the Low Temperature Service Section of API 610.

6.1.7.11.2 Refer to Annex B.3 Table B.4, which covers temperature limits for elastomers.

6.2 Design Requirements (Category-specific)

6.2.1 Seals for Category 1

6.2.1.1 General Information (Category 1)

This subsection provides design details for Category 1 seals, as described in Section 4. 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 6.1.3.15, a distributed seal flush system such as a circumferential or multiport arrangement shall be provided for Arrangement 1 and Arrangement 2 seals. The seal flush arrangement shall be located to maximize the uniformity and degree of cooling of the seal faces. For multiport systems, ports having a minimum diameter of 0.125 in. (3 mm) shall be used.

6.2.1.2.2 The seal flush passages shall be designed so that they can be cleaned (see Figure 21).

NOTE In many cases, effective seal operation is dependent on distributed flush systems that maximize heat removal from the seal faces to ensure effective film formation and prevent asymmetrical thermal distortions in sealing components. There are other methods for distributing the flush in addition to those illustrated in Figure 21. Depending on face orientation and space available on some seal designs a distributed flush system as shown in Figure 22 may not be required for Arrangement 2 seals because this may become unnecessarily complex and expensive. In these circumstances, consult the seal manufacturer for detailed information on the features and benefits of variations to the flush distribution systems to achieve even cooling around the circumference of the face components.

6.2.2 Seals for Category 2

6.2.2.1 General Information (Category 2)

This subsection provides design details for Category 2 seals, as described in Section 4. 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 A distributed flush system shall be provided for Category 2, Arrangement 1 and Arrangement 2 seals except when Piping Plan 13 or Piping Plan 23 are specified or when specified by the purchaser. The seal flush arrangement shall be located to maximize the uniformity and degree of cooling of the seal faces. For multiport systems, ports having a minimum diameter of 0125 in. (3 mm) shall be used.

6.2.2.2.2 The seal flush passages shall be designed so that they can be cleaned (see Figure 21).

NOTE See NOTE in 6.2.1.2.2.

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 If key drives are supplied, keys shall be positively secured to the shaft (see Figure 22).

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

6.2.3 **Seals for Category 3**

6.2.3.1 **General Information (Category 3)**

This subsection provides design details for Category 3 seals, as described in Section 4. 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 subsection.

6.2.3.2 **Seal Chamber and Gland Plate (Category 3)**

6.2.3.2.1 A distributed flush system shall be provided for Category 3, Arrangement 1 and Arrangement 2 seals except when Piping Plan 13 and Piping Plan 23 are specified. The seal piping arrangement shall be located to maximize the uniformity and degree of cooling of the seal faces. For multiport systems, ports having a minimum diameter of 0.125 in. (3 mm) shall be used.

6.2.3.2.2 The seal flush passages shall be designed so that they can be cleaned (see Figure 21).

NOTE See NOTE in 6.2.1.2.2.

6.2.4 **Seals for Category 4**

6.2.4.1 **General Information (Category 4)**

This subsection provides design details for Category 4 seals, as described in Section 4. Specific information provided here is in addition to and supercedes the common seal design features listed in 6.1.

6.2.4.2 **Seal Chamber and Gland Plate (Category 4)**

6.2.4.2.1 A distributed flush system shall be provided for Category 4, Arrangement 1 and Arrangement 2 except when Piping Plan 13 and Piping Plan 23 are specified. The seal flush arrangement shall be located to maximize the uniformity and degree of cooling of the seal faces. For multiport systems, ports having a minimum diameter of 0.125 in. (3 mm) shall be used.

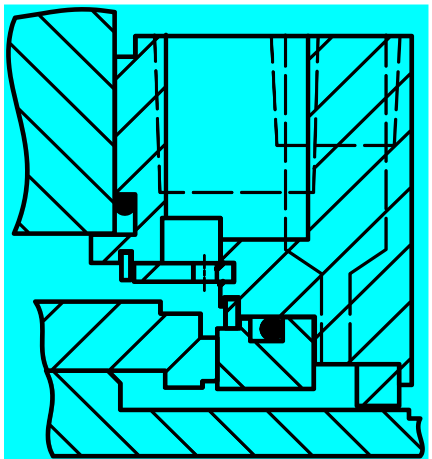
6.2.4.2.2 The seal flush passages shall be designed so that they can be cleaned (see Figure 21).

NOTE See NOTE in 6.2.1.2.2.

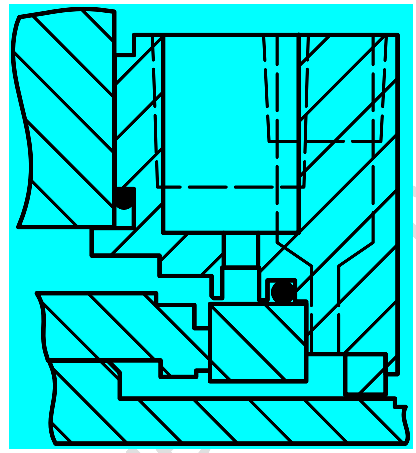
6.2.4.3 **Cartridge Seal Sleeves (Category 4)**

6.2.4.3.1 If key drives are supplied, keys shall be positively secured to the shaft (see Figure 22).

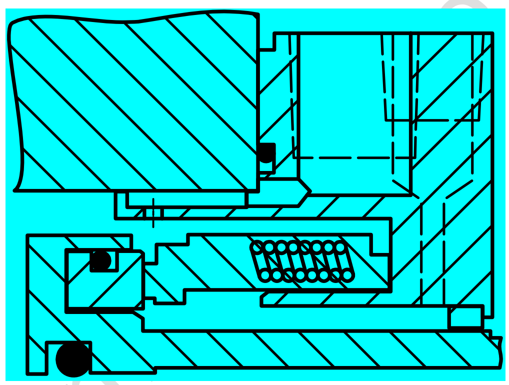
NOTE Keys located on the shaft deep in traditional stuffing boxes cannot be easily reached for seal assembly.



a) Rotating Flexible Element



b) Rotating Flexible Element



c) Stationary Flexible Element

These are only examples—other configurations may be used.

Figure 21—Distributed Flush Systems

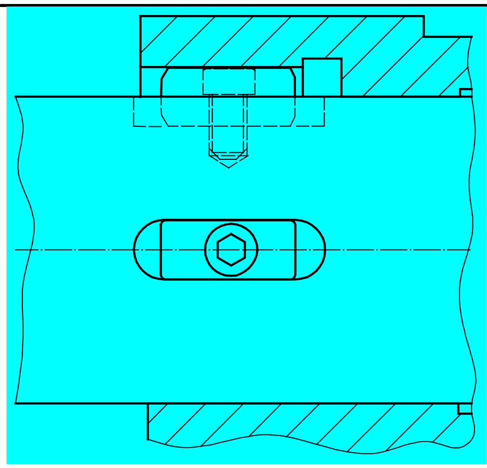


Figure 22—Attachment of Key Drives to Shaft

7 Specific Seal Configurations

7.1 Arrangement 1 Seals

7.1.1 Seal Sleeves

Seal sleeves shall be in one piece.

7.1.2 Seal Chamber and Gland Plate

7.1.2.1 Throttle bushings shall be per Table 5. The default bushing type shall be applied unless an optional bushing type is specified by the purchaser.

Table 5—Recommended Throttle Bushing Type

Seal Category	Fixed	Floating	Segmented
Category 1	Default	Optional	Optional
Category 2	Optional	Default	Optional
Category 3	Optional	Default	Optional
Category 4	Optional	Default	Optional

7.1.2.1.1 Throttle bushings shall be positively retained against pressure blowout to minimize leakage if the seal fails.

7.1.2.1.2 Bushing clearance shall be selected to allow for thermal growth.

NOTE Refer to B.4 and F.6.

Piping Plan 66A and 66B shall use floating carbon bushings.

NOTE When space permits floating segmented carbon bushings can achieve better performance.

● 7.1.2.2 If specified, or if required by the seal manufacturer, an external quench (see Figure G.24) shall be provided to the seal gland plate in accordance with the following:

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

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

c) if a steam quench is specified and if space allows, the seal gland plate shall be equipped with a quench baffle; and

d) the baffle shall be a spark resistant material designed with adequate clearance to prevent contact with adjacent moving components due to distortion or heating. (Reference Table 1)

NOTE 1 Quenching involves the introduction of a medium, usually water, nitrogen or steam, on the atmospheric side of a mechanical seal assembly. Quenching is normally applied if the material being sealed is noxious, flammable, oxidizes, polymerizes, or will crystallize when dry. Quenching can 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.

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 300 °F (150 °C)] services. It also keeps viscous product thin when the pump is not running. If stocks thicken at the faces, seals can be damaged at start-up. Condensation collecting at the seal faces can vaporize and damage the seal faces.

7.1.2.3 Type C, Arrangement 1 seals shall include a quench baffle. The quench baffle shall meet the requirements of 7.1.2.2 d).

7.1.2.4 Seal systems that utilize internal circulating devices, such as a pumping device, 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 when the pump shaft is not rotating.

7.1.2.5 The internal circulating device shall provide adequate flow that considers all operating and transient conditions. For example, this can include consideration for varying pump speeds, temperatures and fluid properties (refer to Annex F).

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

NOTE For conditions other than those encountered in the qualification test, calculated performance curves are based on modeling and/or additional tests as needed.

7.1.2.7 The minimum diametrical clearance between the rotating element of a circulation device and stationary component, seal chamber bore or containment chamber bore shall be in accordance with the values listed in Table 1.

NOTE For axial flow circulation devices, the minimum clearance could impact circulation device performance.

7.1.2.8 Designs of mechanical seals utilizing internal circulating devices shall ensure that the device inlet and outlet ports properly align with the seal flush supply and return connections when installed in the seal chamber.

7.2 Arrangement 2 Seals

7.2.1 General

7.2.1.1 The inner seal shall be a contacting wet seal (2CW-CW, see Figure 3, or 2CW-CS, see Figure 4a) with a face to back configuration. The inner seal shall have an internal (reverse) balance feature designed and constructed to withstand reverse pressure differentials up to 40 psi (0.275 MPa) (2.75 bar) without opening or dislodging components. Refer to Figure 10.

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 40 psi (0.275 MPa) (2.75 bar) even under upset conditions.

● 7.2.1.2 If specified, a noncontacting inner seal (2NC-CS, see Figure 4b) shall be provided.

NOTE Noncontacting 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 noncontacting 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 noncontacting design inner seal as a gas seal. The leakage rate from a noncontacting design is normally higher than a contacting wet design.

7.2.1.3 A contacting wet outer seal shall be used with liquid buffer systems.

7.2.1.4 A non-contacting containment seal shall be used for gas buffer systems.

● 7.2.1.5 If specified, a contacting containment seal face design may be provided for containment seals.

NOTE 1 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 buffer gas environment with dew points below −40 °F (−40 °C),

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

d) may experience higher leakage rates.

NOTE 2 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 10 psi (0.07 MPa) (0.7 bar). Refer to Annex F.

● 7.2.1.6 The buffer fluid type shall be specified on the datasheet.

NOTE If a buffer gas is not used, the containment seal chamber is typically filled with vaporized process fluid.

7.2.2 Buffer Seal Chamber and Gland Plates

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

NOTE 1 A throttle bushing is rarely required with a dual seal but may be used in cold services where a quench is used to avoid icing.

NOTE 2 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.

7.2.2.2 Seal systems that utilize internal circulating devices shall comply with the provisions of 7.1.2.4 through 7.1.2.8.

7.2.3 Contacting Wet Seals with a Liquid Buffer Fluid (2CW-CW)

7.2.3.1 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:

— 15 °F (8 °C) for glycol/water or buffer fluids with viscosity close to that of water and

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

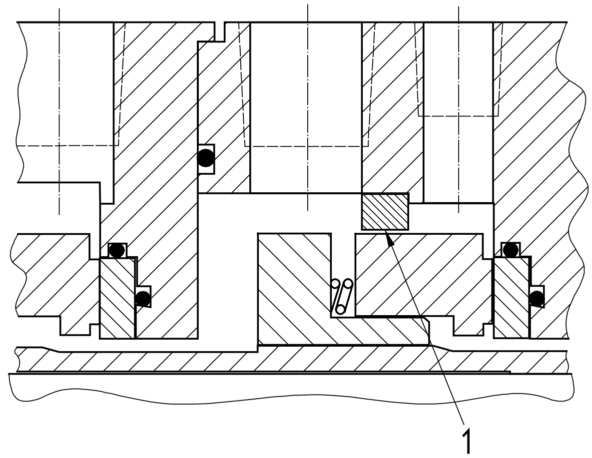
NOTE The allowable temperature differential includes the effects of both "heat soak" and seal-face-generated heat. The allowable temperature differential across the seal should not be confused with the bulk temperature rise of the buffer fluid during steady-state operation or with the differential temperature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

7.2.3.2 There are various ways to achieve enhanced flow in and out of the buffer seal chamber such as tangential ports, internal dams or cut-waters, radial and axial flow rings, and modified buffer seal chamber designs. The seal shall meet the temperature rise criteria, and the vendor qualification testing of Section 10. See 7.1.2.4 through 7.1.2.8 for requirements on internal circulating devices.

7.2.4 Buffer Seal Chamber and Gland Plates for Contacting Wet Inner Seal with a Dry-running Containment Seal (2CW-CS)

7.2.4.1 A fixed spark resistant bushing, or equivalent device approved by the purchaser, shall be installed to separate the containment-seal faces from the containment seal vent and drain connection ports. The bushing shall be positively retained to prevent axial movement and damage to seal components. The clearance for a fixed bushing shall be in accordance with Table 1 (see Figure 23).

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



Key

1 containment-seal chamber bushing

Figure 23—Section Showing Containment-Seal Chamber Bushing for 2CW-CS and 2NC-CS Configurations

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

7.2.5 **Seal Chamber and Gland Plates for Noncontacting Inner Seal with a Dry-running Containment Seal (2NC-CS)**

7.2.5.1 A fixed spark resistant bushing, or equivalent device approved by the purchaser, shall be installed to separate the containment-seal faces from the containment vent and drain connection ports. The bushing shall be positively retained to prevent axial movement and damage to seal components. The minimum diametral clearance between the bushing and rotating parts in the seal chamber shall in accordance with Table 1 (see Figure 4b).

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

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

7.3 Arrangement 3 Seals

7.3.1 General

● 7.3.1.1 The barrier fluid shall be agreed to by the seal vendor and purchaser. It can be a liquid or gas.

NOTE Refer to Annex F for guidance on setting barrier fluid pressures.

7.3.1.2 The inner seal shall be designed and constructed to operate in conditions per a – d. Refer to 6.1.1.9 and Figure 10.

a) In static operation, the seal shall be able to contain the rated seal chamber pressure if barrier fluid pressure is lost. (reverse pressure scenario)

b) In static operation, the seal shall be able to contain the rated barrier pressure if seal chamber pressure is atmospheric. (This is a seal qualification test point.)

c) In dynamic operation, the seal shall be capable of operation for a time period agreed between the purchaser and the vendor to allow orderly pump shutdown upon loss of gas or liquid barrier fluid pressure.

d) In continuous dynamic operation, the purchaser shall inform the seal vendor if the seal shall be required to operate continuously under abnormal conditions such as at rated barrier pressure with atmospheric pressure in the pump (gas or liquid barrier) or at rated seal chamber pressure if barrier pressure is lost for gas barrier seals. The purchaser shall advise the vendor of these abnormal conditions.

NOTE The internal or reverse balance feature requires that the mating ring and the secondary seal be designed to stay in place and contain pressure if either the barrier fluid or the process pressure is lost. Continuous, dynamic operation under these special conditions may have an impact on the selection of the seal design and configuration as well as the selection of the seal cooling system.

7.3.1.3 Standard Arrangement 3 configurations shall utilize two seal rings and two mating 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 Chamber and Gland Plates

● 7.3.2.1 If specified as a result of the process conditions and if additional length for the seal arrangement is available, a fixed throttle bushing made of carbon 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, for example, can 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.

● 7.3.2.2 If specified or recommended by the seal supplier and approved by the purchaser, 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.

7.3.3 Contacting Wet Seal Configurations with a Liquid Barrier Fluid (3CW-FB, 3CW-FF, 3CW-BB)

7.3.3.1 General

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

— 15 °F (8 °C) for glycol/water or barrier fluids with viscosity close to that of water and

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

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

7.3.3.1.2 Seal systems that utilize internal circulating devices shall comply with 7.1.2.4 through 7.1.2.8.

7.3.3.2 **Default Seal Types and Arrangements**

7.3.3.2.1 The default configuration shall have the inner and outer seals arranged in a face to back (3CW-FB) configuration (see Figure 5a).

● 7.3.3.2.2 If specified, a face-to-face (3CW-FF) or a back-to-back (3CW-BB) configuration shall be provided (Figure 5b and Figure 5c).

NOTE See Annex A for information to select the preferred seal configuration.

7.3.4 **Default Seal Types and Arrangements for Noncontacting Seal Configurations with a Gas Barrier Fluid (3NC-FB, 3NC-FF, 3NC-BB)**

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

● 7.3.4.2 If specified, a face-to-face (3NC-FF) or a face-to-back (3NC-FB) configuration shall be provided (Figure 6b and Figure 6c).

7.3.4.3 The purchaser should verify that any special pump casing vent needs are satisfied.

NOTE If the pump seal chamber and casing is a not a self-venting design, then gas from inner seal leakage may accumulate in the pump during long idle periods and may require the pump to be vented prior to operation.

8 Accessories

8.1 General

8.1.1 Sealing systems consist of a seal arrangement and external accessories to operate the seal arrangement according to specified piping plans. The selection of the piping plans depends on the application and is described in Annex A sheets 7 to 9.

8.1.2 The purchaser and the mechanical seal manufacturer shall mutually agree which piping plan or plans (refer to Annex G) shall be realized to meet the seal chamber pressure and temperature requirements of 6.1.3.15.

8.1.3 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.

8.1.4 For piping plans other than Plan 32, 72 or 74, the piping, components and appurtenances shall have a pressure-temperature rating at least equal to the MAWP and MAT of the pressure casing to which the system will be attached, but in no case shall they be designed for gauge pressures less than:

Category 1: 275 psi (20 bar) at 100F (38C);

Category 2 and Category 3: 600 psi (40 bar) at 100F (38C);

Category 4: 1440 psi (100 bar) @ 100F (38C)

8.1.4.1 Components or equipment fitted of a piping plan that are located in a dead-leg may have a lower MAT

NOTE Accumulators or other components may be installed in a dead-leg of the system. The dead-leg will never be exposed to high temperatures due to lack of circulation.

8.1.4.2 For Piping Plans 32, 72 or 74 supplied as assembled panels or modules, the maximum allowable working pressure and temperature for the regions shown in Figures G.14, G.30 and G.31 respectively shall be specified by the purchaser.

8.1.4.3 The check valve pressure and temperature rating at the Piping Plan 32, 72 or 74 panel outlet shall comply with 8.1.4.

NOTE 1 Piping plans 32, 72 and 74 supply external fluids at a pressure often much lower than the MAWP of the pressure casing and are not exposed to the MAT of the casing. See also NOTE to 9.1.7.

NOTE 2 Refer to Annex G for API Flush Plan specific details.

NOTE 3 For high-discharge pressure pumps, where the seal chamber pressure can get higher than the static or dynamic sealing pressure rating of the seal, purchasers could consider the installation of a pressure relief valve in the suction piping of the pump, downstream of the suction block valve, instead of building the seal auxiliary system to the MAWP of the pump casing. The relief valve can be arranged to exit on the upstream side of the suction block valve. For further information about relief valves refer to 9.8.

8.1.5 A pressurized piping plan system shall be designed to not exceed the dynamic pressure rating of the seal, the MAWP of the pump pressure casing and the MAWP of the seal auxiliary system.

NOTE For Piping Plan 53A and Piping Plan 53B the liquid barrier fluid can be pressurized by an external gas system. If necessary, to reduce the pressure differences within the seal, the same can be done for Piping Plan 52. The pressurization system for Piping Plan 54 can be part of the seal auxiliary system or also be external. The seal auxiliary systems for the Piping Plan 72 and Piping Plan 74 are connected to external gas systems that provide pressurized gas.

● 8.1.6 Accessories (including reservoirs) are part of the pump piping system. Accessories shall be designed, fabricated, and inspected in accordance with ASME B31.3, or if specified ISO 15649, using piping components unless otherwise specified. It is the user's responsibility to ensure that local codes do not require that accessories be built in accordance with a pressure vessel code such as EN 13445 or ASME VIII, Division 1.

8.1.7 Filling/refilling systems for liquid buffer and barrier fluids can also be attached to some closed seal auxiliary systems. These filling/refilling systems shall not be operated to exceed the dynamic pressure rating of the seal and the MAWP of the seal auxiliary system.

NOTE Filling/refilling systems for buffer and barrier systems are normally used for the Piping Plans 52, 53A, 53B, and 53C. Users often consider the effect of filling on the system pressure. While the standard does not allow the pressure to exceed the seal or system MAWP, the pressure will rise when closed systems are refilled and may exceed the pressure of the gas supply system. See Annex F for examples.

8.1.8 Components for piping plans shall comply with the requirements in Table 5, Table 6, and Table 7. For further information about suitable metals, refer to Table B.1.

NOTE When using specialized alloys for the flush piping and barrier/buffer systems, purchasers can consider whether these materials are required for services such as Piping Plans 32, 53, 54, 72, and 74 as the components do not normally see the process fluid.

8.1.9 Local operation, venting, filling, and draining should not require the use of a portable ladder or climbing on piping or equipment.

NOTE Some users request connections to be extended to the edge of the baseplate.

8.1.10 Closed systems (Piping Plan 52, 53, 23, etc.) shall be designed with adequate fill and vent connections to allow initial and top up filling without trapping air or other vapor in the system.

8.1.11 All seal auxiliary systems shall be self-venting or shall incorporate vents to remove vapor.

8.1.12 Systems shall have drains to allow safe removal of liquids.

8.1.13 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 buildup of a static liquid head in the vent piping and the possible contamination of the barrier/buffer fluid.

8.1.14 The method of filling the seal auxiliary system shall be considered during the engineering phase of a project. The closed-fill system shall enable the operator to fill the reservoir without exposure to the barrier/buffer fluid.

NOTE 1 Some systems will require adding fluids while the system is pressurized to prevent a pressure reversal in barrier fluid applications.

NOTE 2 Some examples of acceptable refill systems include:

— a centrally located tank that is permanently connected by piping to various reservoirs and/or day tanks utilizing a transfer pump or inert gas pressure to transfer the barrier/buffer fluid;

— a hand pump that can be connected to a day tank or drum with a hose or removable spool piece;

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

8.2 Piping for Seal Auxiliary Systems

8.2.1 Seal auxiliary systems are part of the seal piping system and shall comply with the requirements of Table 5, Table 6, and Table 7.

8.2.2 Seal auxiliary systems shall include all components as defined by figures and tables in Annex G.

8.2.3 The supplier specified on the datasheet shall furnish all seal auxiliary piping systems, including mounted components that are located within the confines of the associated pump's baseplate, any barrier/buffer fluid reservoir baseplate area or any auxiliary baseplate area.

8.2.3.1 If piping is furnished, it shall terminate with flanged connections at the edge of the baseplate.

8.2.3.2 The purchaser shall furnish interconnecting piping or tubing between sealed equipment and auxiliaries that are mounted separate from the baseplate.

8.2.4 The length of piping or tubing and the use of fittings between equipment and auxiliaries should be minimized. In lieu of fittings, it's preferable to use long radius bends (3R or greater).

8.2.5 Piping or tubing shall have a slope of not less than 1:24 (0.5 in/ft or 40 mm/m), using long radius bends.

8.2.6 For systems using an internal circulation device, the total length of connecting piping or tubing between the mechanical seal and the seal auxiliary system should not exceed 16.4ft (5m) in length. Systems greater than 16.4ft (5m) shall have an engineering review to ensure acceptable flow rate. For piping diameters, refer to 8.2.9 and for further general information to Annex F.

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

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

b) flexibility and accessibility for operation, maintenance and cleaning;

c) installation in an arrangement adapted to the contour of the machine without obstructing access to pump coupling from at least one side or other access openings required for maintenance;

d) elimination of air pockets by the use of vents with valves or properly sloped 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;

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

8.2.8 Seamless pipe or tubing shall be furnished in accordance with Table 5, Table 6, and Table 7 for all auxiliary systems.

8.2.9 Piping and tubing used for Piping Plan 23, Plan 52 and Plan 53A/B/C shall be in accordance with 8.1.8, Table 5, and the following:

— 0.5 in. (12 mm) minimum, for shaft diameter 2.5 in. (60 mm) and smaller;

— 0.75 in. (20 mm) minimum, for shaft diameter greater than 2.5 in. (60 mm) or if flow rate exceeds 2 U.S. gal/min (8 L/min) or if the total length of connection pipework between seal and auxiliary system exceeds 16.4 ft (5 m) in length.

NOTE Refer to Annex F.

Table 5—Minimum Requirements for Auxiliary Pipe Components and Assemblies

Component	Fluids and Piping Plans						
	Process-Flush-Buffer-Barrier			Quench		Cooling Water	
	inner seal	between seals	leakage recovery	to/from atmospheric seal area		to/from heat exchanger/cooling coil	
	11,12,13, 14,21,22, 23, 31,32,41	52,53A, 53B,53C ,54,55,72,74	65,66A, 66B,75,76	62		21,22,23,41,52, 53A,53B,53C,54,55	
	Fluid Characteristics			Gauge Pressure		Nominal Size	
	nonflammable, nonhazardous	flammable, hazardous		≤0.5 MPa (5 bar) (75 psi)	>0.5 MPa (5 bar) (75 psi)	Standard ≤DN 25 (NPS 1)	Optional ≥DN 40 (NPS 1 1/2)
Pipe [a]	seamless			seamless		Carbon steel (ASTM A120 Schedule 40 painted to purchaser specifications)	stainless steel (ASTM A269 seamless Type 316)
Tubing	Seamless ASTM A269 Type 316/L; or ASTM A213 Type 316Ti			Seamless ASTM A269 Type 316/L; or ASTM A213 Type 316Ti		Seamless ASTM A269 Type 316/L; or ASTM A213 Type 316Ti	
All Valves	Class 800			Class 800		Class 200 bronze	
Gate and Globe Valve	bolted bonnet and gland			bolted bonnet and gland			
Pipe Fittings	forged Class 3000			forged Class 3000		malleable iron (ASTM A338 and A197Class 150) galvanized to ASTM A153	
Strainer and Filter Housings	Type 304/L or Type 316/L Stainless Steel						

Tube Compression Fittings	manufacturer's standard		manufacturer's standard		manufacturer's standard	
Fabricated Joints ≤DN 25 (NPS 1)	threaded	socket-welded	threaded	socket-welded	threaded	socket-welded
Fabricated Joints ≥DN 40 (NPS 1 1/2)						Purchaser to specify
Flange Gaskets		Type 304 or 316 stainless steel spiral wound		Type 304 or 316 stainless steel spiral wound		
Flange Bolting		Low alloy steel (ASTM A193 Grade B7 ASTM A194 Grade 2H)		Low alloy steel (ASTM A193 Grade B7 ASTM A194 Grade 2H)		
Plugs	metallic solid round or solid hexagonal head plugs in accordance with the dimensional requirements of ASME B16.					

The ASTM standards listed are examples of acceptable materials for each type. Alternate materials may be used if approved by the purchaser (Annex B may be used for guidance). Examples of acceptable materials are:

— carbon steel pipe: ASTM A53 Grade B, ASTM A106 Grade B, ASTM A524 or API Spec 5L Grade A or B;
— carbon steel fittings, valves and flanged components: ASTM A105 and ATMS A181;
— stainless steel piping ASTM A312 Type 316L;
— stainless steel fittings, valves and flanged components: ASTM A403 Type 316L.

[a] The design requirements for seal coolers and cooling coils are specified in 8.3.2 and 8.3.6.2.13.

Table 6—Minimum Pipe Wall Thickness

Materials	Nominal Pipe Size Minimum		
	DN	**NPS**	**Schedule**
Carbon steel	DN 15 to DN 40	1/2 to 1 1/2	80
	DN 50 to DN 200	2 to 8	40
	>DN 200	>8	20
Stainless steel	DN 15 to DN 25	1/2 to 1	80S
	DN 40 to DN 75	1 1/2 to 3	40S
	DN 100	4	10S

Note: Schedule 40 piping and flanges are permissible for cooling water piping.

Table 7—Minimum Tubing Wall Thickness

Nominal Tubing Size (mm)	Minimum Wall Thickness (mm)	Nominal Tubing Size (in)	Minimum Wall Thickness (in)
12	1.5	1/2	0.065
20	2.0	3/4	0.095
25	2.6	1	0.109

[a] The tubing size is the outside diameter.

● 8.2.10 If specified, Schedule 80S, austenitic stainless steel piping in accordance with Table 5 and the following shall be provided:

— 0.5 in. (12 mm) minimum, for shaft diameter 2.5 in. (60 mm) and smaller;

— 0.75 in. (20 mm) minimum, for shaft diameter greater than 2.5 in. (60 mm) or if flush flow rate exceeds 2 U.S. gal/min (8 L/min) or if the total length of connection pipework between seal and auxiliary system exceeds 16.4 ft (5 m) in length.

8.2.11 Piping design and joint fabrication, examination and inspection shall comply with ASME B31.3, or other international standard as approved by the purchaser. Welding shall be performed by operators and procedures qualified in accordance with the appropriate part of EN 287 and EN 288, or ASME IX.

8.2.12 Piping systems shall be fabricated by bending and welding to minimize the use of flanges and fittings where practical.

8.2.12.1 Welded flanges are permitted only at equipment connections, at the edge of any base, and for ease of maintenance.

8.2.12.2 The use of flanges at other points is permitted only with the purchaser's approval.

8.2.12.3 Other than tees and reducers, welded fittings are permitted only to facilitate pipe layout in congested areas.

8.2.12.4 The number of threaded connections shall be minimized.

8.2.12.5 Pipe bushings shall only be used with approval by purchaser.

8.2.12.6 Pipe unions shall not be used.

8.2.13 Tubing shall be fabricated by bending and the use of compression fittings.

NOTE Combining different components of compression fittings from differing manufacturers could cause a fitting to leak.

8.2.13.1 Piping or tubing shall not be welded if the wall thickness is less than 0.1 in. (2.5 mm). This includes fixation of external fins or other surface area extension devices on the OD of the pipe or tube.

8.2.13.2 Connections that are internal to auxiliary devices are not permitted including coolers and seal reservoirs. This includes but is not limited to welding, brazing, and compression fittings.

NOTE Leaky internal connections are difficult to discover and can cause contamination, vaporization and excessive pressurization of the cooling water.

8.2.13.3 Connection methods for fins on pipe or tube shall be suitable for the maximum specified operating temperature of the pump.

8.2.13.4 Fabricated joints for Piping Plan 72 and Piping Plan 74 auxiliary systems shall be butt welded instead of socket welded.

NOTE Socket welding creates a cavity for debris accumulation that can subsequently damage a gas seal.

● 8.2.14 Pipe shall have tapered threads in accordance with ASME B1.20.1 or ISO 7.

8.2.14.1 Flanges shall be in accordance with ASME B16.5.

NOTE For the purpose of these provisions, ISO 7005-1 is equivalent to ASME B16.5.

8.2.14.2 Slip-on flanges may be used only with the purchaser's approval.

8.2.14.3 For socket-welded construction a 0.063 in. (1.5 mm) gap shall be left between the pipe end and the bottom of the socket.

8.2.15 The following nominal sizes of connections, piping, valves and fittings shall not be used: NPS 1.25 (DN 30), NPS 2.5 (DN 65), NPS 3.5 (DN 90), NPS 5 (DN 125), NPS 7 (DN 175), or NPS 9 (DN 225), excluding piping used to manufacture reservoirs and seal coolers.

● 8.2.16 The purchaser shall specify hazardous and/or flammable services to determine if special requirements are necessary for piping, flanges, gaskets and o-rings, valves and other appurtenances.

● 8.2.17 The purchaser shall specify if chlorides are present in a concentration above 10 mg/kg (parts per million by weight). Caution should then be used in applying stainless steel because of the potential for chloride stress-corrosion cracking.

8.2.18 The minimum nominal size of any connection—other than the gland plate and piping to the gland plate shall be NPS 0.5 (DN 15). Gland plate connections shall be in accordance with 6.1.3.18 and 6.1.3.19.

8.2.19 The sizing of the internal tubing and connections in an auxiliary system for Piping Plan 72 and Piping Plan 74 shall be according to the vendor standards.

8.2.20 Flanged or tapped openings not designed to be connected to piping or tubing shall be blanked or plugged with fittings rated for the specified pressure rating per the design drawings.

8.2.20.1 Solid hexagonal head or solid round plugs shall be furnished in accordance with the dimensional requirements of ASME B16.11.

8.2.20.2 All plugs shall be of the same material as the gland plate.

8.2.20.3 A sealant with lubricant properties shall be used on the threads to ensure the threads are vapor tightper ASME B1.20.1.

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

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

8.3 Components of Seal Auxiliary Systems (if Specified in Annex G)

8.3.1 General

If a piping plan in Annex G includes a component described in this section, that component shall meet the requirements of this section. Not all piping plans will have all of the components described in this section.

8.3.2 Coolers

8.3.2.1 General

8.3.2.1.1 If furnished, external-seal flush coolers shall be in accordance with 8.3.2.1.2 to 8.3.2.1.12. Requirements for coolers mounted within or integral to barrier/buffer fluid reservoirs are given in 8.3.6.2.13.

NOTE 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 6.1.3.15).

● 8.3.2.1.2 Seal flush coolers shall be designed, fabricated, and inspected in accordance with ASME B31.3, ISO 15659, ASME VIII, or EN 13445 as specified or agreed.

8.3.2.1.3 A separate external seal flush cooler shall be provided for each mechanical seal.

8.3.2.1.4 An austenitic stainless steel tag shall be securely fastened to all coolers. In letters a minimum of 6 mm (0.25 in.) high, this tag shall read: “IMPORTANT: ALL TRAPPED GAS SHALL BE VENTED FROM THIS SYSTEM PRIOR TO OPERATION TO PREVENT DAMAGE TO THE MECHANICAL SEAL.”

8.3.2.1.5 For separate coolers mounted in Piping Plan 23 flush loops and for external coolers in buffer/barrier systems see Figure G.37 and Figure G.38 for recommendations.

NOTE When the pump shaft is stationary and in a standby mode, localized cooling to improve the seal life can be achieved within the auxiliary system by use of a thermosyphon principle. This mechanism requires a minimum difference in height between the heat exchanger and the seal.

● 8.3.2.1.6 If Piping Plan 23 is specified, a positive circulating device shall be provided. The circulation device shall be in accordance with 7.1.2.4 to 7.1.2.8. The purchaser shall specify if an external circulating pump or a flow-through system from an external source is required.

8.3.2.1.7 The tube material and wall thickness shall be per 8.1.8, Table 5 and Table 7. No tubing connectors, fittings, or seams mounted internal to the cooler are allowed.

8.3.2.1.8 Seal flush coolers shall be sized for the seal manufacturer's recommended seal flush flow rates but shall not be sized for less than 2 U.S. gal/min (8 L/min) per seal.

8.3.2.1.9 The criteria for thermal sizing of the cooler and internal cooling coils of reservoirs shall be provided by the seal manufacturer. The seal manufacturer shall confirm that the selected cooler will meet the expected thermal duty requirements at the site utility conditions specified on the datasheets.

NOTE The performance of air coolers is impacted by environmental conditions (e.g. ambient temperature, solar radiation, confined spaces, hot adjacent equipment, etc.)

8.3.2.1.10 For buffer/barrier systems the performance of the internal or external pumping device, combined with the total resistance of the flow circuit shall provide sufficient flow rate to achieve the limits defined in 7.2.3.1 and 7.3.3.1 (see also Annex F).

8.3.2.1.11 At low ambient temperature or high wind chill locations the selection of water coolers and air coolers should be reviewed because of possible freezing inside the cooler or connection piping.

8.3.2.1.12 The user shall design the cooling water system to avoid shell over-pressurization resulting from blocking-in of the water side 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.

8.3.2.1.13 The cooling-water system shall be designed for the conditions specified in Table 8.

8.3.2.2 **Water Coolers**

8.3.2.2.1 Water coolers shall be arranged with the seal flush fluid on the tube side and the cooling water on the shell side.

● 8.3.2.2.2 If specified, water coolers shall be arranged with the seal flush fluid on the shell side and cooling water on the tube side. When this option is specified the purchaser shall provide material selections.

8.3.2.2.3 Water Coolers shall have 316/L or equivalent tubes and a carbon steel shell. Cast Iron shall not be used.

● 8.3.2.2.4 If specified, other material selections shall be per 8.1.8 and 8.2.16.

8.3.2.2.5 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.

Table 8—Conditions Affecting Cooling Water System Design

Condition	Value
Velocity over heat exchange surfaces	5 ft/s to 8 ft/s (1.5 m/s to 2.5 m/s)
Maximum allowable working pressure, gauge	100 psi (0.7 MPa) (7 bar)
Test pressure, gauge	See 10.3.3

Maximum pressure drop	15 psi (0.1 MPa) (1 bar)
Maximum inlet temperature	90 °F (32 °C)
Maximum outlet temperature	120 °F (49 °C)
Fouling factor on water side	0.002 hr-ft^2-°F/Btu (0.35 m^2·K/kW)
Shell corrosion allowance [a]	0.125 in. (3 mm)

[a] Not applicable for piping and other, non-shell components

8.3.2.2.6 Welding of tubes or fillet welds at tube sheets with a tube wall thickness less than 0.1 in. (2.5 mm) is not allowed inside the cooler.

8.3.2.3 **Air Coolers**

8.3.2.3.1 The air cooler shall be constructed with finned tubing components in accordance with Table 5 and Table 7.

● 8.3.2.3.2 If specified, the air cooler shall be constructed using finned austenitic stainless steel piping components in accordance with Table 5 and Table 6.

8.3.2.3.3 The default cooler shall be a natural draft air cooler.

● 8.3.2.3.4 If specified, forced draft air coolers are acceptable.

● 8.3.2.3.5 If specified, the purchaser may consider the inclusion of a high-temperature alarm to warn of loss or limited air flow rate.

8.3.2.3.6 If finned tubing or piping is used the fins shall be aluminum or stainless steel.

8.3.2.3.7 Welded connections shall be according to 8.2.12.

8.3.2.3.8 The air cooler design shall be arranged for complete draining and venting.

8.3.2.3.9 The design of the air cooler shall include a fouling factor 0.0006 hr-ft^2-°F/Btu to 0.0023 hr-ft^2-°F/Btu (0.1 m^{2}K/kW to 0.4 m^{2}K/kW) on the air side.

8.3.3 **Strainers and Filters**

8.3.3.1 **General**

8.3.3.1.1 Housing and elements shall be made of stainless steel per Table 5.

8.3.3.1.2 Requirements in this section refer to wet seal piping plans.

NOTE See section 8.3.10.4 for gas seal system requirements.

8.3.3.1.3 A drain shall be provided at the bottom of the housing to allow for particulate isolation and removal.

8.3.3.2 **Strainers**

NOTE Strainers are used in Piping Plan 12, Piping Plan 22, and Piping Plan 32 to remove large particles from normally clean fluids.

8.3.3.2.1 Strainers shall have a size no finer than 120 mesh (125 μm). (See Figure G.7, G.11 and G.14.)

8.3.3.3 **Filters**

NOTE Filters are used in Piping Plan 15, 25, 35, 54 and 55 systems to condition product, barrier or buffer fluids. They remove particulates that may be harmful to mechanical seal internal components.

8.3.3.3.1 The default filter element shall be designed to remove particles 10 micron and larger.

NOTE Seals in volatile services can use special patterns, recesses, and grooves for enhanced face lubrication, having tighter requirements for particulate removal.

8.3.3.3.2 Filters shall have provisions for on-line filter element monitoring and change out.

NOTE Provisions can include equalization lines, cross-over valves, isolation valves, and other appurtenances (See Figures in Annex G).

8.3.4 **Cyclone Separator**

8.3.4.1 Cyclone separators shall not be used unless the solids have a density of at least twice the density of the flushing fluid.

NOTE Common materials frequently found in refinery process streams and their approximate densities are listed in Table 9.

8.3.4.2 Cyclone separators shall not be used with a pressure differential less than 25 psi (1.7 bar).

8.3.4.3 Cyclone separators shall be selected to maximize the removal of solids for a specific pump stage differential.

8.3.4.4 The default for Piping Plan 31 and 41 shall be designed so that the cyclone separator is the flow-limiting device.

8.3.4.4.1 If the pressure differential exceeds the cyclone separator design differential or if required to balance flows, flow orifices can be used.

8.3.4.4.2 The orifice shall minimum diameter greater than the separator inlet hole.

NOTE 1 See Figure G.13 and Figure G.15 in Annex G.

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 particle size decreases, separation efficiency also decreases.

8.3.4.5 A separate cyclone separator shall be provided for each mechanical seal.

8.3.4.6 Unless required by 8.1.8, cyclone separators shall be austenitic stainless steel type 316/L, or 316Ti per Annex B.

8.3.5 Flow Control Orifice

8.3.5.1 The number and location of flow control orifices needed shall be determined by the vendor specified to furnish the auxiliary piping system. An orifice may be required in the seal flush system solely or in conjunction with a throat bushing to:

— limit the seal flush circulation rate to the seal;

— control the seal chamber pressure.

NOTE Frequently, buffer fluid reservoirs for Piping Plan 52 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.

8.3.5.2 The pump vendor and the seal auxiliary system vendor shall clarify which orifices belong to their scope of supply.

Table 9—Approximate Densities of Materials Found in Process Streams

Substance Material	Density	
	kg/m³	lb/ft³
Cement, sand, stone	2307	144
Clay	1762	110
Coke	513	32
Earth (mud)	1538	96
Gasoline (relative density 0.7)	721	45
Glass	2595	162
Kerosene	801	50
Limestone	2355	147
Paraffin	897	569
Sand	2018	126
Steel	7801	487
Sulfur	2002	125
Tar	1201	75
Water	993	62
Wood (pine)	432	27

● 8.3.5.3 When piping is supplied a plate orifice or orifices shall be furnished and mounted in the auxiliary piping between a pair of flanges. If tubing is specified, the same design shall be used with the flanges connected by tubing fittings to the tube.

● 8.3.5.3.1 If specified, a bar-stock orifice (also called an orifice fitting or orifice nipple) shall be supplied.

8.3.5.3.2 Pipe unions with an orifice shall not be used. See Figure 24.

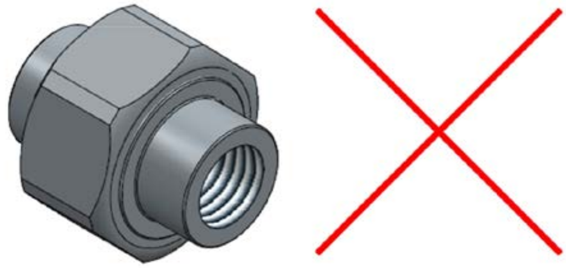


Figure 24—Example Illustration of Pipe Unions with an Orifice

8.3.5.3.3 To prevent leakage, orifice fittings relying on a threaded connection shall not be used unless approved by the owner.

8.3.5.3.4 Orifices in liquid or fouling fluids shall have a minimum bore of 0.125 in. (3 mm).

NOTE Orifice bores smaller than 0.125 in. (3 mm) become blocked more easily and can cause a seal failure.

8.3.5.3.5 Orifices shall have a visible tang that extends beyond the outside diameter of the flange and be stamped with the bore diameter, line size, and material.

8.3.5.3.6 When bar stock orifices or orifice fittings are specified, they shall be stamped with the bore diameter, line size and material. If insulated, there shall be a visible tag with this information.

8.3.5.4 Multiple orifices, installed in series, may be used if more pressure drop is required than can be accomplished with a single 0.125 in. (3 mm) orifice.

● 8.3.5.5 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.

8.3.5.6 The material for flow control orifices shall be in accordance with 8.1.8.

8.3.5.7 For Piping Plan 66B, the drain connection of the gland plate shall be plugged with a socket or hex-head plug of austenitic stainless steel type 316 with a drilled hole.

8.3.5.7.1 For clean fluids with a viscosity less or equal to 5 cSt (5 mm^2/s), the hole shall have a diameter of 0.0625 in.(1.5 mm).

8.3.5.7.2 For fluids with a viscosity above 5 cSt (5 mm^2/s) or that contain solids that may cause plugging, the hole shall have a diameter of 0.125 in. (3 mm).

8.3.5.8 The effects of auto refrigeration of leakage across an orifice in a vent system shall be reviewed to determine if the design temperature of the components is acceptable for low temperature service.

8.3.6 Barrier/Buffer Fluid Reservoirs and Accumulators

8.3.6.1 General

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

8.3.6.1.2 A separate reservoir or accumulator shall be furnished for each mechanical seal.

8.3.6.1.3 The barrier/buffer fluid reservoir or accumulator shall be mounted on a rigid support and should not be affected by pump vibration.

8.3.6.1.4 Reservoirs and accumulators should be located leaving room for operation and maintenance. They should not be located directly above the pump. Typical configuration details for barrier/buffer fluid reservoirs can be found in Figure G.38.

8.3.6.1.5 The thermal effects of solar radiation or other ambient conditions on reservoirs and bladder accumulators shall be mitigated. (see Annex F).

8.3.6.1.6 The connections on reservoirs and accumulators shall be per Table 10.

Table 10—Default Connection Types for Reservoirs and Accumulators

	Reservoir	**Accumulator**
Category 1	Threaded	Threaded
Category 2, 3 & 4	Flanged	Threaded

● 8.3.6.1.7 If specified by the purchaser, other connections may be provided for reservoirs and accumulators.

8.3.6.1.8 Piping Plan 53 accumulator and reservoir designs shall achieve a refill frequency of greater than twenty-eight days (28 d). The refill frequency shall be calculated by the vendor using 2 times the actual qualification test leakage rate adjusted linearly for the job seal size and barrier pressure versus the qualification test barrier pressure. The vendor and purchaser shall mutually agree to a solution for systems that do not meet the twenty-eight day (28 d) minimum refill frequency requirement.

● 8.3.6.1.9 If Piping Plans 52, 53A, 53B, or 53C are specified, a positive-circulating device shall be provided.

8.3.6.1.9.1 The circulation device shall be in accordance with 7.1.2.4 to 7.1.2.8.

8.3.6.1.9.2 The purchaser shall specify if an external circulating pump or a flow-through system from an external source is required.

8.3.6.1.9.3 Systems that rely only on a thermosyphon to maintain circulation during normal operation shall not be used.

● 8.3.6.1.10 The purchaser shall specify on the datasheets the characteristics of the barrier/buffer fluid (see Annex A, Sheet 10 of the recommended selection procedure).

8.3.6.1.11 The seal manufacturer shall use the purchaser's selection of barrier/buffer fluid properties for all design calculations. If properties are not acceptable for the application, the manufacturer shall discuss alternative options with the purchaser.

8.3.6.1.12 The minimum barrier pressure shall ensure a pressure of 20 psi (0.14 MPa) (1.4 bar) above the maximum seal chamber pressure.

8.3.6.1.13 Auxiliaries, including reservoirs and accumulators, shall be designed for outdoor installation and site environmental conditions specified by the purchaser. The purchaser and equipment vendors shall agree to supplied equipment protection for the jobsite location. (i.e., winterization for low ambient temperatures, sun shields for radiant heat, heat tracing, insulation, etc.).

NOTE 1 See API Project Design Datasheet Figure N.4 in API 610 as an example for specifying site environmental conditions.

NOTE 2 Annex F contains application guidance on the need for protection features and methods for evaluating their effects on sealing system performance.

8.3.6.2 **Barrier/Buffer Fluid Reservoirs**

8.3.6.2.1 The barrier/buffer fluid reservoir shall be constructed as shown in Annex G (Figure G.35 and Figure G.36).

8.3.6.2.2 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.

8.3.6.2.2.1 The height shall be greater than 3 ft (1 m).

8.3.6.2.2.2 The height 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.

8.3.6.2.3 The reservoir for 52 and 53A shall be equipped with an indicating pressure transmitter PIT sensing the vapor space above the high liquid level (HLL) in the reservoir.

● 8.3.6.2.4 The reservoir shall be equipped with a level transmitter and low-level alarm (LLA). When specified, a high-level alarm (HLA) shall be provided.

8.3.6.2.5 The reservoir shall be designed to meet the sizing criteria as follows (see Figure G.35 and Figure G.36).

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

   1) 3 U.S. gal (12 L) for shaft diameters 2.5 in. (60 mm) and smaller,

   2) 5 U.S. gal (20 L) for shaft diameters larger than 2.5 in. (60 mm).

b) Sizing reservoirs larger than clause 8.3.6.2.5.a shall be based on maintenance intervals and cooling requirements.

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

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

d) 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 LLA point.

NOTE The requirements in Items c) and d) allow for fluctuations in liquid level while ensuring adequate vapor space above the liquid.

e) The HLA, if furnished, shall be at least 2 in. (50 mm) above the NLL.

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

f) The LLA shall be at least 2 in. (50 mm) above the top of the return connection.

NOTE The distance specified in Item f) allows the level to fluctuate but still cover the return nozzle.

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

h) The barrier/buffer supply (outlet) from the reservoir shall be at least 2 in. (50 mm) 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. An internal stand-pipe may be installed in the reservoir.

NOTE Having the supply line exit the reservoir above the bottom prevents any particulate that may have settled out in the reservoir from being carried into the mechanical seal.

i) The type and size of the reservoir connections shall be in accordance with Table 5 and 8.2.9 or 8.2.10.

8.3.6.2.6 The barrier/buffer fluid reservoir shall be fabricated in accordance with 8.3.6.2.7 to 8.3.6.2.12.

● 8.3.6.2.7 The standard reservoir shall be in accordance with Figure G.35. If specified, the reservoir shall be in accordance with Figure G.36.

8.3.6.2.8 The reservoir is part of the pump piping system. The reservoir shall be designed, fabricated and inspected in accordance with ASME B31.3, or if specified ISO 15649 using piping components. However, local regulations or certifications may require the reservoir to comply with a pressure vessel code like ASME VIII or EN 13445. This shall be clearly called out on the drawing and the datasheet. It is the user's responsibility to make sure local regulations are met and indicated on the datasheet.

8.3.6.2.9 As a minimum, reservoirs shall be fabricated as follows:

— 3 U.S. gal (12 L) reservoirs shall be fabricated from NPS 6 (DN 150) Schedule 40 pipe;

— 5 U.S. gal (20 L) reservoirs shall be fabricated from NPS 8 (DN 200) Schedule 40 pipe.

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

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

8.3.6.2.12 The barrier/buffer fluid reservoir and any piping or components welded directly to the reservoir shall be austenitic stainless steel type 316L.

8.3.6.2.13 The barrier/buffer fluid reservoir shall be equipped with a cooling coil as follows.

a) The design of the cooling coil shall comply with 8.3.2.1.7, 8.3.2.1.9, 8.3.2.1.10, and 8.3.2.1.13.

b) 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.

c) Reservoirs equipped with cooling coils that will not be used in the field installation shall have the cooling water inlet and outlet connection plugged with metal plugs.

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

8.3.6.3 **Bladder Accumulator**

● 8.3.6.3.1 The bladder accumulator shall be designed, fabricated, and inspected in accordance with a pressure vessel code such as ASME VIII, EN 13455, or equivalent.

NOTE Bladder accumulators do not typically comply with piping codes such as ASME B31.3 due to their fabrication method.

8.3.6.3.2 The minimum size of the bladder accumulator for Plan 53B shall be in accordance with Table 11.

Table 11—Sizing of Bladder Accumulators for Plan 53B

Shaft Size	**Seal Category**	**Seal Chamber Gauge Pressure**	**Accumulator Nominal Size, Minimum**
Less than or equal to 60 mm (2.5 in.)	Category 1	Less than 1.2 MPa (12 bar) (175 psi)	20 L (5 U.S. gal)
	Category 2 and 3	Less than 2.5 MPa (25 bar) (360 psi)	
60 mm (2.5 in.) to 110 mm (4.375 in.)	Category 1	Less than 1.2 MPa (12 bar) (175 psi)	35 L (9 U.S. gal)
	Category 2 and 3	Less than 2.5 MPa (25 bar) (360 psi)	
Any	Category 1	Greater than 1.2 MPa (12 bar) (175 psi)	Designed
	Category 2, 3 and 4	Greater than 2.5 MPa (25 bar) (360 psi)	

Note 1. The accumulator working liquid volume is the difference between maximum and minimum barrier liquid volumes. A typical working liquid volume is 15 % to 25 % of the accumulator volume.

Note 2. There are a number of variables that impact the design of Plan 53B accumulator auxiliary seal systems. The accumulator sizes detailed in Table 11 are minimum sizes, however a design review is required that takes into consideration refill frequency and the impact of ambient temperature conditions to ensure the MAWP of the auxiliary system and the dynamic seal pressure rating of the seal cartridge are not exceeded. Refer to Annex F.3.3.3. for more detail.

Note 3 As the accumulator working liquid volume is affected by ambient temperature change, two different alarm strategies have been developed: the fixed alarm strategy and if specified a floating alarm strategy. Refer to Annex F.3.3.3. for more detail.

8.3.6.3.3 There should always be a minimum liquid volume retained in the accumulator to prevent loss of barrier pressure at the accumulator minimum barrier pressure condition. This should be enough to prevent any contact between the bladder and the fluid port that may either damage the bladder or close the valve.

NOTE A typical accumulator supplier recommendation is 10% of the total accumulator volume.

The pre-charge gas pressure and the refill barrier fluid pressure shall be provided by the seal vendor based on minimum ambient temperature and every 10 °F (5 °C) temperature increment to the maximum ambient temperature.

8.3.6.3.4 The maximum and minimum barrier pressure shall be calculated by the seal vendor at minimum ambient temperature and maximum ambient temperature. Unless otherwise specified, these values together with a method of estimating the maximum operating barrier pressure at intermediate temperature conditions shall be provided to the purchaser for the initial setting and subsequent replenishment of barrier fluid.

NOTE 1 The maximum operating barrier pressure is dependent on the temperature of the gas in the bladder at the time of filling or refilling. See Annex F for more detail on pre-charge gas and barrier pressure calculations.

NOTE 2 The bladder accumulator is normally piped and situated such that its bladder gas volume is not affected by the barrier liquid temperature changes but is primarily influenced by local ambient temperature conditions. The corresponding barrier pressure fluctuations will assume the high and low ambient conditions apply to the gas in the bladder. Refer to Annex F for details regarding barrier pressure calculations.

NOTE 3 A local or plant wide (ambient) temperature measurement can be sufficient

8.3.6.3.5 Plan 53B systems shall be equipped with a pressure transmitter on the liquid side to provide a refill alarm.

8.3.6.3.6 With the fixed pressure alarm strategy the alarm set point shall not be less than the accumulator minimum barrier pressure calculated at the maximum ambient temperature.

● 8.3.6.3.7 If specified, a temperature transmitter shall be supplied on the gas side of the accumulator in addition to the pressure transmitter on the liquid side.

NOTE The use of a temperature and pressure transmitter provide a temperature compensated alarm floating alarm. See Annex F.3.3.3.3.

8.3.6.3.7.1 The output signal from these transmitters shall be available for connection to the plant distributed control system (DCS) for alarm calculation and function.

8.3.6.3.7.2 Specific input for programming the DCS to establish the floating pressure alarm algorithm shall be provided by the vendor.

NOTE 1 Specific input required for the alarm algorithm will typically include the minimum and maximum barrier liquid volume, the accumulator volume, and the minimum barrier system pressure at minimum ambient temperature. The vendor will use this data and the site ambient temperature data to optimize system design, minimize the frequency of refilling, and verify that the system design is suitable for the local installation. Refer to Annex F for more detail.

NOTE 2 The temperature transmitter on the gas side itself is not intended to provide alarm point or trip point. The purpose of this transmitter is to measure the gas temperature of the accumulator and to provide information for the DCS to calculate the pressure related alarm point with temperature compensation – hence floating alarm points depending on gas temperature of the accumulator.

● 8.3.6.3.7.3 If specified or if the plant DCS system is not available, a locally mounted single loop controller shall be provided for each accumulator. Parameters used by the controller to establish the floating pressure alarm algorithm shall be provided by the vendor.

8.3.6.3.8 Bladder accumulator shells shall be minimum of carbon steel or higher corrosion resistance as the application requires and rated to the MAWP of the casing.

NOTE Internal cladding or coating may be supplied for barrier fluid compatibility or to lower the chance of rupture of the bladder

8.3.6.3.8.1 The rated MAT of the bladder accumulator shell shall be according to manufacturer's standard, but not less than 175°F (80°C).

8.3.6.3.8.2 Bladder materials shall be according to manufacturer's standard and compatible with the barrier liquid.

8.3.6.3.8.3 Provided that a failure of the elastomeric bladder does not represent a loss of containment, its temperature rating may be lower than the maximum allowable temperature to which the system will be attached.

NOTE Bladder materials are often not suitable for elevated temperatures

8.3.6.3.9 Vendor shall provide an austenitic stainless steel nameplate, prominently attached. It shall be stamped with at least the information described below. See an example nameplate in Annex F.3.3.3.3.

a) Pump Item Number
b) Auxiliary piping system design pressure
c) Minimum and maximum design temperature
d) Barrier liquid
e) Nitrogen pre-charge pressure at the minimum ambient temperature and every 10 °F (5 °C) temperature increment to the maximum ambient temperature
f) Barrier fluid refill pressure at the minimum ambient temperature and every 10 °F (5 °C) temperature increment to the maximum ambient temperature
g) Maximum barrier pressure to be achieved when the system is full at the specified nitrogen pre-charge pressure.

h) Low pressure alarm value which is either fixed (per fixed alarm strategy) or temperature compensated (per floating alarm strategy)
i) Lettering shall be easily readable from grade.

NOTE The design conditions listed above may appear on a separate nameplate

8.3.6.3.10 The MAWP of the bladder accumulator shell shall exceed the maximum possible supply pressure of the nitrogen pre-charge system used.

8.3.6.3.11 The barrier fluid cooling circuit should be arranged in accordance with Figure G.37. If a water cooler is selected the height of the cooler in the barrier fluid circuit above the seal gland plate shall be established by the seal vendor. The height of the cooler shall not be less than 18 in. (450 mm).

8.3.6.4 **Piston Accumulator**

● 8.3.6.4.1 The piston accumulator shall be designed, fabricated, and inspected in accordance with a pressure vessel code such as ASME VIII, EN 13455, or equivalent.

NOTE Piston accumulators do not typically comply with piping codes such as ASME B31.3 due to their fabrication method.

8.3.6.4.2 The barrier system shall contain an accumulator with a mechanism to provide the barrier fluid with a positive differential pressure above the seal chamber pressure. The differential pressure shall be a minimum 20 psi (0.14 MPa) (1.4 bar).

NOTE This ensures the inner seal operates with a minimal differential pressure and a positive barrier pressure is provided with unplanned excursions in the seal chamber pressure.

8.3.6.4.3 For shaft diameters equal or smaller than 60 mm the barrier minimum liquid volume in accumulator shall be 0.05 U.S. gal (0.2 L) and a maximum liquid volume of at least 0.7 U.S. gal (2.8 L). For shaft diameters above 60 mm the barrier minimum liquid volume in accumulator shall be of 0.09 U.S. gal (0.35 L) and a maximum liquid volume of at least 1.28 U.S. gal (5.1 L).

NOTE These working volumes are similar to the working volume of the two barrier reservoirs in 8.3.6.2.

8.3.6.4.4 Piston accumulators shall be equipped with a:

— differential pressure transmitter with a low-level alarm;

— level indicator and level transmitter with a low- and high-level alarm to warn if piston reaches minimum or maximum end position.

8.3.6.4.5 Piston accumulators and any piping or components welded directly to the accumulator shall be of the same material as the gland plate or one of a superior corrosion resistance (see 8.1.8).

8.3.6.4.6 The secondary seals of the accumulator shall conform to 6.1.7.5.1 and 6.1.7.5.2 and be of a material compatible with both the process liquid and barrier liquid.

8.3.6.4.7 Provided that a failure of the elastomeric components does not represent a loss of containment, the component temperature rating may be lower than the maximum allowable temperature to which the system will be attached.

NOTE Elastomeric materials are often not suitable for elevated temperatures

8.3.6.4.8 A nameplate, stamped with at least the Pump Item Number, seal auxiliary system MAWP, and the barrier liquid, shall be permanently attached to the system.

8.3.6.4.9 The barrier fluid cooling circuit should be arranged in accordance with Figure G.37. If a water cooler is selected, the height of the cooler in the barrier fluid circuit above the seal gland plate shall be established by the seal vendor but shall not be less than 18 in. (450 mm).

● 8.3.6.4.10 If specified a temperature indicator shall be supplied.

8.3.7 **External Circulating Pump**

● 8.3.7.1 If specified, or if an internal circulating device cannot be provided to meet desired flow rates, an external forced-circulation pump is required. The circulating pump selection shall be 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.

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

8.3.8 **Components for External Seal Flush Systems**

● 8.3.8.1 If Piping Plan 32, Piping Plan 54, or Piping Plan 55 is selected (Figure G.14, Figure G.21, Figure G.22), the purchaser shall specify the fluid characteristics. The seal manufacturer shall specify the minimum flow rate, minimum pressure and temperature required, where these are factors.

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

NOTE Inappropriate selection of flush or excessive flush flow rates can affect pump performance.

8.3.9 **Collection Reservoir for Liquid Leakage**

8.3.9.1 **General**

● 8.3.9.1.1 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.

8.3.9.1.2 The purchaser shall provide any additional requirements for drain disposition.

8.3.9.1.3 The pipe from the gland plate to the collector shall have a minimum slope of 0.5 in./ft (40 mm/m) towards the collector. The minimum pipe size shall be NPS 0.5 (DN 15).

8.3.9.1.4 All components supplied within the scope of Piping Plan 65 and Piping Plan 75, together with interconnecting pipework shall be considered part of the pump casing and meet the requirements of 8.1.4.

8.3.9.1.5 Each seal assembly shall have an independent collection reservoir with instrumentation as specified in Figure G.25, Figure G.26, and Figure G.32.

8.3.9.2 **Reservoir for Atmospheric Leakage (Piping Plan 65A and Piping Plan 65B)**

8.3.9.2.1 The system shall comply with 8.3.9.2.2 to 8.3.9.2.6 and Figure G.25 or Figure G.26.

8.3.9.2.2 The reservoir shall include a level transmitter with a local indicator.

8.3.9.2.3 The reservoir shall have a volume of at least 0.75 U.S. gal (3 L).

8.3.9.2.4 The orifice for Piping Plan 65A shall have a bore diameter of at least 0.2 in. (5 mm).

8.3.9.2.5 The reservoir shall be in accordance with 8.3.6.2.9, 8.3.6.3.1 and Table 5.

8.3.9.2.6 The components of the reservoir shall be fabricated from appropriate size, Schedule 40 pipe.

8.3.9.2.7 The upper drain connection of the reservoir shall be positioned below the drain connection of the gland plate.

8.3.9.3 **Reservoir for Containment Seal Chamber Leakage (Piping Plan 75)**

8.3.9.3.1 If a condensate collection system is provided, the system shall comply with 8.3.9.3.2 to 8.3.9.3.5 (see Figure G.32).

8.3.9.3.2 The condensate collection reservoir:

a) shall be at least 8 in. (200 mm) diameter carbon steel, Schedule 40, and 3 U.S. gal (12 L) minimum capacity in accordance with 8.3.6.2.9, 8.3.6.3.1 and Table 5;

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) shall have a NPS 0.75 (DN 20) minimum drain connection that terminates with a full ported globe valve; and

e) shall have a NPS 0.5 (DN 15) minimum vent connection, to which a pressure indicator, a pressure transmitter with a HLA and a restriction orifice is installed to detect primary seal leakage.

● 8.3.9.3.3 A transmitter with a high-level alarm shall be provided, if specified.

● 8.3.9.3.4 A test connection shall be installed for injection of nitrogen to test containment seal and/or purge collector, if specified.

8.3.9.3.5 The vent restriction orifice of the leakage collection reservoir shall be below the drain connection of the seal gland plate.

8.3.10 **Barrier/Buffer Gas Supply Systems**

8.3.10.1 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.

8.3.10.2 Barrier/buffer gas supply systems shall be provided by the seal supplier and include components and instrumentation as specified in Figure G.30 and Figure G.31.

8.3.10.3 The minimum and maximum operating pressures shall also be within the range of the instrument. If possible, the pressure regulator, indicator, and transmitters shall be selected such that the normal operating pressure is in the middle third of the range.

8.3.10.4 A coalescing filter with a replaceable element or cartridge design shall be supplied and include a drain valve.

8.3.10.4.1 The coalescing filter shall have an efficiency of 98.8 % on particles of diameter equal or greater than 4 µm with a beta ratio β4 ≤ 85.

● 8.3.10.4.2 If specified, the filter shall have a liquid-level indicator.

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

● 8.3.10.5 An indicating pressure transmitter and indicating flow transmitter shall be provided upstream of the check valve. High pressure, high flow, and low flow shall be remotely alarmed from the transmitters. If specified a high-flow switch shall be provided and installed between the flow meter and the check valve (see Figure G.30 and Figure G.31).

8.3.10.6 Each seal arrangement shall have an independent barrier/buffer gas supply system.

8.3.10.7 All external connections of the system shall be NPS 0.5 (DN 15) minimum and in accordance with Table 5.

8.3.10.8 Gas supply systems shall be mounted on a metallic panel that has a minimum thickness of 0.25 in. (6 mm). All components shall be suitably supported to avoid damage to the components and internal piping/tubing.

9 Instrumentation

9.1 General

9.1.1 Instrumentation and installation shall conform to this standard.

9.1.2 Controls and instrumentation shall be designed for outdoor installation and shall comply with IEC 60529 designation IP 56 or with NEMA 250 enclosure Type 4.

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, such as level gauges and switches, exposed to the pumped fluid and barrier/buffer fluid (if any).

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

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.

9.1.6 The MAWP of instruments and accessories shall be at least equal to the piping or device into which they are mounted.

9.1.7 Instruments in contact with auxiliary system fluids shall be suitable for the normal operating temperatures of those fluids but their temperature limit shall not be below 212 °F (100 °C). If a failure of the instruments in an auxiliary circuit does not represent a loss of containment, the temperature limit of an instrument may be lower than the maximum allowable temperature of the pressure casing.

NOTE The temperature limit of some common instruments can be below the possible maximum allowable temperature of a pressure casing. Many bourdon tube pressure gauges with liquid filling, for example, do normally have a temperature limit of about 212 °F (100 °C). The operation temperature of a buffer/barrier medium is often much lower than the maximum allowable temperature of the pump.

● 9.1.8 If specified by the purchaser, instrumentation in buffer/barrier circuits shall be suitable for the maximum allowable temperature of the pump. When instruments need to be suitable for the maximum temperature of the pump, special design features for the instrumentation have to be considered by the seal vendor.

9.2 Temperature-indicating Gauges

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

9.2.2 Dial temperature gauges shall be installed in pipe sections or in tubing runs as specified. Auxiliary equipment may be either piping or tubing. 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 1.5 in. (38 mm) in diameter, and the stem shall have a minimum length of 2 in. (50 mm). All other gauges shall be a minimum of 3.5 in. (90 mm) in diameter, and the stem shall have a minimum length of 3 in. (75 mm).

NOTE The use of 3.5 in. (90 mm) gauge diameter instead of standard 5 in. (125 mm) is due to the normally small size of piping used in seal systems.

9.3 Thermowells

9.3.1 Temperature gauges that are in contact with flammable or toxic fluids or that are located in pressurized or flooded lines shall be furnished with 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 NPS 0.5 (DN 15) minimum. Thermowells for use in tubing shall be approved by the purchaser. Thermowell designs and installation should not restrict liquid flow.

9.3.2 The thermowell connection into the piping, tubing, or accessories shall be consistent with other connections in the piping system.

9.4 Pressure Indicators

9.4.1 Pressure indicators shall be in accordance with API 614.

9.4.2 Pressure indicators shall have block-bleed valves.

● 9.4.3 If specified, oil-filled pressure indicators shall be furnished.

9.5 Transmitters and Switches

9.5.1 **General**

9.5.1.1 Transmitters and switches shall be per API 614.

● 9.5.1.2 If specified, switches shall be provided in place of transmitters .

9.5.1.3 If switches are specified instead of transmitters these devices should be substituted at locations shown for transmitters in Annex G. Depending on the function of the transmitter, a local indicator could also be required in addition to the switch.

9.5.2 Pressure Transmitters

9.5.2.1 Pressure transmitter shall be designed for the maximum pressure to which the transmitter may be exposed. Transmitters exposed to vacuum shall be suitable for full vacuum.

9.5.2.2 The measuring element and all pressure-containing parts shall be austenitic stainless steel type 316 unless the pumped fluid requires the use of alternative materials.

9.5.2.3 Connections for pressure input shall be NPT 0.5 minimum.

9.5.2.4 If specified, connections for pressure input shall be flanged.

9.5.3 Level Transmitters

Level transmitters shall be hydrostatic.

9.5.4 Flow Transmitters

Flow transmitters provided with buffer/barrier gas systems shall be inline, mechanically actuated, that respond to gas motion within the line.

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 Instruments

9.7.1 Flow Indicators

Flow indicators shall be of the nonrestrictive bull's-eye type and shall have a body that matches or exceeds the line material specification. To facilitate viewing of the flow through the line, each flow indicator shall be installed in accordance with the manufacturer's instructions. The diameter of the bull's eye shall be at least one-half the inside diameter of the line and shall clearly show the minimum flow.

9.7.2 Flow Meters

Flow meters shall be armored 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.

d) Glass tube flow meters may only be used on air or inert gas at temperatures of 140 °F (60 °C) or less, and gauge pressures of 100 psi (0.7 MPa) (7 bar) or less.

9.8 Relief Valves

9.8.1 The seal system supplier shall furnish the relief valves that are to be installed on the seal support system.

9.8.1.1 The system supplier shall determine the size and set pressure of supplied relief valves.

9.8.1.2 Relief valves for all operating equipment shall meet the relief-valve requirements defined in API 520, Part I and Part II, and if applicable in API 526 (diameter ≥ 1 in.).

9.8.1.3 The seal support system suppliers' quotation shall list all relief valves they supply.

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

9.9 Pressure Control Valves

Pressure control valves for gas buffer and barrier systems shall be supplied in accordance with the following.

a) Pressure control valves shall be self-contained, spring-loaded with an internal pressure-sensing connection.

b) The pressure control valve 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 pressure control valve body shall be rated for the maximum upstream and downstream pressure and temperature to which it may be subjected.

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.

f) Pressure control valves shall not be self-venting.

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 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-vendors of the purchaser's inspection and testing requirements.

10.1.3 The vendor shall provide a minimum of five working days 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/her participation in the inspection and testing.

10.1.5 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 H.

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 6.1.7.10, the purchaser may specify the following:

— parts that shall be subjected to surface and subsurface examination and

— the type of examination required, such as magnetic-particle, liquid-penetrant, radiographic, or ultrasonic examination.

10.2.3 The nondestructive examination (NDE) shall be performed as required by the material specification. If additional radiographic, ultrasonic, magnetic particle, or liquid penetrant examinations of the welds or materials are specified by the purchaser, the methods and acceptance criteria shall be as follows. Alternative standards may be proposed by the vendor or specified by the purchaser.

a) Radiography shall be in accordance with Section V, Article 2 and Article 22 of the ASME *Code*.

b) The radiographic acceptance standard used for welded fabrications shall be ASME VIII, Division 1, UW-51 (for 100 % radiography) and UW-52 (for spot radiography). The acceptance standard used for castings shall be ASME VIII, Division 1, Appendix 7.

c) Ultrasonic inspection shall be in accordance with ASME V, Articles 4, 5 and 23.

d) 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.

e) Magnetic particle inspection shall be in accordance with ASME V, Article 7 and Article 25.

f) The magnetic particle acceptance standard used for welded fabrications shall be ASME VIII, Division 1, Appendix 6. The acceptance standard used for castings shall be ASME VIII, Division 1, Appendix 7.

g) Liquid penetrant inspection shall be in accordance with ASME V, Article 6 and Article 24.

h) The liquid penetrant acceptance standard used for welded fabrications shall be ASME VIII, Division 1, Appendix 8. The acceptance standard used for castings shall be ASME VIII, Division 1, Appendix 7.

i) Regardless of the acceptance criteria in Items b), d), f), and h), it shall be the manufacturer's responsibility to review the design limits of the equipment if more stringent requirements are necessary. Defects that do not meet the acceptance criteria imposed in Items b), d), f), and h) above shall be removed to meet the quality standards cited, as determined by the inspection method specified.

j) 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.

● k) 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

10.3.1 **General**

The sequence for seal testing is shown in Figure 25.

10.3.2 **Seal Qualification Testing**

10.3.2.1 **Purpose**

10.3.2.1.1 In order to provide the end user with a high degree of confidence that a manufacturer's commercial product seal will perform as required by this standard, each seal configuration in combination with other seal system attributes as noted in Annex I shall be suitably qualification tested by the seal manufacturer prior to its market availability. The qualification test does not constitute an acceptance test. The intent is not to perform the qualification test for every individual seal cartridge or seal size in every qualification test fluid but to qualify specific seal configurations and attributes in specific qualification test fluids to simulate various process fluids and typical plant operation.

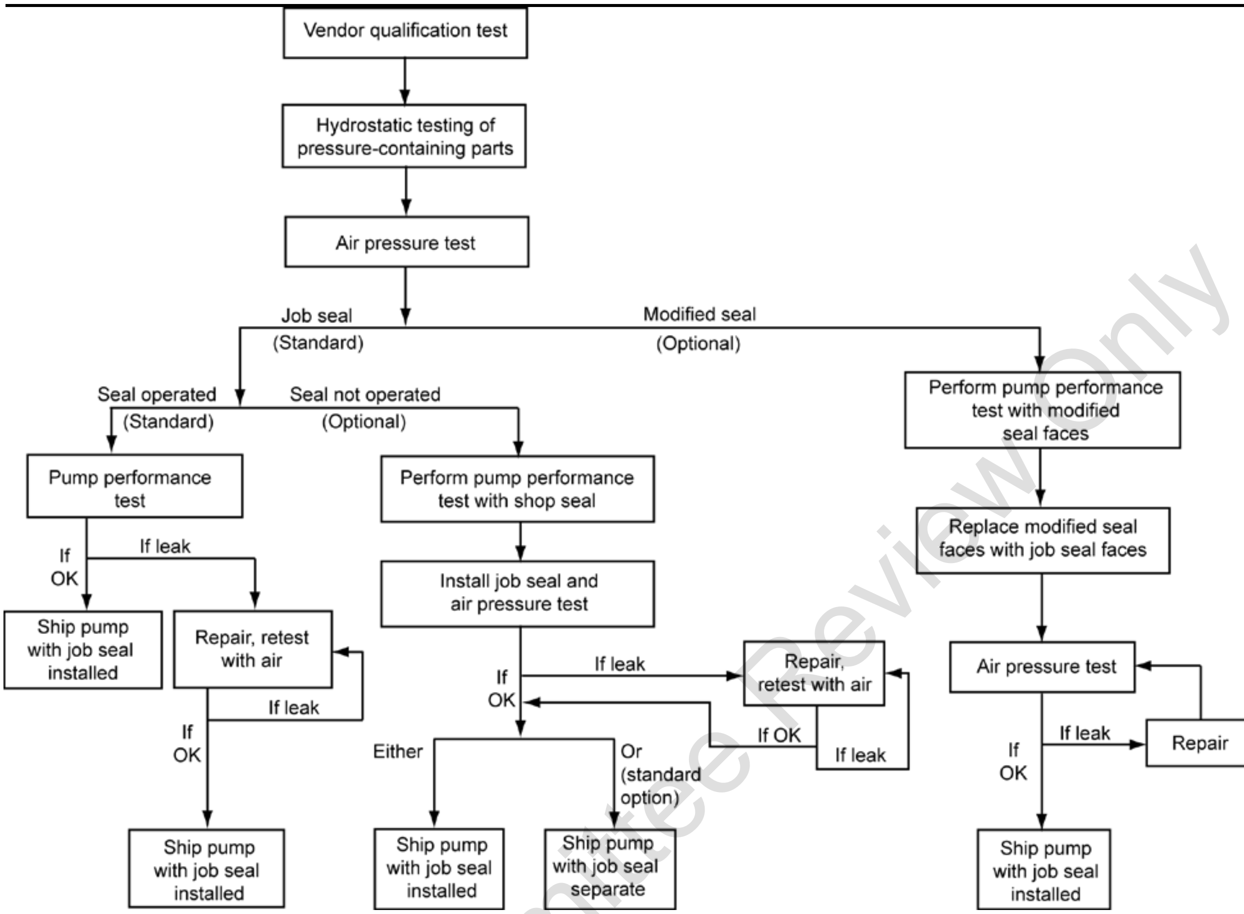


Figure 25—Seal Testing Sequence

● 10.3.2.1.2 If specified, optional testing shall be performed as mutually agreed upon by the seal manufacturer and the purchaser. The purchaser may specify test conditions that differ from the standard qualification test, as applicable.

10.3.2.2 **Scope of Test**

10.3.2.2.1 Qualification tests shall be conducted using an appropriate test rig by the seal manufacturer in accordance with Annex I.

10.3.2.2.2 To be qualified for a particular pumped fluid, a manufacturer's commercial product shall be successfully tested using the appropriate qualification test fluid as given in Table I.2.

NOTE A seal manufacturer's commercial product need be tested only in the representative qualification test fluid to its required service. It is not necessary to test a commercial product in all qualification test fluids. See Annex I for more information.

10.3.2.3 **Minimum Performance Requirements**

10.3.2.3.1 To meet more stringent local emissions regulations, when single seals are tested in accordance with I.4.2, I.4.3, I.4.4, and I.4.9, the permitted leakage shall be:

— a concentration of vapors less than 1000 ppm vol (1000 ml/m^3);

— an average liquid leakage rate of less than two drops per minute (5.6 g/h) per pair of seal faces.

NOTE 1 All mechanical seals require face lubrication to achieve reliability; this results in a minimal level of leakage, see F.1.1. On a water pump test of a contacting wet seal (1CW), the leakage typically evaporates and is not visible. Face design features, however, can increase leakage levels and visible droplets may occur. Pressurized dual contacting wet seals (3CW), when used with a nonevaporative, lubricating-oil barrier fluid, can also produce visible leakage in the form of droplets, but at a rate less than two drops per minute (5.6 g/h).

NOTE 2 The owner or purchaser determines the applicable emission/leakage limits at the intended point of application and compares 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 does not comply with local emission or leakage requirements, then Arrangement 2 or Arrangement 3 may be required to meet the applicable limits.

10.3.2.3.2 To meet more stringent local emissions regulations, when containment seals are tested in accordance with I.4.5, the maximum permitted leakage concentration of vapors shall be 1000 ppm vol (1000 ml/m^3).

10.3.2.3.3 After completion of the qualification test, the total wear of the primary seal faces shall be less than 1 % of the available seal-face wear.

NOTE 1 Excessive wear of a single seal in a particular test can 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 nonlinear. Most seal-face wear occurs during startup or shortly thereafter.

10.3.2.3.4 For containment seals, the sum of the wear during testing according to I.4.2 to I.4.5 shall be less than 1 % of the available seal-face wear.

10.3.2.4 **Test Results**

The seal manufacturer shall provide the results of the qualification tests and certification in accordance with Annex E. The results of the tests shall include at least the information shown on the qualification test results form Figure I.9 or Figure I.10. Any conditions observed that would jeopardize the ability of the seal to meet the reliability and performance requirements of this standard shall be reported.

10.3.3 **Hydrostatic Test for Pressure-containing Mechanical Seal Parts and Accessories**

10.3.3.1 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 MAWP of the pump casing to which the component is connected but not less than a gauge pressure of 20 psi (0.14 MPa) (1.4 bar). The test liquid shall be at a higher temperature than the nil ductility transition temperature of the material being tested.

10.3.3.2 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 EN 13445 or 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 datasheets shall list actual hydrostatic test pressures.

10.3.3.3 Where applicable, tests shall be in accordance with the EN 13445 or ASME VIII. If a discrepancy exists between the code test pressure and the test pressure in this standard, the higher pressure shall govern.

10.3.3.4 The chloride content of liquids used to test austenitic stainless steel materials shall not exceed 50 ppm wt (50 mg/kg). To prevent deposition of chlorides because of evaporative drying, all residual liquid shall be removed from tested parts at the conclusion of the test.

10.3.3.5 Tests shall be maintained for minimum of 30 minutes. There shall be no leaks nor seepage through the part.

10.3.4 **Test of Job Seal by Seal Manufacturer**

10.3.4.1 Each mechanical seal shall be tested with air by the seal manufacturer after final assembly in accordance with 10.3.5. Provisions for the test shall include the requirements in 10.3.4.1 a) to 10.3.4.1 c).

a) 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 specified shall be used.

b) The test 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.

c) Arrangement 2 seals shall have provisions to test each sealing section independently.

10.3.4.2 Following the successful completion of the air test, the tested seal cartridge shall not be disassembled. The cartridge assembly shall be tagged with the words "certified seal manufacturer air test acceptable," giving the test date and the inspector's name.

10.3.4.3 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.

10.3.5 **Assembly Integrity Test**

10.3.5.1 **Purpose**

10.3.5.1.1 In order to provide the purchaser with a high degree of confidence that a manufacturer's commercial product seal has been correctly assembled, each new or repaired cartridge assembly shall be tested in pressurized air or nitrogen by the seal manufacturer in accordance with 10.3.5 prior to shipment. This integrity test is an acceptance test.

NOTE The intent of the assembly integrity test is to show that the seal cartridge was assembled correctly. The seals are not expected to be leak-free, see A.1.3 for a tutorial on leakage. Many years of practical experience have shown that this simple low-pressure test is beneficial. Results from the assembly integrity test are not representative of the seal performance in liquid.

● 10.3.5.1.2 If specified, optional air or nitrogen testing shall be performed as mutually agreed upon by the seal manufacturer and the purchaser. The purchaser may specify test conditions that differ from the standard assembly integrity test, as applicable.

10.3.5.2 **Scope of Assembly Integrity Test**

10.3.5.2.1 Integrity tests shall be conducted using an appropriate test rig by the seal manufacturer in accordance with 10.3.5.2.2 to 10.3.5.2.5.

NOTE Typically a test rig simulates a large seal chamber using a canister having various connections, bolting, valves, and instrumentation. Adapters are used to accommodate a range of seal sizes.

10.3.5.2.2 The test rig shall have connections to test the simulated seal chamber, the buffer chamber, the barrier chamber, or the containment chamber independently in accordance with 10.3.5.3.

10.3.5.2.3 The test rig shall have a fill and pressurizing system capable of being isolated from the simulated seal chamber, the buffer chamber, the barrier chamber or the containment chamber that is being tested.

10.3.5.2.4 The volume of gas to be pressurized and tested in any of the chambers shall be a maximum of 1 ft^3 (28 L)

10.3.5.2.5 The pressure gauge used for the test shall have a range so that the gauge pressure of 25 psi (0.17 MPa) (1.7 bar) is close to the midpoint.

10.3.5.3 **Procedure for Assembly Integrity Test**

10.3.5.3.1 Each simulated seal chamber, buffer chamber, barrier chamber, or containment chamber being tested shall be independently pressurized with clean gas to a gauge pressure of 25 psi (0.17 MPa) (1.7 bar).

10.3.5.3.2 After pressurizing according to 10.3.5.3.1, isolate each simulated seal chamber, buffer chamber, barrier chamber, or containment chamber from the pressurizing source for five minutes.

10.3.5.4 **Minimum Performance Requirements for Assembly Integrity Test**

10.3.5.4.1 The maximum pressure decrease during the test according to 10.3.5.3 shall be 2 psi (0.014 MPa) (0.14 bar).

NOTE 1 Pressure drop is inversely proportional to the volume being tested. This is an important consideration if the test chamber contains only a small volume of gas. When testing noncontacting seals, two sets of core seal components simultaneously, or field testing dual seals having a small volume of gas, special test conditions and/or acceptance criteria may apply. For example, assembly integrity tests of dual seals by testing both sets of core seal components simultaneously or field tests using small volumes of gas may exceed the criteria of 10.3.5.4.1 yet operate successfully in the intended service.

NOTE 2 Because of variations in volume, installation, and alignment, the results of the assembly integrity test may not be repeatable after installation.

10.3.6 **Test of Job Seal by Pump Manufacturer**

10.3.6.1 **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 10.3.5.

10.3.6.2 **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, 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 10.3.5. It shall be specified if the seal is to be shipped uninstalled.

10.4 Preparation for Shipment

10.4.1 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 of any 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 0.1875 in. (4.8 mm) 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) Seal gland plate threaded openings shall be plugged in accordance with 10.4.6.

g) Threaded connections other than on the seal gland shall have metal plugs inserted for shipment in accordance with 8.2.20.

h) Shipping units shall be marked with industry standard cautionary symbols indicating center of gravity, sling or lifting points, top heavy packages, fragile and liquid contents, moisture sensitive contents, etc. per ASTM D5445-05.

i) 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.

10.4.6 The seal gland threaded connection points shall be plugged with plastic plugs for shipment.

10.4.6.1 These plugs shall be red in color and have a center tab to be easily pulled and distinguished from metal plugs. (See Figure 26.)

10.4.6.2 A yellow warning tag shall be attached to the plugs or seal indicating that the plugs shall be removed prior to operation. The warning tag shall include the international warning symbol and the following text in English, French, Spanish, German, Japanese, and Mandarin Chinese: "Remove red plug. Install metal plugs or piping as specified on seal drawing." See Figure 26 for an example of such a tag.

10.4.6.3 Plastic plugs, tags, and seal gland plates shall not be painted over on any equipment.

10.4.6.4 Metal plugs shall be of the same material as the gland, or with superior corrosion resistance for the intended service.

10.4.6.4.1 Metal plugs shall be furnished and packaged separately from the seal with a warning label that all unused seal connections shall be plugged. The same warning shall be included in the seal drawing and instructions. The seal drawing is to be included with the metal plugs in addition to the copy of the seal drawing that is included in the box with the seal.

10.4.6.4.2 The metal plugs shall be solid round or solid hexagonal head plugs furnished in accordance with the dimensional requirements of ASME B16.11.

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

10.4.6.4.3 Category 1 seals provided with flush-mount socket head plugs are acceptable.

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

Figure 26—Plastic Plug with Center Tab and Example of Warning Tag

11 Data Transfer

11.1 General

11.1.1 The transfer of the required data and documents is the joint responsibility of the purchaser and vendor. The following checklists and forms shall be used to facilitate the transfer of data for inquiries, proposals, and contracts. The purchaser may submit the required data to the vendor in a form other than that indicated herein. However, the alternative forms shall include at least all the information specified in Annex C and Annex E.

● 11.1.2 Other or additional documentation requirements for proposals and contracts shall be specified in the inquiry of the purchaser.

11.1.3 The minimum information to be furnished by the seal vendor is specified in the Data Requirement Forms and shall be sent to the address or addresses noted on the enquiry or order.

11.1.4 The following information shall be identified on proposal letters, contract cover sheets, and on mechanical seal datasheets for Category 1, Category 2 and Category 4 installations. Category 3 installations shall have the information on cover letters, mechanical seal datasheets, arrangement drawings, and on 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 inquiry or purchase order number;

e) any other identification specified in the inquiry 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.

11.1.5 At the inquiry stage, the installation, operation, and maintenance manuals 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.

11.1.6 A copy of the seal drawing shall be put into the box in which the seal is shipped and another copy shall be put into the bag that also contains the metal plugs for the gland plate.

11.2 Data Requirement Forms

The information to be furnished for inquiries, proposals and contracts is described in the Data Requirements Forms (see Annex E). These forms specify the required data. The Data Requirement Forms also specify which party is responsible for supplying the data.

11.3 Datasheet

Completion of the datasheets (Annex C) is the joint responsibility of the purchaser and the vendor. The purchaser may submit the datasheets to the vendor in a form other than that indicated herein. However, the alternative datasheets shall include at least all the information provided in Annex C. Mechanical seals can be described in a general manner by using mechanical seal codes such as those given in Annex D.

NOTE This information is the basis for the selection, the specification and the purchasing agreement.

11.4 Inspector Checklist

This list can be used to check the compliance and completeness of the delivered seals and seal auxiliary systems according to this standard.