

Pumps—Shaft Sealing Systems for Centrifugal and Rotary Pumps

**ANSI/API Standard 682
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**ISO 21049: 2004, (Identical) Pumps—Shaft Sealing
Systems for Centrifugal and Rotary Pumps**



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This American National Standard is under the jurisdiction of the API *Committee on Refinery Equipment, Subcommittee on Mechanical Equipment*. This standard is considered identical to the English version of ISO 21049. ISO 21049 was prepared by Technical Committee ISO/TC 115, *Pumps*, SC 3, *Installation and special applications*, in collaboration with Technical Committee, ISO TC 67, *Materials, equipment, and offshore structures for petroleum, petrochemical and natural gas industries*, SC 6 *Procession equipment and systems*.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 21049 was prepared by Technical Committee ISO/TC 115, *Pumps*, Subcommittee SC 3, *Installation and special applications*, in collaboration with Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, SC 6, *Processing equipment and systems*.

Introduction

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

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

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

This International Standard is a stand-alone seal standard and is referenced normatively in ISO 13709. It is applicable to both new and retrofitted pumps, and to pumps other than ISO 13709 pumps (e.g. ASME B73.1, ASME B73.2 and API 676 pumps).

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

A bullet (●) at the beginning of a clause or subclause indicates that either a decision is required or further information is to be provided by the purchaser. This information should be indicated on data sheets or stated in the enquiry or purchase order (see examples in Annex C).

Pumps — Shaft sealing systems for centrifugal and rotary pumps

1 Scope

This International Standard specifies requirements and gives recommendations for sealing systems for centrifugal and rotary pumps used in the petroleum, natural gas and chemical industries. 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 20 mm (0,75 in) to 110 mm (4,3 in).

This International 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 International Standard into categories, types, arrangements and orientations is provided.

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.

ISO 7 (all parts), *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*

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

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

ISO 4200, *Plain end steel tubes, welded and seamless — General tables of dimensions and masses per unit length*

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

ISO 10438 (all parts), *Petroleum, petrochemical and natural gas industries — Lubrication, shaft-sealing and control-oil systems and auxiliaries*

ISO 13709, *Centrifugal pumps for petroleum, petrochemical and natural gas industries*

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

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

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

AISI, *Standards, codes and specifications of the American Iron and Steel Institute* ¹⁾

API RP 520 (all parts), *Sizing, selection, and installation of pressure-relieving devices in refineries* ²⁾

API Std 526, *Flanged steel pressure relief valves*

ASME V, *ASME Boiler and pressure vessel code, Section V, Non-destructive examination* ³⁾

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 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, *Structural welding code — Steel* ⁴⁾

EN 287 (all parts), *Approval testing of welders — Fusion welding* ⁵⁾

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

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

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

NEMA 250, *Enclosures for electrical equipment (1 000 volts maximum)* ⁷⁾

NFPA 70, *National Electrical Code* ⁸⁾

Title 1, Part A, Section 112, *U.S. National Emission Standards for Hazardous Air Pollutants (NESHAPs) (Clean Air Act Amendment)* ⁹⁾

1) Available from the American Iron and Steel Institute: 1140 Connecticut Ave., Suite 705, Washington, D.C. 20036, USA.

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

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

4) Available from the American Welding Society, 550 N.W. Le Jeune Rd, Miami, FL 33126, USA.

5) Comité Européen de Normalisation, 36, rue de Stassart, B-1050 Brussels, Belgium.

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

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

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

9) Environmental Protection Agency, Ariel Rios Building, 1200 Pennsylvania Avenue, N.W., Mail Code 3213A, Washington, D.C. 20460, USA.

3 Terms and definitions

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

3.1

anti-rotation device

device used to prevent rotation of one component relative to an adjacent component in a seal assembly

EXAMPLES Key, pin.

3.2

Arrangement 1 seal

seal configuration having one seal per cartridge assembly

3.3

Arrangement 2 seal

seal configuration having two seals per cartridge assembly with a containment seal chamber which is at a pressure lower than the seal chamber pressure

3.4

Arrangement 3 seal

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

3.5

back-to-back configuration

dual seal in which both of the flexible elements are mounted between the mating rings

3.6

balanced seal

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

3.7

barrier fluid

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

3.8

bellows seal

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

3.9

buffer fluid

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

3.10

cartridge seal

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

3.11

connection

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

3.12

contacting seal

seal design 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.

3.13

containment seal

seal design with one flexible element, seal ring and mating ring mounted in the containment seal chamber

NOTE The outer seal for all Arrangement 2 configurations is a containment seal.

3.14

containment seal chamber

component forming the cavity into which the containment seal is installed

3.15

crystallizing fluid

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

3.16

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, qualified by testing in accordance with this International Standard

3.17

drive collar

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

3.18

dual mechanical seal

Arrangement 2 or Arrangement 3 seal of any kind

3.19

dynamic sealing-pressure rating

highest pressure differential that the seal or seal assembly can continuously withstand at the maximum allowable temperature while the shaft is rotating

NOTE Thereafter, the seal retains its static sealing pressure rating.

3.20

face-to-back configuration

dual seal in which one mating face is mounted between the two flexible elements and one flexible element is mounted between the two mating seal rings

3.21

face-to-face configuration

dual seal in which both of the mating seal rings are mounted between the flexible elements

3.22

flashing

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 vapour pressure because of a pressure drop across the seal faces.

3.23

flashing hydrocarbon

liquid hydrocarbon with an absolute vapour pressure greater than 0,1 MPa (1 bar) (14,7 psi) at the pumping temperature, or a fluid that will readily boil at ambient conditions

3.24

flexible element

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

3.25

flexible graphite

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

3.26

floating bushing

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

3.27

FFKM perfluoroelastomer

FFKM

chemically resistant O-ring elastomer material suitable for high temperature service

3.28

FKM fluoroelastomer

FKM

type of O-ring elastomer material commonly used in mechanical seals

3.29

flush, noun

fluid which 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

3.30

flush plan

configuration of pipe, instruments and controls designed to route the fluid concerned to the seals

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

3.31

gland plate

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

3.32

hook sleeve

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

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

3.33

inner seal

(Arrangement 2 and Arrangement 3) seal that is located closest to the pump impeller in the seal chamber

3.34

internally-mounted seal

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

3.35

**internal circulating device
pumping ring**

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

3.36

leakage concentration

measure of the concentration of a volatile organic compound or other regulated emission in the environment immediately surrounding the seal

3.37

leakage rate

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

3.38

light hydrocarbon

hydrocarbon liquid that will readily boil at ambient conditions

NOTE Typically this definition includes pure and mixed streams of pentane (C₅) and lighter liquids.

3.39

mating ring

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

3.40

maximum allowable temperature

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

NOTE 1 This information is supplied by the seal manufacturer.

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

3.41

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** (3.69), **dynamic sealing-pressure rating** (3.19)

3.42

maximum dynamic sealing pressure

MDSP

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

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

3.43

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.

3.44

maximum static sealing pressure

MSSP

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

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

3.45

non-contacting seal

seal design in which the mating 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 Non-contacting seals are specifically designed so that there is always an operating gap between the stationary and rotating face.

3.46

non-flashing hydrocarbon

liquid hydrocarbon whose vapour pressure at any specified operating temperature is less than an absolute pressure of 0,1 MPa (1 bar) (14,7 psi), or a fluid that will not readily boil at ambient conditions

3.47

non-hydrocarbon 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

3.48

non-pusher seal

seal in which the secondary seal is not required to slide axially to compensate for wear and misalignment

NOTE A non-pusher seal is usually the metal-bellows Type B or C.

3.49

observed test

product test which 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

3.50

orifice nipple

pipe nipple made of solid bar stock with an orifice hole drilled through it to regulate the flush flow

NOTE Orifice nipples are commonly found on Plan 11 systems.

3.51

O-ring

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

3.52

outer seal

(Arrangement 2 and Arrangement 3) seal located farthest from the pump impeller

3.53

polymerizing fluid

fluid which 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

3.54

port

fluid passageway, typically located in the gland plate

3.55

pressure casing

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

3.56

product temperature margin

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.

3.57

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.

3.58

purchaser

agency that issues the order and specifications to the vendor

3.59

pusher seal

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

3.60

quench, noun

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

3.61

seal

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

3.62

seal balance ratio

ratio of seal face area exposed to closing force by hydraulic pressure in the seal chamber, to the total seal face area

See Figure 10.

NOTE It is sometimes expressed as a percentage.

3.63

seal chamber

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

3.64

seal face

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

3.65

seal manufacturer

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

3.66

seal ring

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

3.67

secondary seal

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

3.68

service condition

maximum or minimum temperature or pressure under static or dynamic conditions

3.69

static sealing-pressure rating

highest pressure that the seal can continuously withstand at the maximum allowable temperature while the shaft is not rotating

NOTE Thereafter, the seal maintains its dynamic sealing pressure rating.

3.70

throat bushing

device that forms a restrictively close clearance around the sleeve (or shaft) between the inner seal and the impeller

3.71

throttle bushing

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

3.72

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.

3.73

Type A seal

balanced, inside-mounted, cartridge-design pusher seal with multiple springs and in which the flexible element normally rotates

3.74

Type B seal

balanced, inside-mounted, cartridge-design non-pusher (metal bellows) seal in which the flexible element normally rotates, and in which the secondary sealing elements are elastomeric O-rings

3.75

Type C seal

balanced, inside-mounted, cartridge-design non-pusher (metal bellows) seal in which the flexible element is normally stationary, and in which the secondary sealing elements are flexible graphite

3.76

vendor supplier

manufacturer of the equipment, or his agent, normally responsible for service support

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

3.77

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)

3.78

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 representative is in attendance

4 Sealing systems

4.1 Seal categories, types and arrangements

4.1.1 General

The seal configurations covered by this International Standard can be classified into three categories (1, 2 and 3), three types (A, B and C) and three arrangements (1, 2 and 3). Further, Arrangement 2 and 3 seals can be in three orientations: "face-to-back", "back-to-back" and "face-to-face". These categories, types, arrangements and orientations are defined below.

See Figures 1 to 9 for typical representations.

4.1.2 Seal categories

There are three seal categories, as follows.

- **Category 1** seals are intended for use in non-ISO 13709 pump seal chambers, preferably meeting the dimensional requirements of ASME B73.1, ASME B73.2 and ISO 3069 Type C seal chamber dimensions and their application is limited to seal chamber temperatures from $-40\text{ }^{\circ}\text{C}$ ($-40\text{ }^{\circ}\text{F}$) to $260\text{ }^{\circ}\text{C}$ ($500\text{ }^{\circ}\text{F}$) and absolute pressures up to 2,2 MPa (22 bar) (315 psi).
- **Category 2** seals are intended for use in seal chambers meeting the chamber envelope dimensional requirements of ISO 13709. Their application is limited to seal chamber temperatures from $-40\text{ }^{\circ}\text{C}$ ($-40\text{ }^{\circ}\text{F}$) to $400\text{ }^{\circ}\text{C}$ ($750\text{ }^{\circ}\text{F}$) and absolute pressures up to 4,2 MPa (42 bar) (615 psi).
- **Category 3** provides the most rigorously tested and documented seal design. It is required that the entire seal cartridge is qualification tested as an assembly in the required fluid. They meet the seal chamber envelope requirements of ISO 13709 (or equal). Their application is limited to seal chamber temperatures from $-40\text{ }^{\circ}\text{C}$ ($-40\text{ }^{\circ}\text{F}$) to $400\text{ }^{\circ}\text{C}$ ($750\text{ }^{\circ}\text{F}$) and absolute pressures up to 4,2 MPa (42 bar) (615 psi).

A summary of the main differences in seal categories is given in Annex A.

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 International Standard.

4.1.3 Seal types

There are three seal types, as follows.

- **Type A seal** is a balanced, inside-mounted, cartridge design, pusher seal with multiple springs and in which the flexible element normally rotates. Secondary sealing elements are elastomeric O-rings.

Materials are specified in Clause 6. Guidance on equivalent materials standards is given in Annex B. Figure 7 depicts a Type A seal.

- **Type B seal** is a balanced, inside-mounted, cartridge design, non-pusher (metal bellows) seal in which the flexible element normally rotates. Secondary sealing elements are elastomeric O-rings.

Materials are specified in Clause 6. Guidance on equivalent materials standards is given in Annex B. Figure 8 depicts a Type B seal. A metal bellows seal offers the advantage of having only static secondary seals. It may be specified instead of the standard Type A seal for low temperature service.

- **Type C seal** is a balanced, inside-mounted, cartridge-design non-pusher (metal bellows) seal in which the flexible element is normally stationary. Secondary sealing elements are flexible graphite.

Materials are specified in Clause 6. Guidance on equivalent materials standards is given in Annex B. Figure 9 depicts a Type C seal. Bellows seals are inherently balanced. Stationary metal bellows seals are the primary choice for high temperature service.

The Type C stationary bellows configuration is chosen as standard because of its advantage if the gland plate and shaft lose their perpendicular alignment. In this arrangement, the bellows can deflect to a fixed position to match the rotating face. In a rotating arrangement, Type B, the bellows would have to flex and change positions once per shaft revolution to accommodate the runout of the stationary face; however, rotating metal bellows tend to throw out particulate from between the bellows in coking or other particulate-bearing services. The user should note that rotating bellows seals often have a tendency to vibrate and are, therefore, equipped with dampening tabs or other devices to control vibration. Stationary bellows seals largely avoid this issue. Metal bellows seals offer the advantage of having only static secondary seals. This allows their application in high-temperature services where suitable O-ring elastomers are not available. Metal bellows seals are also a cost-effective alternative for services where chemical resistance or cost of O-ring materials is an issue.

Type A and Type B seals are suitable for temperatures up to 176 °C (350 °F). Type C seals are for high temperatures up to 400 °C (750 °F).

4.1.4 Seal arrangements

There are three seal arrangements, as follows:

- **Arrangement 1:** Seal configurations having one seal per cartridge assembly;
- **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 A flush plan descriptions.

NOTE 2 In Arrangement 2 and Arrangement 3, the containment seal (3.13) can be a conventional wet seal or a dry-running seal. The inner seal utilizes a flush plan typical of Arrangement 1 seals. If the containment seal is a conventional wet seal design, an unpressurized liquid buffer fluid is supplied to the containment seal chamber (3.14). If the containment seal is a dry-running seal, a gas buffer may be used.

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

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

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

4.1.5 Seal orientations

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

- face-to-back: dual seal configuration in which one mating ring is mounted between the two flexible elements and one flexible element is mounted between the two mating rings;
- back-to-back: dual seal configuration in which both of the flexible elements are mounted between the mating rings; and
- face-to-face: dual seal configuration in which both of the mating rings are mounted between the flexible elements.

4.2 Objectives

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

- a) All seals should operate continuously for 25 000 h without need for replacement;
- b) Containment seals should operate for at least 25 000 h without need for replacement (wet or dry seals) at any containment seal chamber pressure equal to or less than the seal leakage pressure switch setting [not to exceed a gauge pressure of 0,07 MPa (0,7 bar) (10 psi)] and for at least 8 h at the seal chamber conditions;
- c) All seals should operate for 25 000 h without need for replacement while either complying with local emissions regulations, or exhibiting a maximum screening value of 1 000 ml/m³ (1 000 ppm vol) as measured by the EPA Method 21, whichever is more stringent.

4.3 Specifying and/or purchasing a sealing system

The data sheet (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 data sheet to obtain budgetary pricing on a sealing system is expressed in the seal code. Typical seal codes which can be used are given in Annex D. This assumes all standard defaults (construction features and materials). The minimum information required on the data sheet to purchase a seal with assurance that the selection will satisfy the objectives of 4.2 is the pump data, fluid data and seal specification.

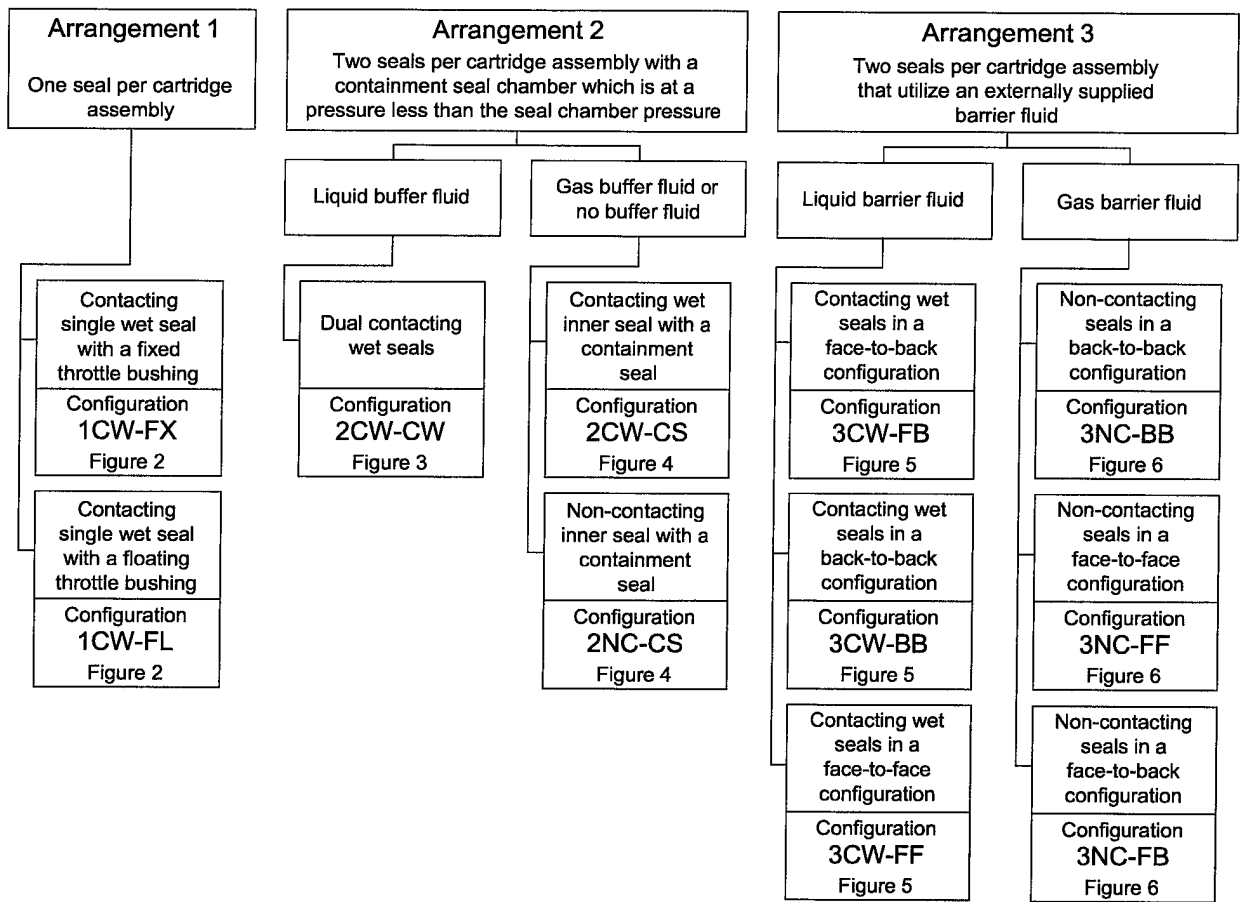
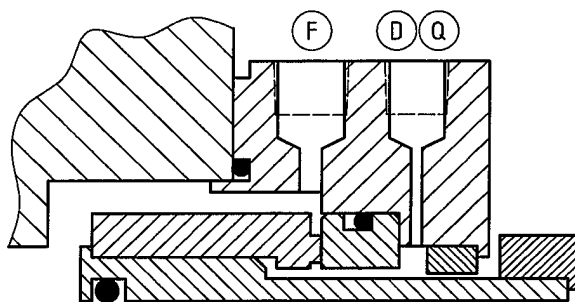
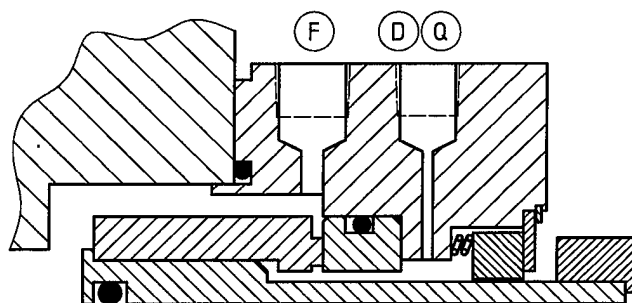


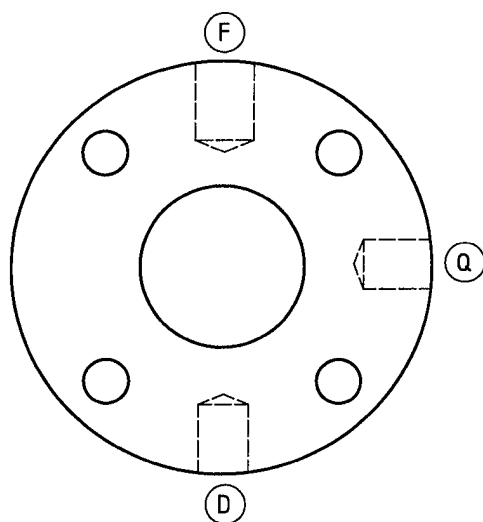
Figure 1 — Seal configurations



a) 1CW-FX, contacting single wet seal with a fixed throttle bushing



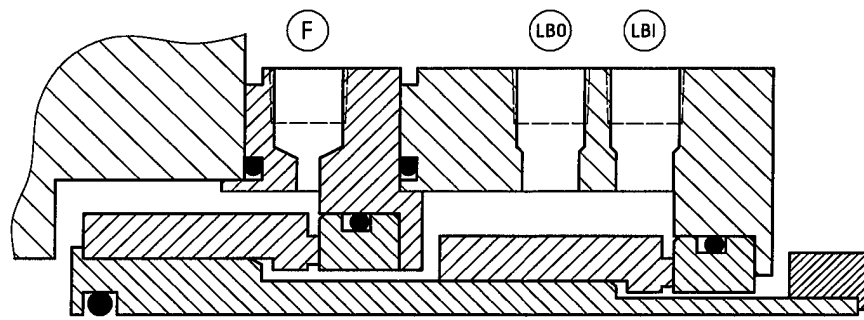
b) 1CW-FL, contacting single wet seal with a floating throttle bushing



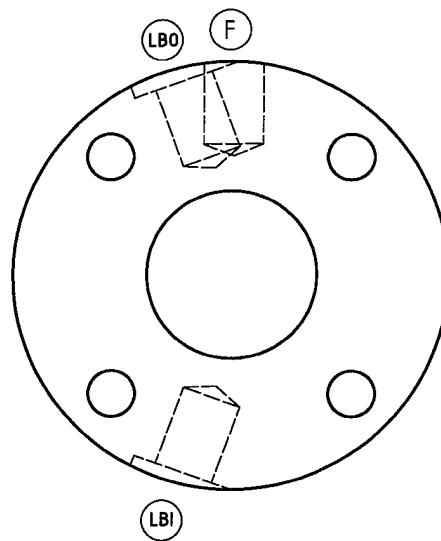
c) Typical gland plate connection orientation

NOTE For connection designations, see 6.1.2.17, Table 1.

Figure 2 — Arrangement 1: One seal per cartridge assembly



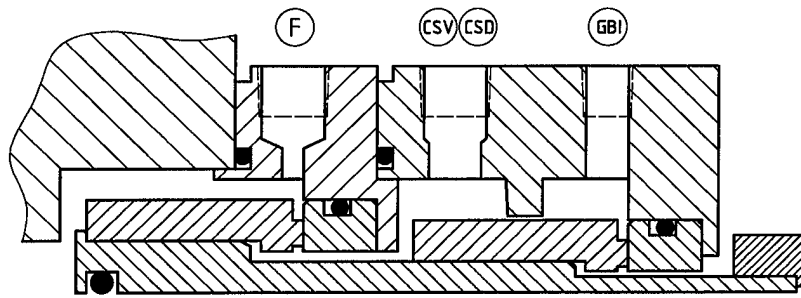
a) 2CW-CW , dual contacting wet seal



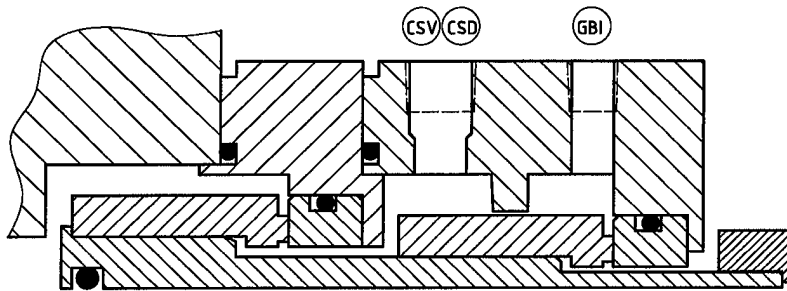
b) Typical gland plate connection orientation

NOTE For connection designations, see 6.1.2.17, Table 1.

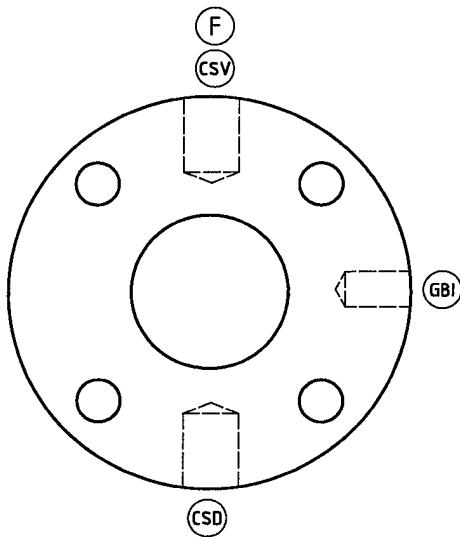
Figure 3 — Arrangement 2: Two seals per cartridge assembly with a liquid buffer fluid



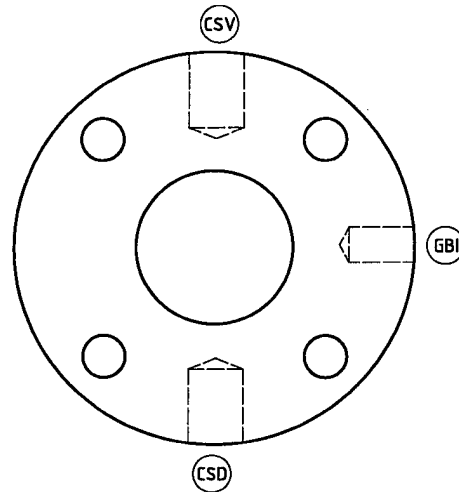
a) 2CW-CS, contacting wet inner seal with a containment seal



b) 2NC-CS, non-contacting inner seal with a containment seal



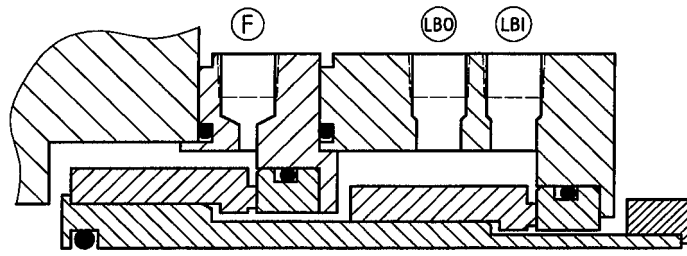
c) Typical gland plate connection orientation for 2CW-CS



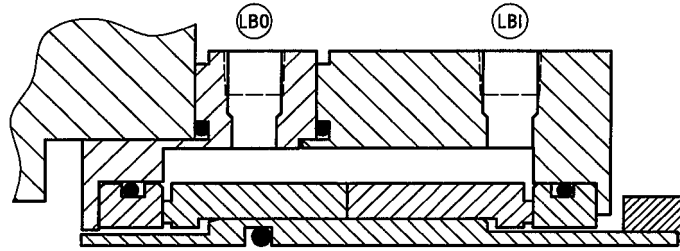
d) Typical gland plate connection orientation for 2NC-CS

NOTE For connection designations, see 6.1.2.17, Table 1.

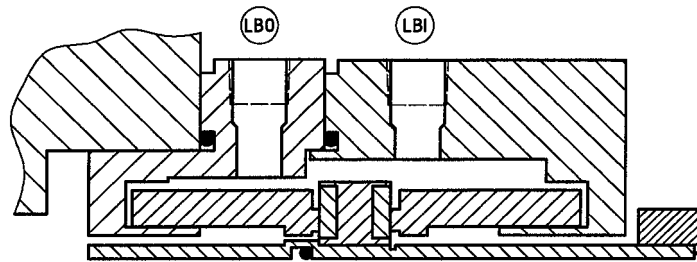
Figure 4 — Arrangement 2: Two seals per cartridge assembly with or without a gas buffer fluid



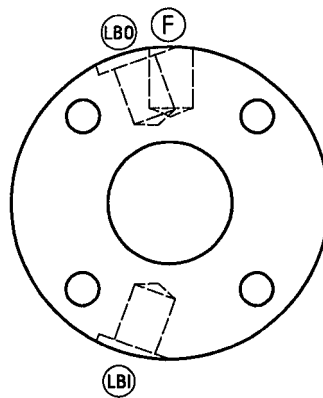
a) 3CW-FB, contacting wet seals in a face-to-back configuration



b) 3CW-BB, contacting wet seals in a back-to-back configuration



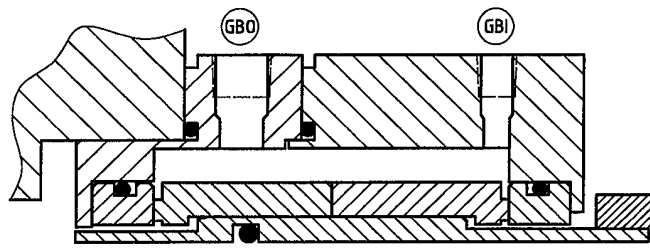
c) 3CW-FF, contacting wet seals in a face-to-face configuration



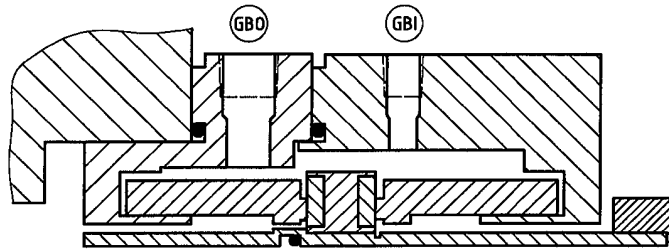
d) Typical gland plate connection orientation

NOTE For connection designations, see 6.1.2.17, Table 1.

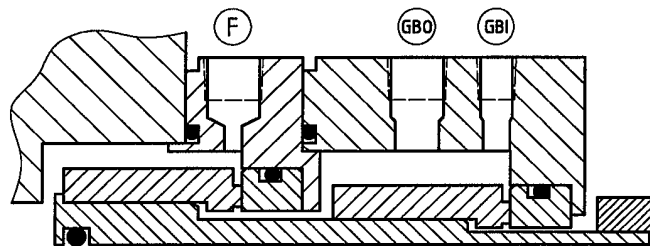
Figure 5 — Arrangement 3: Two seals per cartridge assembly with a liquid barrier fluid



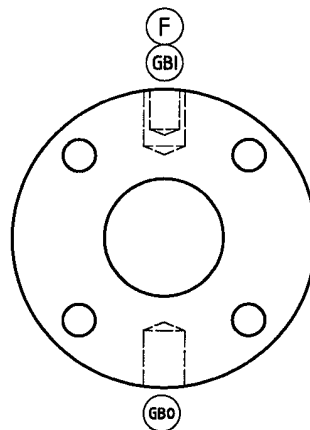
a) 3NC-BB, non-contacting seals in a back-to-back configuration



b) 3NC-FF, non-contacting seals in a face-to-face configuration



c) 3NC-FB, non-contacting seals in a face-to-back configuration



d) Typical gland plate connection orientation

NOTE For connection designations, see 6.1.2.17, Table 1.

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

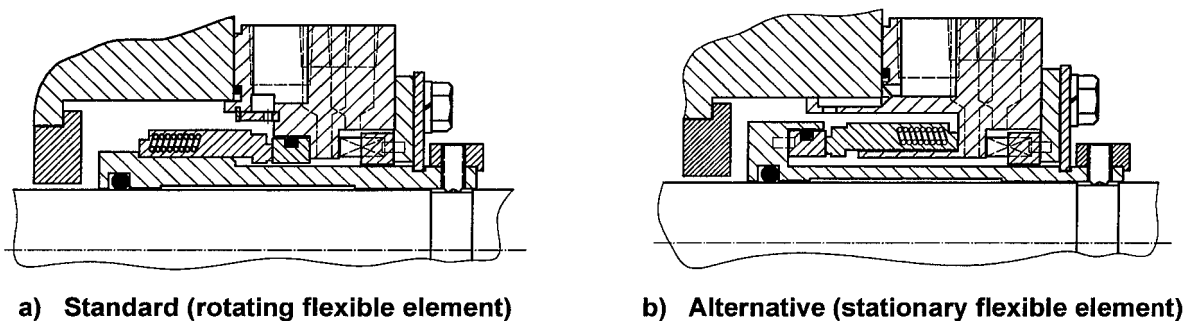


Figure 7 — Arrangement 1 Type A seals

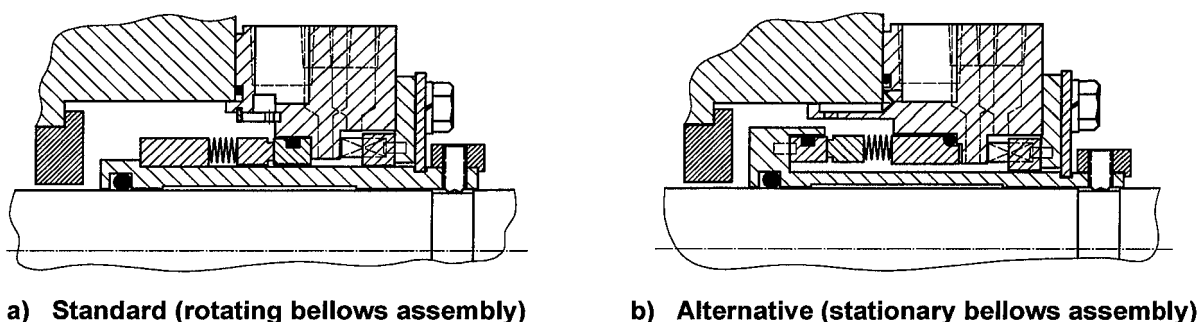


Figure 8 — Arrangement 1 Type B seals

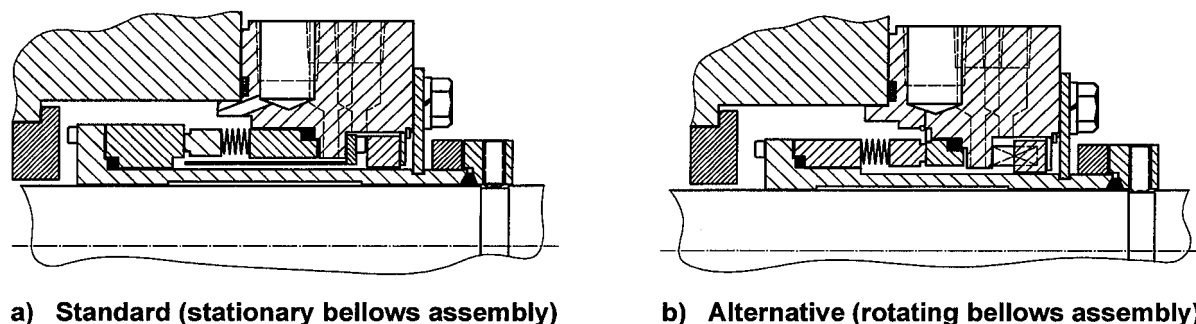


Figure 9 — Arrangement 1 Type C seals

5 General

5.1 Unit responsibility

Unless otherwise specified, the pump vendor shall have unit responsibility for the seal system if the seal system is purchased as part of a pump system. If not purchased as part of a pump system, the seal vendor shall have unit responsibility for the seal system. The vendor who has unit responsibility shall ensure that all sub-vendors comply with the requirements of this International 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 International Standard shall use SI units or US 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.

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

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

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

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

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

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

NOTE 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.

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

- balance diameter exceeds 115 mm (4,5 in) (see 6.1.1.7);
- pump case or gland plate distortion and misalignment exist due to pipe loads, thermal distortion, pressure distortion, etc.;
- the perpendicularity of the seal chamber mounting surface to the shaft is a problem, aggravated by high rotational speed; or
- the seal chamber face runout requirements described in 6.1.2.13 cannot be met (as found with some slender-shaft, multi-stage pump designs).

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

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

6.1.1.7 The seal manufacturer shall design the seal faces and seal balance ratio to minimize seal-face-generated heat consistent with optimum life expectations in 4.2 and emissions limit requirements. The seal balance ratio measurement points shall be as shown in Figure 10.

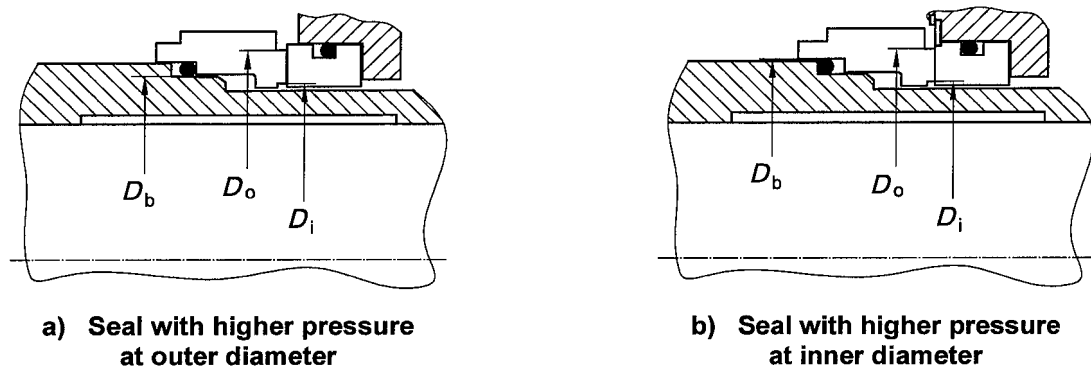


Figure 10 — Balance ratio measurement points

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

$$B = \frac{(D_o^2 - D_b^2)}{(D_o^2 - D_i^2)}$$

where

D_o is the seal face outside diameter;

D_i is the seal face inside diameter;

D_b is the balance diameter of the seal.

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

$$B = \frac{(D_b^2 - D_i^2)}{(D_o^2 - D_i^2)}$$

where

D_o is the seal face outside diameter;

D_i is the seal face inside diameter;

D_b is the balance diameter of the seal.

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

Temperature control plays an important role in the success of a mechanical seal. Every seal generates heat at the seal faces. In some cases, heat soak from the fluid pumped should also be controlled. Heat soak is the heat transferred from the pump and pumped fluid to fluid in the seal chamber. For example, if a particular fluid must be maintained at 60 °C (140 °F) to maintain a satisfactory vapour pressure margin and the pump

operating temperature is 146 °C (295 °F), heat would be transferred through the pump case into the seal chamber. The combined heat load (soak- and face-generated) should be carried away by the flush. Annex F provides guidance on the calculation of heat soak and seal-generated heat.

NOTE 1 The calculated heat load allows sizing of the cooling system, determination of start-up and running torques, determination of flush rates, and boiling point margins. Normally, seal flush rates are based upon a maximum allowable 5 °C (10 °F) temperature rise, considering all heat inputs. Certain seal chamber arrangements such as dead-ended and taper bore boxes have other considerations.

NOTE 2 Starting torque, seal power and seal-generated heat can be significant issues for small pump drivers, seals at or above the balance diameter and pressure boundaries of this International Standard, and for Arrangement 3 seals.

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

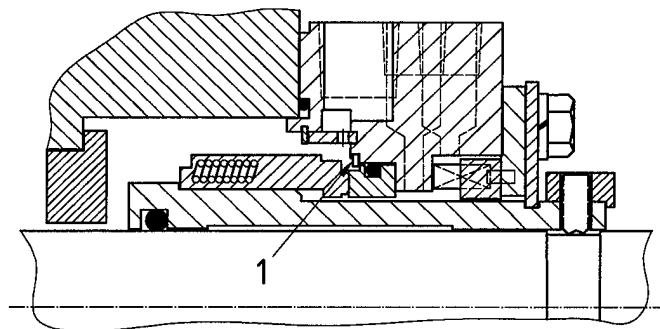
NOTE Maximum axial movement is of particular concern in hot multi-stage pumps. During start-up conditions, it is not unusual for a large amount of differential thermal growth to occur between the shaft and casing. This differential can exceed the capabilities of some seals. Axial movement is also a concern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

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

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

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

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



Key

1 retaining feature as required in 6.1.1.11

Figure 11 — Positive retention of seal components in vacuum services

6.1.2 Seal chamber and gland plate

6.1.2.1 Gland plates shall be provided by the seal manufacturer.

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

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

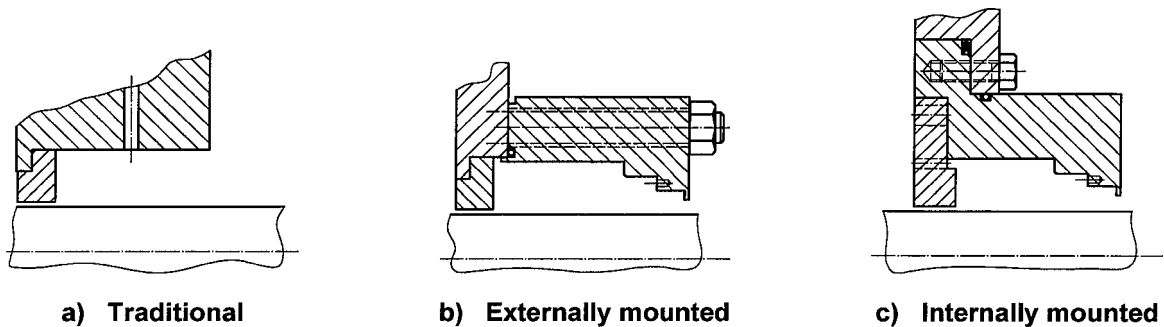


Figure 12 — Seal chamber types

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

Category 1 seals shall be designed to fit into the dimensional envelope defined by ISO 3069 Type C or by ASME B73.1 and ASME B73.2.

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

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

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 International 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.

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

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

6.1.2.6 The minimum radial clearance between the rotating components of the seal and the stationary surfaces of the seal chamber and gland plate shall be 3 mm (1/8 in) except as noted in 8.6.2.3 (circulation devices), 7.2.5.1, and 7.2.6.1 (Arrangement 2 containment seal chamber bushings).

NOTE The 3 mm (1/8 in) radial clearance might not be possible in small pump sizes and ISO 3069 Type C seal chambers. See 6.1.2.4.

6.1.2.7 All bolt and stud stresses shall be in accordance with the pressure design code at the maximum allowable working pressure. Four studs shall be used. The diameter of the studs shall be in accordance with the seal chamber dimensional references in 6.1.2.4. Larger studs shall be furnished only if required to meet the stress requirements of EN 13445 or ASME VIII, or to sufficiently compress spiral-wound gaskets in accordance with ASME B16.20.

6.1.2.8 The maximum allowable working pressure of the seal pressure casing shall be equal to or greater than that of the pump pressure casing on which it is installed. The seal pressure casing shall have a corrosion allowance of 3 mm (1/8 in), and shall have sufficient rigidity to avoid any distortion that would impair seal operation, including distortion that may occur during tightening of the bolts to set gasketing. If approved by the purchaser, a smaller corrosion allowance may be acceptable for some higher alloy materials.

The following shall also apply.

- a) Unless otherwise specified, gland plates shall be provided with holes (not slots) for attachment studs.
- b) Provisions shall be made for centring the seal gland plates and/or chamber with either an inside- or an outside-diameter register fit. The register-fit surface shall be concentric to the shaft and shall have a total indicated runout of not more than 0,125 mm (0,005 in), see Figure 13. The rabbet diametrical clearance shall be H7/f7 in accordance with ISO 286-2.
- c) A shoulder at least 3 mm (1/8 in) thick shall be provided in the seal gland plate to prevent the stationary element of the mechanical seal from dislodging as a result of chamber pressure, see Figure 14.

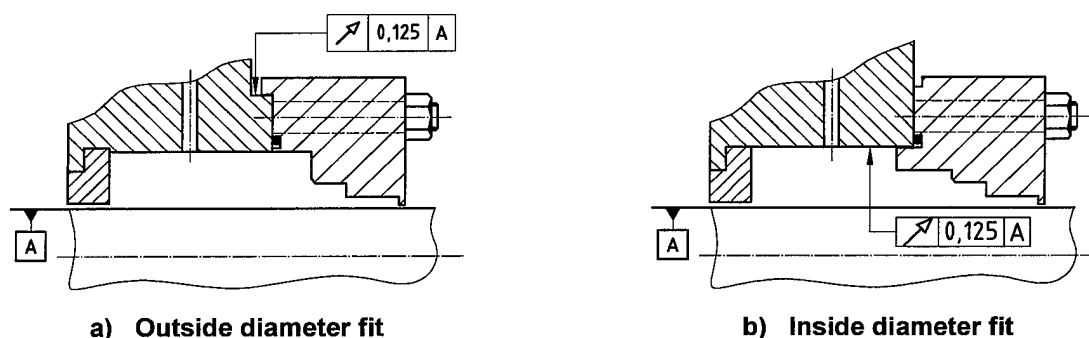
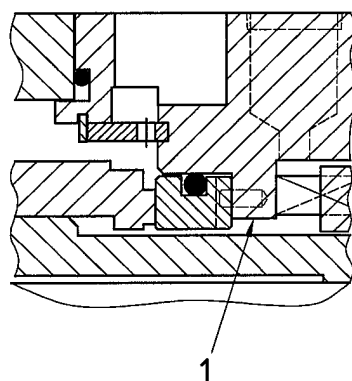


Figure 13 — Seal chamber register concentricity



Key

- 1 seal gland plate shoulder

Figure 14 — Section showing seal gland plate shoulder

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

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

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

6.1.2.12 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.

Unless otherwise specified, studs 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.

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

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

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

6.1.2.13 The seal manufacturer shall design for seal chamber face runout (TIR) up to $0,5 \mu\text{m}/\text{mm}$ ($0,0005 \text{ in/in}$) of seal chamber bore, see Figure 15. Some multistage, slender-shaft designs may not be able to meet the requirements of this clause (see 6.1.1.5).

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.

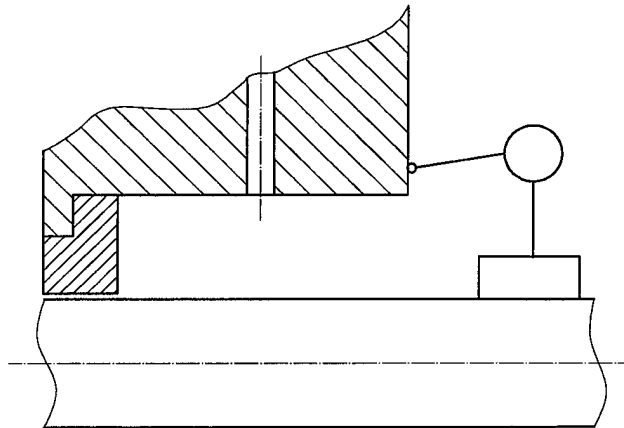


Figure 15 — Seal chamber face runout

6.1.2.14 For Arrangement 1 and Arrangement 2, seal chamber pressure and support systems for contacting wet seals (excluding containment seals) shall be designed for a margin of not less than 30 % between seal chamber pressure and maximum fluid vapour pressure, or a 20°C (36°F) product temperature margin based on the maximum process fluid temperature.

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

- a) confirm the adequacy of the seal selection and flush plan based on the specified fluid,
- b) recommend the seal chamber operating conditions (minimum pressure and maximum temperature) that will result in a seal installation that has a high probability of achieving 3 years of uninterrupted service,
- c) furnish the seal gland plate or seal chamber with a second flush connection to permit measurement of seal chamber pressure directly, and
- d) furnish a distributed flush system unless space limitations preclude its use.

During operation, the seal chamber pressure shall be at least 35 kPa (0,35 bar) (5 psi) above atmospheric pressure. This is particularly important if the inlet pressure to the pump is below atmospheric.

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

NOTE For contacting wet seal designs, maintaining an adequate vapour pressure margin helps protect the seal faces against localized boiling of the process fluid at the seal faces. Boiling of the process fluid at the seal faces can cause loss of seal-face lubrication and subsequent seal failure. Low-density fluids are some of the most troublesome fluids to seal and account for a high percentage of seal repairs. These margins can be achieved in many ways. For example, using one or a combination of the following options can provide a vapour pressure and product temperature margin for reliable seal performance. The application of these solutions is usually the result of mutual agreement between the purchaser, seal manufacturer and pump manufacturer:

- lowering the seal chamber fluid temperature by cooling the flush fluid;
- raising the seal chamber pressure by removing the back wear ring and plugging impeller balance holes;
- utilizing an external flush fluid; and/or
- raising the seal chamber pressure through the use of a close-clearance (floating) throat bushing.

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

Some applications may not need complicated seal flush systems. A generic example of this is cooling water service. Assuming the water is at 38 °C (100 °F) and an atmospheric pump suction and seal chamber pressure exists, the absolute vapour pressure would be 6,5 kPa (0,065 bar) (0,94 psi). The absolute vapour pressure at 58 °C (136 °F) would be about 18,6 kPa (0,186 bar) (2,7 psi). Ample product temperature margin would be present in the seal chamber to provide good seal life without seal flush fluid cooling or pressurizing the seal chamber.

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

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

- to increase or decrease seal chamber pressure;
- to isolate the seal chamber fluid; and/or
- to control the flow into or out of the seal chamber.

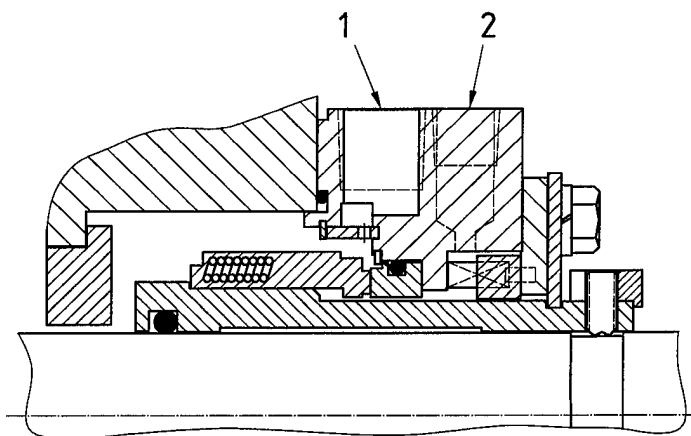
See also Annex A for additional guidance concerning the use of throat bushings.

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

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

The lack of space for tap and port connections in the seal chamber area may require that these be included within the pump manufacturer's scope of supply. Annex E specifies the interface responsibilities of the pump and seal vendors.

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



Key

- 1 process side
- 2 atmospheric side

Figure 16 — Mechanical seal piping connections

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

Seal configuration	Symbol	Connection	Location	Type	Size ^a		Connection required ^g
					Category 1	Categories 2 and 3	
1CW-FX 1CW-FL	F	flush	0	process	1/2 ^c	1/2	required
	FI	flush in (Plan 23 only)	180	process	1/2 ^c	1/2	WS
	FO	flush out (Plan 23 only)	0	process	1/2 ^{c, f}	1/2	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
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	WS
	FO	flush out (Plan 23 only)	0	process	1/2 ^{c, f}	1/2	WS
	GBI	gas buffer fluid in	90	process	1/4	1/4	WS
	CSV	containment seal vent	0	process	1/2	1/2	required
	CSD	containment seal drain	180	process	1/2	1/2	required
	D	drain (outer seal)	180	atmospheric ^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 are NPT tapered thread connections, unless the purchaser specifies the equivalent ISO 7 thread.

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

^d 1/2 NPT required for shaft diameters 63,5 mm (2,5 in) or smaller, 3/4 NPT for larger shaft sizes.

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

^f A tangential connection is preferred for the outlet.

^g WS = Connection is provided only when the appropriate flush plan is specified.

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

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

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

NOTE 2 The head on a pipe plug interferes with the installation and actual 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 due to the limited axial space.

6.1.2.19 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.

6.1.2.20 Gland plates and/or seal chambers for contacting wet seals shall be designed such that the seal chamber and piping system is self-venting during start-up and operation through the piping system. Designs, other than Plan 23, requiring manual seal chamber venting shall be approved by the purchaser. 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 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 3 mm (1/8 in) above the seal faces to allow the removal of trapped gas if contacting wet seal arrangements are vertically oriented. This port shall be uppermost in the chamber (see Figure 17). This applies to ports for both sets of faces in Arrangement 2 (2CW-CW configuration) and the outer seal face of Arrangement 3 contacting wet seals when they are vertically oriented.
- c) Horizontal or vertical pumps having a flush Plan 23 or vertical pumps having flush Plans 11, 21, 31 and 41 shall be provided with a separate vent connection in the piping. Vertical pumps having flush Plan 2 shall have a vent connection in the gland plate. Designs, other than these, requiring manual seal chamber venting require purchaser's approval.
- 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 Plan 11 or Plan 13 on a small pump). Entrained gas will quickly purge from the piping and seal chamber upon start-up of the pump.
- 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.

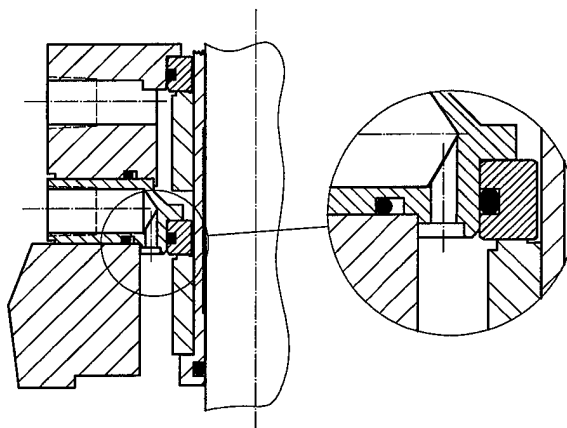


Figure 17 — Seal chamber/gland plate for vertical pumps

6.1.2.21 Drilled passages shall be sized for the application and shall have a minimum diameter of 5 mm (3/16 in).

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

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

Table 2 — Floating carbon throttle bushing diametrical clearances

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

- **6.1.2.24** If specified, heating jackets or inserts shall be provided on seal chambers. Heating requirements shall be agreed between the purchaser, vendor and seal manufacturer.
- **6.1.2.25** If specified by the purchaser, or if recommended by the seal manufacturer, a flush connection to the process side of the seal chamber shall be provided in Arrangement 3 configurations. 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 assist in the 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.

6.1.2.26 The supply of flush tap and port connections shall satisfy the requirements in 5.1. The lack of space for tap and port connections off the gland plate may require that these be included within the pump manufacturer's scope of supply, if approved by the purchaser.

6.1.3 Cartridge seal sleeves

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

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

6.1.3.2 The seal manufacturer shall obtain the shaft diameter and tolerance from the pump manufacturer and ensure a shaft-to-sleeve fit of F7/h6 in accordance with ISO 286-2. This correlates to a clearance of 0,020 mm (0,000 8 in) to 0,093 mm (0,003 7 in) for the range of seal sizes covered by this International Standard, and varies as a function of diameter. The intent is to minimize sleeve runout (see Figure 18), while allowing for ease of assembly/disassembly. Shrink disks typically require tighter clearances, and should follow the shrink-disk manufacturer's design criteria (see Figure 19).

ISO 13709 requires a shaft diameter tolerance of h6, however special cases may exist in which pumps are supplied with shaft diameter tolerances outside this. In such cases, the seal manufacturer shall ensure an appropriate fit.

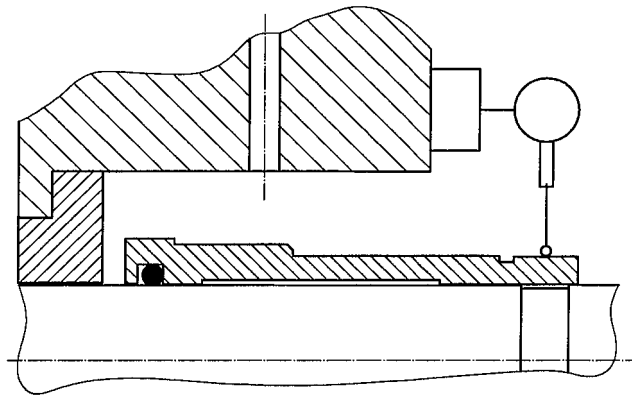


Figure 18 — Seal sleeve runout

6.1.3.3 Sleeves shall have a shoulder (or shoulders) to positively locate the rotating flexible element.

6.1.3.4 Unless otherwise specified, 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.

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

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

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

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

6.1.3.7 Sleeves shall have a minimum radial thickness of 2,5 mm (0,100 in) at their thinnest section, such as under seal-setting plate grooves.

The sleeve thickness in the area of component drive set screws shall be in accordance with Table 3.

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

NOTE 2 Excessively thin sleeves distort easily.

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

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

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

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

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

6.1.3.10 Drive-collar set screws shall not pass through clearance holes unless the sleeve bore is relieved. For between-bearing pumps, the shaft shall be relieved in this area.

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.

6.1.3.11 Drive-collar set screws shall be of sufficient hardness to securely embed in the shaft. The pump and seal vendor shall ensure that adequate relative hardness exists between the pump shaft and the drive-collar set screws. See Annex E.

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

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

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

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

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

NOTE 3 It may not be possible to use pre-existing spot drilling for replacement seals.

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

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

6.1.4 Mating rings

6.1.4.1 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 21).

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

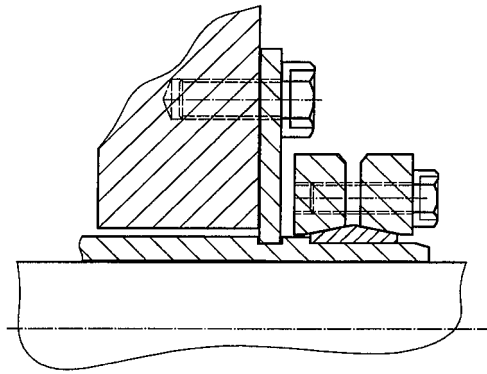


Figure 19 — Seal sleeve attachment by shrink disk

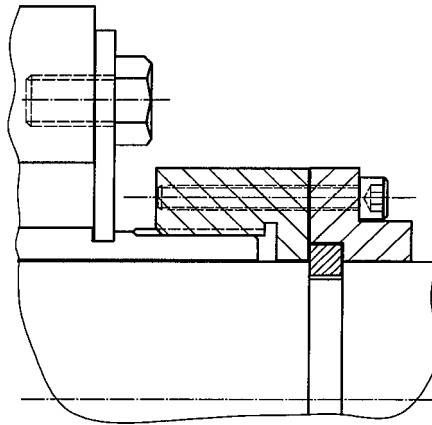


Figure 20 — Seal sleeve attachment by split ring

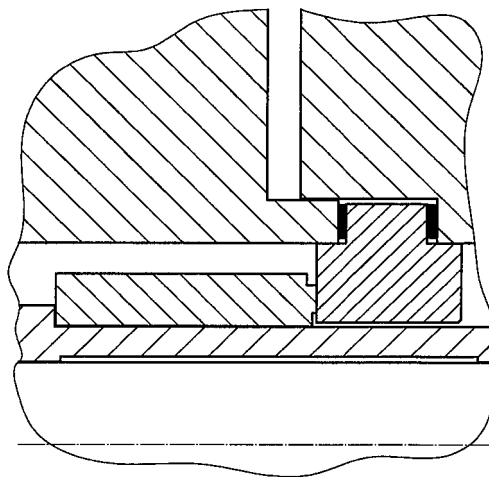


Figure 21 — Clamped faces

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

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

6.1.5 Flexible elements

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

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

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

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

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.

6.1.6 Materials

6.1.6.1 General

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

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

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

6.1.6.1.3 Materials identified in the proposal other than those specified in this International Standard, or materials for an engineered seal, or exceptions to materials in this International 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.

6.1.6.2 Seal faces

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

6.1.6.2.2 Except as required by 6.1.6.2.4, one of the rings shall be premium grade, blister-resistant carbon graphite, with manufacturing treatment to reduce wear, provide chemical resistance and minimize porosity consistent with the intended service.

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

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

NOTE See B.3 for guidance related to manufacture and use of RBSiC versus SSSiC.

6.1.6.2.4 Abrasive, viscous and high-pressure services may require two hard materials. For such services, unless otherwise specified, both the seal ring and the mating rings shall be silicon carbide. Other hard face combinations of SSSiC, RBSiC and tungsten carbide are widely used, and are acceptable with purchaser approval (see B.4 for further guidance).

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

The user should be aware of the potential inappropriateness of some seal face material combinations for use during pump shop testing because of the test fluid, water.

NOTE See B.4 for guidance regarding the selection of optimum hard face-material combinations.

6.1.6.2.5 Seal and mating rings shall be of one 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.

6.1.6.3 Seal sleeves

Unless otherwise specified, seal sleeves shall be stainless steel [AISI Type 316, 316L or 316Ti, or equivalent (see B.1)].

6.1.6.4 Springs

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

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 AISI Type 316 stainless steel may be just as suitable in the same service using a single spring.

6.1.6.5 Secondary sealing components

6.1.6.5.1 Unless otherwise specified, O-rings shall be fluoroelastomer (FKM). Temperature limitations for elastomers are listed in B.5.

6.1.6.5.2 Unless otherwise specified, if operating temperatures or chemical compatibility preclude the use of fluoroelastomers (FKM), O-rings shall be perfluoroelastomers (FFKM). See B.6 for additional details.

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

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

6.1.6.6 Metal bellows

Unless otherwise specified, metal bellows shall be Alloy C-276 for Type B seals and Alloy 718 for Type C seals.

6.1.6.7 Gland plates

6.1.6.7.1 Gland plates for alloy pumps shall be of the same alloy as the casing, or one with superior corrosion resistance and mechanical properties. Unless otherwise specified, gland plates for other pumps shall be stainless steel [AISI Type 316, 316L or 316Ti, or equivalent (see B.1)].

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

NOTE Spiral-wound gaskets have bolt torque requirements for full compression. See 6.1.2.7 for bolting requirements for spiral-wound gaskets.

6.1.6.8 Bolt-on seal chambers

6.1.6.8.1 Bolt-on seal chambers 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 [AISI 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.

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

6.1.6.9 Miscellaneous parts

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

6.1.6.9.2 The pump and seal vendors shall ensure that outside drive components have suitable corrosion resistance for the service (see Annex E for guidance). If used, set screws shall have sufficient hardness and design to carry the load. Alternative methods may be used, such as spot drilling, split rings or shrink disks. See also 6.1.3.12 and 6.1.3.13.

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

6.1.6.10 Welding

6.1.6.10.1 Welding of piping, pressure-containing parts, rotating parts and other highly stressed parts, weld repairs and any dissimilar metal welds shall be performed and inspected by operators and procedures qualified in accordance with the appropriate part of EN 287 and EN 288, or ASME IX. Metal bellows used in non-pusher seal construction are exempted from this requirement because they are manufactured using a proprietary welding process which is not covered by general welding codes or industry standards.

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

6.1.6.10.3 Unless otherwise specified, non-pressure-retaining structural welding, such as welding on baseplates, non-pressure ducting, lagging and control panels, shall be performed in accordance with AWS D1.1.

6.1.6.10.4 Pressure casings made of wrought materials or combinations of wrought and cast materials shall conform to the conditions specified in a) to d) below. This includes bolt-on seal chambers if constructed by welding.

- a) Plate edges shall be inspected by magnetic particle or liquid penetrant examination as required by ASME VIII, Division 1, UG-93(d)(3).
- b) Accessible surfaces of welds shall be inspected by magnetic particle or liquid penetrant examination after back-chipping or gouging and again after post-weld heat treatment.
- c) Pressure-containing welds, including welds of the case to horizontal and vertical joint flanges, shall be full-penetration welds.
- d) Fabricated pressure-retaining parts (regardless of thickness) shall be post-weld heat-treated.

6.1.6.10.5 Connections welded to the pressure-retaining parts shall be installed as follows.

- a) In addition to 6.1.6.10.1, if specified, 100 % radiography, magnetic particle examination, ultrasonic examination, or liquid penetrant examination of welds shall be performed.
- b) Auxiliary piping welded to alloy steel pressure-retaining parts shall be of a material with the same nominal properties as the casing material or shall be of low carbon austenitic stainless steel. Other materials compatible with the casing material and intended service may be used with the purchaser's approval.
- c) If heat treatment is required, piping welds shall be made before the component is heat-treated.
- d) If specified, proposed connection designs shall be submitted to the purchaser for approval before fabrication. The drawings shall show weld designs, size, materials, and pre- and post-weld heat treatments.
- e) All welds shall be heat-treated in accordance with the methods described in EN 13445 or ASME VIII, Division 1, UW-40.

6.1.6.11 Low temperature service

- **6.1.6.11.1** For operating temperatures below $-29\text{ }^{\circ}\text{C}$ ($-20\text{ }^{\circ}\text{F}$) or, if specified, for other low ambient temperatures, steels shall have properties as described in 6.1.6.11.2 to 6.1.6.11.6.

NOTE Also see B.5, which covers temperature limits for elastomers.

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

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

6.1.6.11.3 All pressure-retaining steels applied at a specified minimum design metal temperature below $-29\text{ }^{\circ}\text{C}$ ($-20\text{ }^{\circ}\text{F}$) require a Charpy V-notch impact test of the base metal and the weld joint unless they are

exempt in accordance with ASME VIII, Division 1, UHA-51. Impact test results shall meet the requirements of ASME VIII, Division 1, UG-84.

6.1.6.11.4 Carbon and low alloy steel pressure-retaining parts applied at a specified minimum design metal temperature between $-30\text{ }^{\circ}\text{C}$ ($-20\text{ }^{\circ}\text{F}$) and $40\text{ }^{\circ}\text{C}$ ($100\text{ }^{\circ}\text{F}$) shall require impact testing, as follows.

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

6.1.6.11.5 The governing thickness used to determine impact-testing requirements shall be the greater of the following:

- a) the nominal thickness of the largest butt welded joint;
 - b) the largest nominal section for pressure containment, excluding:
 - structural support sections such as feet or lugs; and
 - structural sections required for attachment or inclusion of mechanical features such as jackets or seal chambers; or
 - c) one fourth of the nominal flange thickness, including gland plate and seal chamber flanges.
- **6.1.6.11.6** The purchaser shall specify the minimum design metal temperature to be used to establish impact test requirements.

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

6.2 Design requirements (category-specific)

6.2.1 Category 1 seals

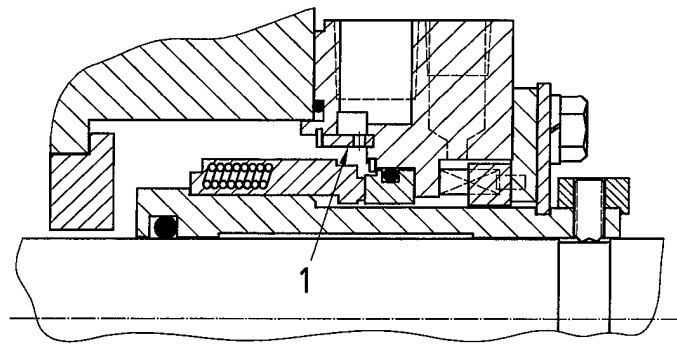
6.2.1.1 General information (Category 1)

This subclause provides design details for Category 1 seals, as described in Clause 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 6.1.2.14, a distributed seal flush system such as a circumferential or multi-port arrangement shall be provided for Arrangement 1 and Arrangement 2 seals with rotating flexible elements. The seal flush arrangement shall be located to maximize the uniformity and degree of cooling of the seal faces. For multi-port systems, ports having a minimum diameter of 3 mm (1/8 in) shall be used. The seal flush passages shall be designed so that they can be cleaned (see Figure 22).

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

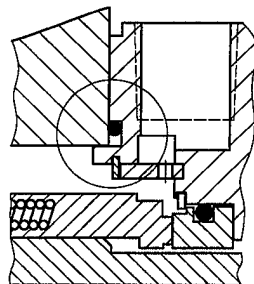
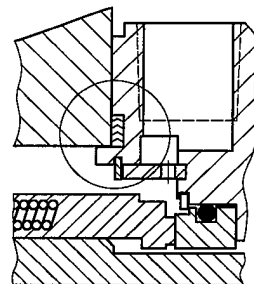
**Key**

1 distributed flush

Figure 22 — Distributed seal flush system

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

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

**a) O-ring****b) Spiral-wound gasket****Figure 23 — Mating joint gasket****6.2.2 Category 2 seals****6.2.2.1 General information (Category 2)**

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

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

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

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

6.2.2.3 Cartridge seal sleeves (Category 2)

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

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

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

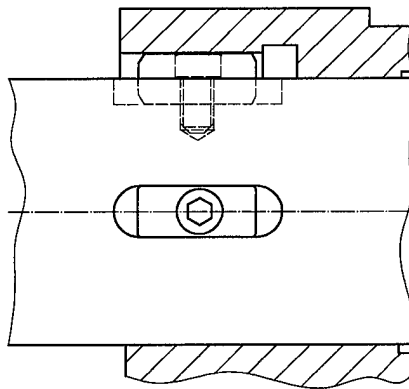


Figure 24 — Attachment of key drives to shaft

6.2.3 Category 3 seals

6.2.3.1 General information (Category 3)

This subclause provides design details for Category 3 seals, as described in Clause 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 subclause.

6.2.3.2 Seal chamber and gland plate (Category 3)

A distributed seal flush system such as a circumferential or multi-port arrangement shall be provided for all Category 3 Arrangement 1 and Arrangement 2 seals with rotating flexible elements. The seal flush arrangement shall be located to maximize the uniformity and degree of cooling of the seal faces. For multi-port systems, a minimum of 3 mm (1/8 in) diameter ports shall be used. The seal flush passages shall be cleanable (see Figure 22).

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

7 Specific seal configurations

7.1 Arrangement 1 seals

7.1.1 Seal sleeves

Seal sleeves shall be in one piece.

7.1.2 Seal chamber and gland plate

7.1.2.1 Unless otherwise specified:

- a) a fixed carbon throttle bushing shall be installed in the gland plate for Category 1 seals;
- b) a fixed non-sparking metal bushing shall be installed in the gland plate for Category 2 seals; and
- c) a close-clearance (floating) carbon throttle bushing shall be installed in the gland plate for Category 3 seals.

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

Bushings may be sized to allow for thermal growth of the shaft.

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

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

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

7.2 Arrangement 2 seals

7.2.1 General

7.2.1.1 Unless otherwise specified, the inner seal shall be a contacting wet seal (2CW-CW or 2CW-CS). The inner seal shall have an internal (reverse) balance feature designed and constructed to withstand reverse pressure differentials up to 0,275 MPa (2,75 bar) (40 psi) without opening or dislodging components.

NOTE The containment seal chamber pressure is normally less than the inner seal chamber pressure. The containment seal chamber is usually connected through an orifice to a vapour recovery system, in which case it will operate at the pressure of the system to which it is connected. It is unusual for a vapour recovery system to reach a gauge pressure of 0,275 MPa (2,75 bar) (40 psi) even under upset conditions.

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

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

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

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

Inner and outer seal faces are a contacting design if a liquid buffer system is provided. For gas buffer systems, contacting or non-contacting containment seal face designs may be used.

NOTE Non-contacting containment seals utilize a face pattern (grooves, waves, etc.) to provide lift-off of the seal faces. Relative to contacting "dry-running" containment seals, non-contacting face designs:

- a) have a lower wear rate in operation;
- b) are more tolerant to a "bone-dry" buffer gas environment; and
- c) are designed for higher surface speeds and pressure differentials.

Contacting containment seal designs normally provide the lowest leakage of vapours and liquids. Manufacturer's standard dry contacting seal designs are pressure-limited for continuous service, usually below a gauge pressure of 0,07 MPa (0,7 bar) (10 psi). However, designs are suitable in a gas environment of product vapours for continuous operation with excursions in gauge pressure to 0,275 MPa (2,75 bar) (40 psi) to allow for variation in the vapour recovery system pressure. Friction and rubbing wear is dependent on the shaft speed, containment seal chamber pressure, and properties of the vapour being sealed. Use of "bone-dry" nitrogen as a buffer gas can result in rapid carbon face wear.

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

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

7.2.2 Seal sleeves

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

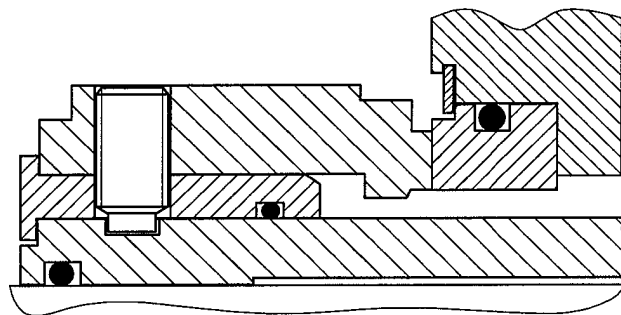


Figure 25 — Auxiliary sleeve arrangement

7.2.2.2 If recommended by the vendor and agreed by the purchaser, alternative auxiliary sleeve designs may be provided. To ensure reliable seal performance, the fit of the auxiliary sleeve and the seal sleeve should meet the requirements of Clause 6.

NOTE Having an auxiliary sleeve at the inboard end of a dual seal cartridge permits the inner seal to be installed from the inboard end. It reduces the time and complexity involved in cartridge assembly. It also makes it possible for the inner and outer pusher seal to be the same size.

7.2.3 Seal chamber and gland plates

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

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

NOTE Limited axial space between the seal chamber face and the bearing housing often makes the use of a throttle bushing with an Arrangement 2 seal impractical.

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

7.2.4.1 General

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

- 8 °C (15 °F) for glycol/water or diesel buffer fluids; and
- 16 °C (30 °F) for mineral oil buffer fluids.

NOTE The allowable temperature differential 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.

7.2.4.2 Seal chamber and gland plates

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

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

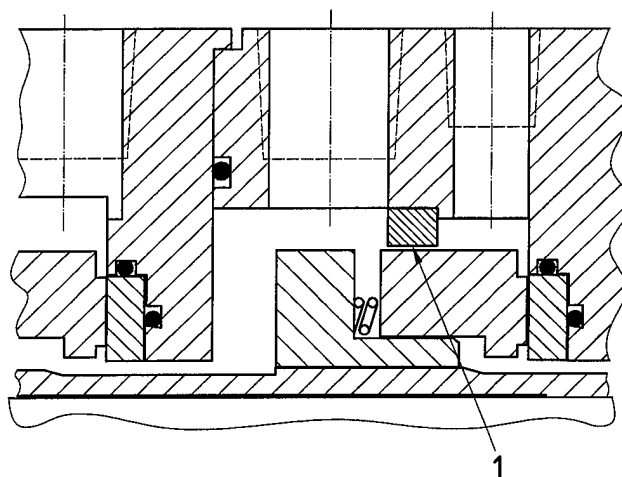
7.2.5 Seal chamber and gland plates for contacting wet inner seal with a dry-running containment seal (2CW-CS)

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

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

NOTE The bushing 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.

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

**Key**

1 containment-seal chamber bushing

Figure 26 — Section showing containment-seal chamber bushing for 2CW-CS and 2NC-CS configurations

7.2.6 Seal chamber and gland plates for non-contacting inner seal with a dry-running containment seal (2NC-CS)

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

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

NOTE The bushing 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.

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

7.3 Arrangement 3 seals

7.3.1 General

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

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

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

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

NOTE The internal or reverse balance feature requires that the mating ring and the secondary seal be designed to stay in place in the event that barrier fluid pressure is lost. Barrier-fluid pressure is usually regulated between a gauge pressure of 0,14 MPa (1,4 bar) (20 psi) and 0,41 MPa (4,1 bar) (60 psi) over the pressure in the seal chamber.

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

7.3.2 Seal sleeves

Where possible, seal sleeves shall be designed as one piece. Cartridge designs that incorporate an auxiliary sleeve at the inboard end of the seal sleeve to facilitate the assembly of the inner seal components are acceptable. The auxiliary sleeve shall be axially located on the seal sleeve by a shoulder and driven by dog-point set screws (see Figure 25). To ensure reliable seal performance, the fit of the auxiliary sleeve and the seal sleeve should meet the requirements of Clause 6.

NOTE Having an auxiliary sleeve at the inboard end of a dual-seal cartridge permits the inner seal to be installed from the inboard end. It reduces the time and complexity involved in cartridge assembly. It also makes it possible for the inner and outer pusher seal to be the same size.

7.3.3 Seal chamber and gland plates

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

The specification of a throttle bushing for a dual seal is rarely required, but may be used in services where a quench is used to avoid icing.

NOTE Limited axial space between the seal-chamber face and the bearing housing often makes the use of a throttle bushing with an Arrangement 3 seal impractical.

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

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

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

7.3.4.1 General

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:

- 8 °C (15 °F) for glycol/water or diesel barrier fluids; and
- 16 °C (30 °F) for mineral oil barrier fluids.

NOTE The allowable temperature differential 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.

7.3.4.2 Standard seal types and arrangements

7.3.4.2.1 Unless otherwise specified, the configuration shall have the inner and outer seals arranged in series (see Figure 5, 3CW-FB).

NOTE The series arrangement is preferred because any abrasive contamination is centrifuged out and has less effect on the inner seal and, in the event of loss of barrier-fluid pressure, the seal will behave like an Arrangement 2 seal.

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

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

7.3.4.3 Seal chambers and gland plates

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

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

7.3.5 Standard seal types and arrangements for non-contacting seal configurations with a gas barrier fluid (3NC-FB, 3NC-FF, 3NC-BB)

7.3.5.1 The standard seal shall be a back-to-back (3NC-BB) configuration (Figure 6). 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. The purchaser should verify that any special pump casing vent needs are satisfied.

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

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

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

8 Accessories

8.1 Auxiliary piping systems

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

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

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

b) Group II (quench systems):

- 1) steam injection or quench;

- 2) water injection or quench;
 - 3) drains and vents; or
 - 4) inert gas quench.
- c) Group III (cooling-water systems):
- 1) cooling water; or
 - 2) drains and vents.

Auxiliary systems shall comply with the requirements of Table 4.

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

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

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

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

8.1.6 Piping design and joint fabrication, examination and inspection shall comply with ISO 15649. Welding shall be performed by operators and procedures qualified in accordance with the appropriate part of EN 287 and EN 288, or ASME IX.

NOTE For the purpose of these provisions, ASME B31.3 is equivalent to ISO 15649.

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

- a) proper support and protection to prevent damage from vibration or from shipment, operation and maintenance;
- b) proper flexibility and normal accessibility for operation, maintenance and thorough cleaning;
- c) installation in a neat and orderly arrangement adapted to the contour of the machine without obstructing access openings;
- d) elimination of air pockets by the use of valved vents or non-accumulating piping arrangements;
- e) complete drainage through low points without disassembly of piping, seal or gland plate components;
- f) reduction of the number of potential emission sources and pressure drop by minimizing the use of threaded connections, flanges, fittings and valves; and
- g) the system should be suitable for any special cleaning/decontamination procedures identified by the purchaser (i.e. steam cleaning, solvent wash, etc.).

Table 4 — Minimum requirements for auxiliary piping materials

Component	Fluid					
	Auxiliary process fluid		Steam		Cooling water	
	Category		Gauge pressure		Nominal size	
	Non-flammable/ non-hazardous	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	seamless ^a	seamless ^a	seamless ^a	seamless ^a	—	carbon steel, (ASTM A 120 Schedule 40 galvanised to ASTM A 153)
Tubing ^b	stainless steel (ASTM A 269 seamless Type 316)	stainless steel (ASTM A 269 seamless Type 316)	stainless steel (ASTM A 269 seamless Type 316)	stainless steel (ASTM A 269 seamless Type 316)	stainless steel (ASTM A 269 seamless Type 316)	—
All valves	Class 800	Class 800	Class 800	Class 800	Class 200 bronze	Class 200 bronze
Gate and globe valve	bolted bonnet and gland	bolted bonnet and gland	bolted bonnet and gland	bolted bonnet and gland	—	—
Pipe fittings and unions	forged Class 3 000	forged Class 3 000	forged Class 3 000	forged Class 3 000	malleable iron (ASTM A 338 and A 197 Class 150) galvanised to ASTM A 153	malleable iron (ASTM A 338 and A 197 Class 150) galvanised to ASTM A 153
Tube fittings	manufacturer's standard	manufacturer's standard	manufacturer's standard	manufacturer's standard	manufacturer's standard	—
Fabricated joints ≤ DN 25 (NPS 1)	threaded	socket-welded	threaded	socket-welded	threaded	—
Fabricated joints ≥ DN 40 (NPS 1 1/2)	—	—	—	—	—	Purchaser to specify
Gaskets	—	Type 304 or 316 stainless steel spiral wound	—	Type 304 or 316 stainless steel spiral wound	—	—
Flange bolting	—	low alloy steel (ASTM A 193 Grade B7 ASTM A 194 Grade 2H)	—	low alloy steel (ASTM A 193 Grade B7 ASTM A 194 Grade 2H)	—	—

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

Examples of acceptable materials are:

Carbon steel pipe: ASTM A 53, Grade B; ASTM A 106, Grade B; ASTM A 524; or or API Spec 5L, Grade A or B.

Carbon steel fittings, valves, and flanged components: ASTM A 105 and ASTM A 181.

Stainless steel piping: ASTM A 312, Type 316L.

Stainless steel fittings, valves and flanged components: ASTM A 182, Type 316L.

^a Schedule 80 shall be used for diameters from DN 15 to DN 40 (NPS 1/2 to NPS 1 1/2); schedule 40 shall be used for diameters DN 50 (NPS 2) and larger.

^b Acceptable tubing sizes are (see ISO 4200): 12,7 mm dia × 1,66 mm wall (1/2 in dia × 0,065 in wall), 19 mm dia × 2,6 mm wall (3/4 in dia × 0,095 in wall), 25 mm dia × 2,9 mm wall (1 in dia × 0,109 in wall).

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

- **8.1.9** Pipe shall have tapered threads in accordance with ISO 7 or ASME B1.20.1, as specified by the purchaser. Flanges shall be in accordance with ISO 7005-1.

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

Slip-on flanges may be used only with the purchaser's approval. For socket-welded construction, a 1,5 mm (1/16 in) gap shall be left between the pipe end and the bottom of the socket.

8.1.10 The following nominal sizes of connections, piping, valves and fittings shall not be used: DN 30 (NPS 1 1/4), DN 65 mm (NPS 2 1/2), DN 90 (NPS 3 1/2), DN 125 (NPS 5), DN 175 (NPS 7) or DN 225 (NPS 9).

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

- a) Category 1: 2,2 MPa (22 bar) (315 psia) at ambient temperature,
- b) Category 2 and Category 3: 4,2 MPa (42 bar) (615 psia) at ambient temperature.

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

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

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

8.1.15 The minimum nominal size of any connection or piping shall be DN 15 (NPS 1/2). Gland plate connections shall be in accordance with 6.1.2.17.

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

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

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

8.1.19 Pressure gauges shall have block-bleed valves.

8.2 Mechanical seal flush/cooling systems (Group I)

8.2.1 The purchaser and the mechanical seal manufacturer shall mutually agree as to which auxiliary seal flush plan or plans (refer to Annex G, Figures G.1 to G.26) shall be furnished to meet the seal chamber pressure and temperature requirements of 6.1.2.14.

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

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

NOTE This requirement enhances venting, and thermosyphoning when the pump shaft is not rotating.

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

8.2.3.2 An austenitic stainless steel tag shall be securely fastened to all coolers provided with seal flush Plan 23. In letters a minimum of 6 mm (1/4 in) high, this tag shall read: "IMPORTANT: ALL TRAPPED GAS MUST BE VENTED FROM THIS SYSTEM PRIOR TO OPERATION TO PREVENT DAMAGE TO THE MECHANICAL SEAL."

8.3 Quench systems (Group II)

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

- a) the design shall direct the quench to the seal face and secondary seals;
- b) seals equipped with a water quench shall be designed to allow quench water to exit via the drain connection; and

NOTE 1 Quenching 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 dried. 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.

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

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

8.4 Cooling-water systems (Group III)

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

- **8.4.2** If specified, galvanized pipe shall be used.
- **8.4.3** If specified, sight flow indicators (open or closed as specified) shall be furnished in each outlet line.
- **8.4.4** If specified, each utility, such as air and inert gas 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 which may require simultaneous use of the specified utility.

Table 5 — Conditions affecting cooling water system design

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

8.5 Accessories and auxiliary system components

8.5.1 Cyclone separator

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

8.5.1.2 Cyclone separators shall be selected to optimize removal of solids for a specific pump stage differential. If the pressure differential exceeds the cyclone separator design differential, a flow orifice may be used. Cyclone separators shall not be used with a pressure differential less than 0,17 MPa (1,7 bar) (25 psi).

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

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

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

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

Table 6 — Approximate densities of materials found in process streams

Substance	Density kg/m ³ (lb/ft ³)
Cement, sand, stone	2 307 (144)
Clay	1 762 (110)
Coke	513 (32)
Earth (mud)	1 538 (96)
Gasoline (relative density 0,7)	721 (45)
Glass	2 595 (162)
Kerosene	801 (50)
Limestone	2 355 (147)
Paraffin	897 (56)
Sand	2 018 (126)
Steel	7 801 (487)
Sulfur	2 002 (125)
Tar	1 201 (75)
Water	993 (62)
Wood (pine)	432 (27)

8.5.2 Flow control orifice

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

An orifice may be required in the seal flush system solely, or in conjunction with a throat bushing and/or cyclone separator to

- a) limit the seal flush circulation rate to the seal,
- b) control the seal chamber pressure.

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

The following shall apply.

- a) All orifices shall have a minimum bore of 3 mm (1/8 in).

NOTE Orifice bores smaller than 3 mm (1/8 in) become blocked more easily and can cause a seal failure.

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

8.5.2.3 Multiple orifices, installed in series, may be used if more pressure drop is required than can be taken in a single 3 mm (1/8 in) orifice. Noise through an orifice can be excessive, especially when the flowrate is high. The purchaser and supplier shall ensure proper sizing of the orifice to minimize airborne noise.

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

8.5.3 Seal flush coolers

8.5.3.1 External-seal flush coolers mounted in the seal flush piping may be considered as a viable means of creating the required product temperature margin (see 6.1.2.14). When furnished, external-seal flush coolers shall be in accordance with 8.5.3.1.1 to 8.5.3.1.7. Requirements for coolers mounted within or integral to barrier/buffer-fluid reservoirs are given in 8.5.4.5.

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

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

The user should design the cooler system to avoid shell overpressurization 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.

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

- **8.5.3.1.4** If specified by the purchaser, or if required by local regulations, the seal flush coolers shall be designed, fabricated, and inspected in accordance with ISO 15649 using piping components.

NOTE For the purpose of this provision, ASME B31.3 is equivalent to ISO 15649.

8.5.3.1.5 Unless otherwise specified, for shaft diameters over 60 mm (2,5 in), tube outside diameters shall be 19 mm (3/4 in) with 2,4 mm (0,095 in) minimum wall thickness. For shaft diameters 60 mm (2,5 in) and below, tube outside diameters shall be 12,7 mm (1/2 in) with 1,6 mm (0,065 in) minimum wall thickness. As a minimum, for all sizes, unless otherwise required by 8.1.12, the tubes shall be of austenitic stainless steel and the shell shall be of carbon steel.

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

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

8.5.4 Barrier/buffer fluid reservoirs

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

- **8.5.4.2** Unless otherwise specified, the barrier/buffer-fluid reservoir shall be arranged as follows (see Figures G.27 and G.28).

- a) A separate reservoir shall be furnished for each mechanical seal.
- b) The barrier/buffer-fluid reservoir shall be mounted on a substantial support furnished by the manufacturer specified on the data sheet and should not be affected by pump vibration (see 8.1.3).
- c) The height of the normal liquid level (NLL) in the barrier/buffer-fluid reservoir above the gland plate of the associated pump shall be established by the seal manufacturer. It shall not be less than 1 m (3 ft). It shall be based on required flowrate, 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.

- d) In order to reduce the pressure drop within the system, the length of the lines and the use of fittings between the reservoir and seal gland plate shall be minimized. All lines shall slope up from the pump gland to the reservoir at a minimum of 10 mm per 240 mm (1/2 in per ft), using smooth long radius bends.
- e) Barrier/buffer-fluid reservoirs should be located as close to the pump as possible while leaving sufficient room for operation and maintenance. Reservoirs should not be located directly above the pump and should not be affected by pump vibration. Hot lines should be insulated as necessary for safety.
- f) Unless otherwise specified, the reservoir shall be provided with a valved high-point vent and an independent fill connection. A method of filling the reservoir shall be considered during the engineering phase of a project to install external barrier/buffer-fluid reservoirs. Provide a means to fill the seal reservoir under pressure (to prevent a pressure reversal for barrier-fluid applications). A closed fill system, one which enables the operator to fill the reservoir without exposure to the barrier/buffer fluid, should be considered. Manual filling is discouraged. It should be possible to fill the reservoir from grade level for safety and operability. A system that requires the use of a ladder or step is unacceptable. Whatever system is incorporated, adequate instrumentation and pressure-relief protection shall be provided to prevent the inadvertent overpressurization of the reservoir or the system. These systems are normally in the user's scope of supply, but can often be supplied by the seal or pump supplier upon request.

Some examples include

- 1) a centrally located tank which is permanently connected by piping to various reservoirs and/or day tanks utilizing gravity fill, a transfer pump, or inert gas pressure to transfer the barrier/buffer fluid,
- 2) a hand pump which can be connected to a day tank or drum with a hose or removable spool piece, or
- 3) 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.

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

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

- g) Unless otherwise specified, flow orifices shall be provided in accordance with 8.5.2.

NOTE Frequently, buffer fluid reservoirs are continuously vented to a vapour 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.

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

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

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

8.5.4.3 Unless otherwise specified, the reservoir shall be designed to meet the sizing criteria as follows (see Figures G.27 and G.28).

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

- 1) 12 l (3 U.S. gal) for shaft diameters 60 mm (2,5 in) and smaller,
- 2) 20 l (5 U.S. gal) for shaft diameters larger than 60 mm (2,5 in).

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

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

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

NOTE The requirements in b) and c) provide adequate volume to allow for fluctuations in level while ensuring adequate vapour space above the liquid.

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

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

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

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

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

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

8.5.4.4 The barrier/buffer fluid reservoir shall be fabricated in accordance with 8.5.4.4.1 to 8.5.4.4.10.

- **8.5.4.4.1** The standard reservoir shall be in accordance with Figure G.27. If specified, the reservoir shall be in accordance with Figure G.28.

8.5.4.4.2 The reservoir is part of the pump piping system. Unless otherwise specified or required by local code, the reservoir shall be designed, fabricated and inspected in accordance with ISO 15649 using piping components.

NOTE For the purpose of this provision, ASME B31.3 is equivalent to ISO 15649.

8.5.4.4.3 Unless otherwise specified, reservoirs shall be fabricated as follows.

- a) 12 l (3 U.S. gal) reservoirs shall be fabricated from DN 150 (NPS 6) schedule 40 pipe; and
- b) 20 l (5 U.S. gal) reservoirs shall be fabricated from DN 200 (NPS 8) schedule 40 pipe.

If the reservoir is built entirely of piping components, ISO 15649 can be applied and provides adequate design for the reservoir just as it does for the pump suction and discharge piping. It is the user's responsibility to ensure that local codes do not require that reservoirs be built in accordance with a pressure vessel code such as EN 13445 or ASME VIII, Division 1.

NOTE For the purpose of this provision, ASME B31.3 is equivalent to ISO 15649.

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

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

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

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

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

- a) 12 mm (1/2 in) minimum, for shaft diameter 60 mm (2,5 in) and smaller; and
 - b) 18 mm (3/4 in) minimum, for shaft diameter greater than 60 mm (2,5 in), if practical.
- **8.5.4.4.9** If specified, schedule 80, austenitic stainless steel pipe in accordance with Table 4 and below shall be provided:
 - a) 12 mm (1/2 in) minimum, for shaft diameter 60 mm (2,5 in) and smaller; and
 - b) 18 mm (3/4 in) minimum, for shaft diameter greater than 60 mm (2,5 in), if practical.

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

8.5.4.5 Unless otherwise specified, the barrier/buffer-fluid reservoir shall be equipped with a cooling coil, as follows.

- a) The criteria for thermal sizing of the cooling coil shall be provided by the seal manufacturer (see 8.4.1). The seal manufacturer shall confirm that the reservoir cooling coil selected will meet the expected thermal duty requirements at the site utility conditions specified on the data sheets. While it is expected that there will be standard-size cooling coils based on the length of the reservoir, the seal manufacturer shall take into account several factors when specifying the minimum size of cooling coil needed. These include internal circulating device or external circulator flowrates, the need for thermosyphon, cooling liquid parameters, and characteristics of the barrier/buffer fluid.
- b) The use of other cooling media should be investigated if ambient conditions do not allow the use of water due to freezing potential or if the available cooling water is of very poor quality and prone to fouling.
- c) 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.
- d) The tubes shall be austenitic stainless steel, 12 mm (1/2 in) with minimum wall thickness of 1,6 mm (0,065 in). No tubing connectors, fittings, or seams mounted internal to the reservoir are allowed.
- e) Reservoirs equipped with cooling coils that will not be used in the field installation shall have the cooling water inlet and outlet connection plugged in accordance with 6.1.2.18.
- f) The cooling coil shall be arranged so that it can be completely drained.

8.5.5 Barrier/buffer-fluid selection criteria

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

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

8.6 Barrier/buffer fluid and seal flush positive-circulating devices

8.6.1 General

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

8.6.2 Internal circulating device

8.6.2.1 The internal circulating device shall provide the required flowrate using the specified barrier/buffer fluid, at all operating and start-up conditions based upon the accessory components supplied and the maximum installation criteria in Figure G.29 and Figure G.30.

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

- **8.6.2.2** 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 test results.

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

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

8.6.3 External circulating pump

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

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

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

8.6.4 External seal flush systems

- **8.6.4.1** If an external source of seal flush is specified (Figure G.11 and Figure G.18) the purchaser shall specify the fluid characteristics. The seal manufacturer shall specify the volume, pressure and temperature required, where these are factors.
- **8.6.4.2** If specified, the seal and/or pump manufacturer shall review the purchaser's selection of external flush.

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

8.6.5 Condensate collection reservoir

8.6.5.1 If a condensate collection system is provided, the system shall comply with 8.6.5.2 to 8.6.5.7 (see Figure G.25).

8.6.5.2 The condensate collection reservoir:

- a) shall be at least 200 mm (8 in) diameter carbon steel, schedule 40, and 12 l (3 U.S. gal) minimum capacity in accordance with 8.5.4.4.2, 8.5.4.4.4 and Table 4. For pumps manufactured from a material other than carbon steel, the reservoirs shall be of the same material as the pump casing, or have corrosion resistance and mechanical properties superior (in the specified process fluid) to the material used for the pump casing;
- 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 3/4 NPT minimum drain connection that terminates with a fully ported globe valve; and
- e) shall have a 1/2 NPT minimum vent connection, to which piping for the primary seal leakage-detection pressure switch, pressure gauge and restriction orifice is installed.

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

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

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

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

8.6.5.7 The pipe from the gland plate to the collector shall have a minimum slope of 42 mm/m (1/2 in/ft) towards the collector. The minimum pipe size shall be DN 15 (NPS 1/2).

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

8.6.6 Barrier/buffer-gas supply systems

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

8.6.6.2 Barrier/buffer-gas supply systems shall be provided by the seal supplier and include as a minimum a pressure regulator, coalescing filter, indicating flow meter, check valve, inlet and outlet isolation valves, low pressure switch and a pressure gauge (see Figure G.31).

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

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

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

- **8.6.6.5** If specified, a high-flow switch shall be provided and installed between the flow meter and the check valve (see Figure G.23 and Figure G.24).

9 Instrumentation

9.1 General

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

9.1.2 Unless otherwise specified, 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).

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

9.2 Temperature-indicating gauges

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

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

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

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

9.3 Thermowells

Temperature gauges that are in contact with flammable or toxic fluids or that are located in pressurized or flooded lines shall be furnished with separable threaded solid-bar thermowells made of austenitic stainless steel or another material more compatible with the liquid as defined by the manufacturer. Thermowells installed in piping shall be DN 15 (NPS 1/2) minimum. Thermowells for use in tubing shall be approved by the purchaser. Thermowell designs and installation should not restrict liquid flow.

9.4 Pressure gauges

9.4.1 Pressure gauges shall be in accordance with ISO 10438.

NOTE For the purpose of this provision, API 614 is equivalent to ISO 10438.

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

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

9.5 Switches

9.5.1 Alarm, trip and control switches

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

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

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

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

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

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

9.5.2 Pressure switches

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

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

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

9.5.3 Level switches

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

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

9.5.4 Flow switches

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

9.6 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

If used, flow indicators shall be of the non-restrictive bull's-eye type and shall have a steel body.

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 armoured rotameter or internal magnetic float design in accordance with the following.

- a) Rotameters shall be installed in the vertical position and piped in accordance with the vendor's recommendations.
- b) The capacity of the rotameter selected shall be such that normal flowrate 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 60 °C (140 °F) or less, and gauge pressures of 0,7 MPa (7 bar) (100 psi) or less.

9.7.3 Flow transmitters

- If specified, flow transmitters shall be furnished.

9.8 Relief valves

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

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

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

9.9 Regulators

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

- a) Regulators shall be self-contained, spring-loaded with an internal pressure-sensing connection.
- b) The regulators shall be designed such that the regulated pressure is applied directly to the diaphragm through the valve body.
- c) An adjusting device shall be provided with a locking mechanism to ensure that the control point cannot shift or be changed inadvertently.
- d) The regulator body shall be rated for the maximum upstream and downstream pressure and temperature to which it may be subjected.
- e) Cast iron valve bodies are not permitted — cast aluminum, if approved by the purchaser, is permitted only in air or nitrogen service; spring and diaphragm housings shall be steel or stainless steel.

9.10 Pressure amplifiers

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

10 Inspection, testing and preparation for shipment

10.1 General

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

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

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

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

10.1.5 Unless otherwise specified, the purchaser's representative shall have access to the manufacturer's quality control programme 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 International 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 6.1.6.10, the purchaser may specify the following:

- a) parts that shall be subjected to surface and subsurface examination; and
- b) the type of examination required, such as magnetic-particle, liquid-penetrant, radiographic or ultrasonic examination.

10.2.3 The non-destructive 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, Articles 2 and 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 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, Articles 7 and 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, Articles 6 and 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 b), d), f) and h) above, it shall be the manufacturer's responsibility to review the design limits of the equipment in the event that more stringent requirements are necessary. Defects that do not meet the acceptance criteria imposed in 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

The sequence for seal testing is shown in Figure 27.

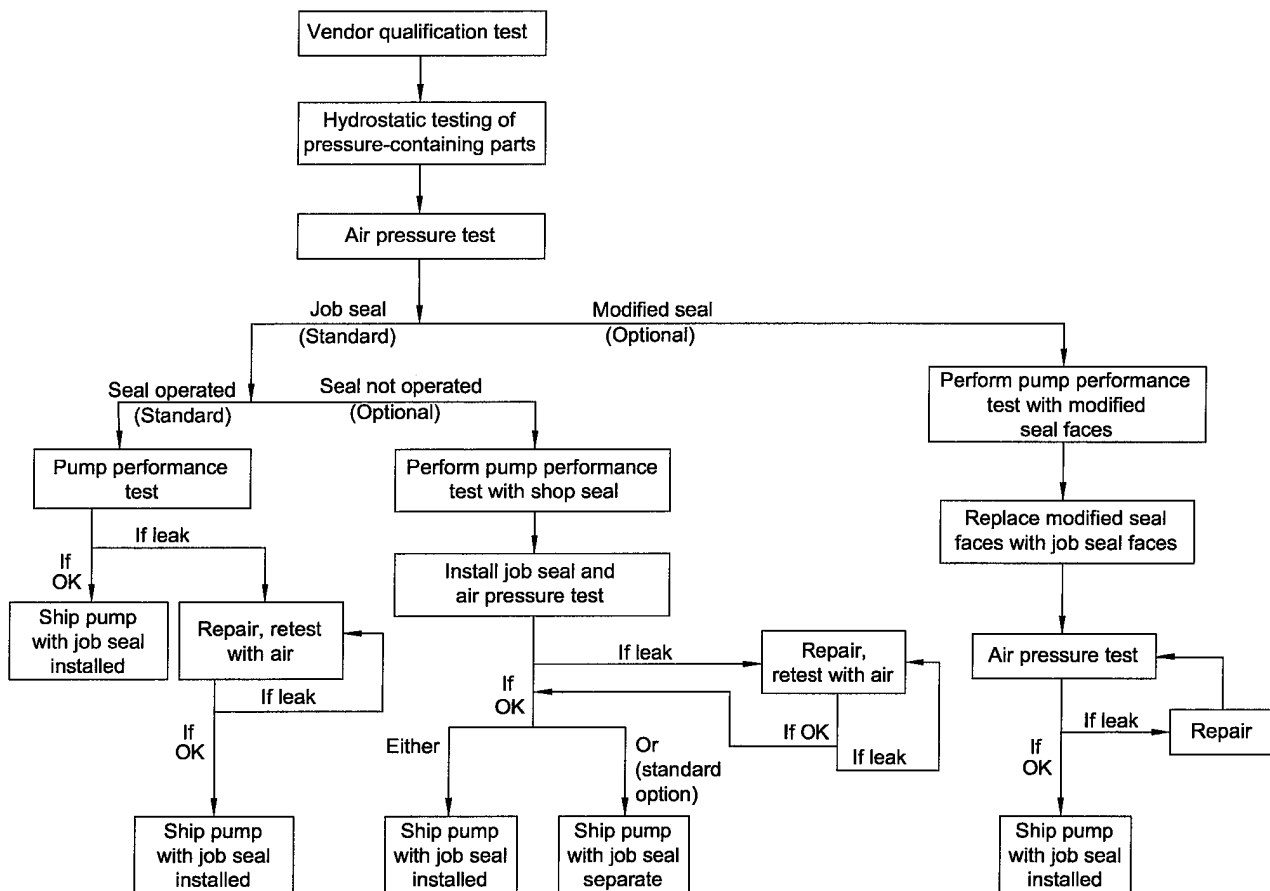


Figure 27 — Seal testing sequence

10.3.1 Seal qualification testing

10.3.1.1 Purpose

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

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

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

The purchaser may specify test conditions that differ from the standard qualification test, as applicable.

10.3.1.2 Scope of test

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

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

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

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

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

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

10.3.1.2.5 Seals shall be tested in four different test fluids that model the fluids shown in the three application groups from the recommended seal selection procedure (Annex A). The test fluids are: water, propane, 20 % NaOH solution, and mineral oil. The mineral oil is a white mineral oil base formulation capable of stable operations at high temperatures up to 315 °C (600 °F). Table 7 identifies the test fluid for each application group.

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

Table 7 — Test fluid and application group selection chart

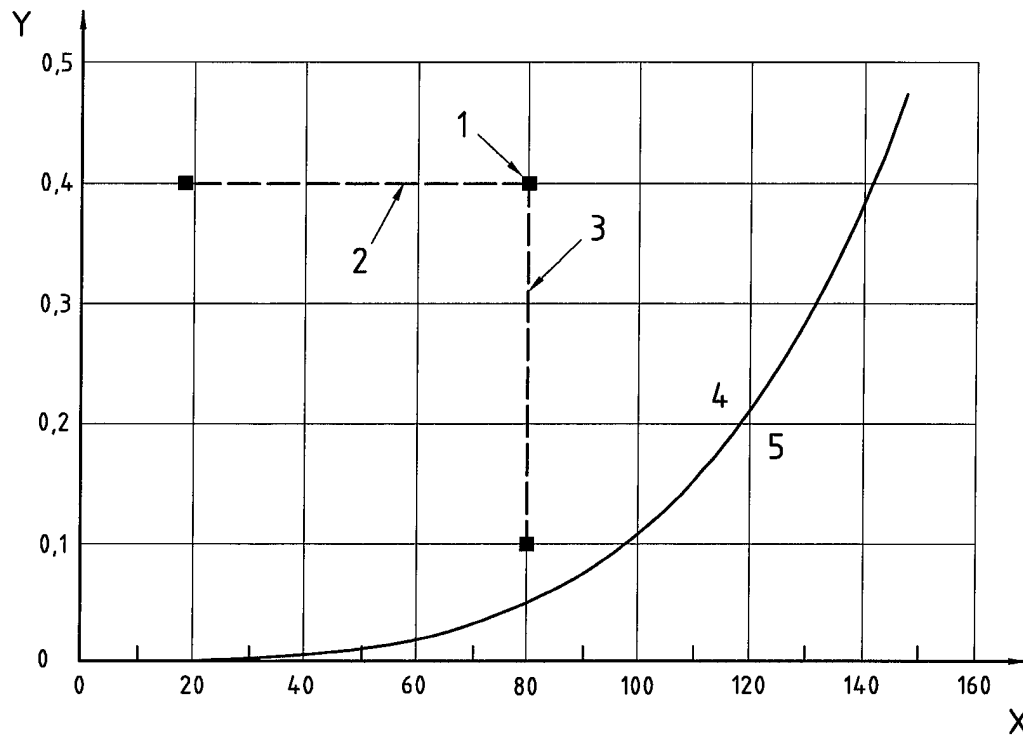
Application group	Test fluid			
	Water	Propane	NaOH (20 %)	Mineral oil
Non-hydrocarbons				
Water	X			
Sour water	X			
Caustic			X	
Acid	X			
Non-flashing hydrocarbons				
– 40 °C to – 7 °C (– 40 °F to 20 °F)		X		
– 7 °C to 150 °C (20 °F to 300 °F)				X
150 °C to 400 °C (300 °F to 750 °F)				X
Flashing hydrocarbons				
– 40 °C to – 7 °C (– 40 °F to 20 °F)		X		
– 7 °C to 38 °C (20 °F to 100 °F)		X		
38 °C to 150 °C (100 °F to 300 °F)				X

10.3.1.2.6 Each qualification test for each test fluid shall consist of the three following phases (see Figures 28 to 32).

- The dynamic phase shall be tested at constant temperature, pressure and speed (base point).
- The static phase shall be tested at 0 r/min using the same temperature and pressure as the dynamic phase.

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

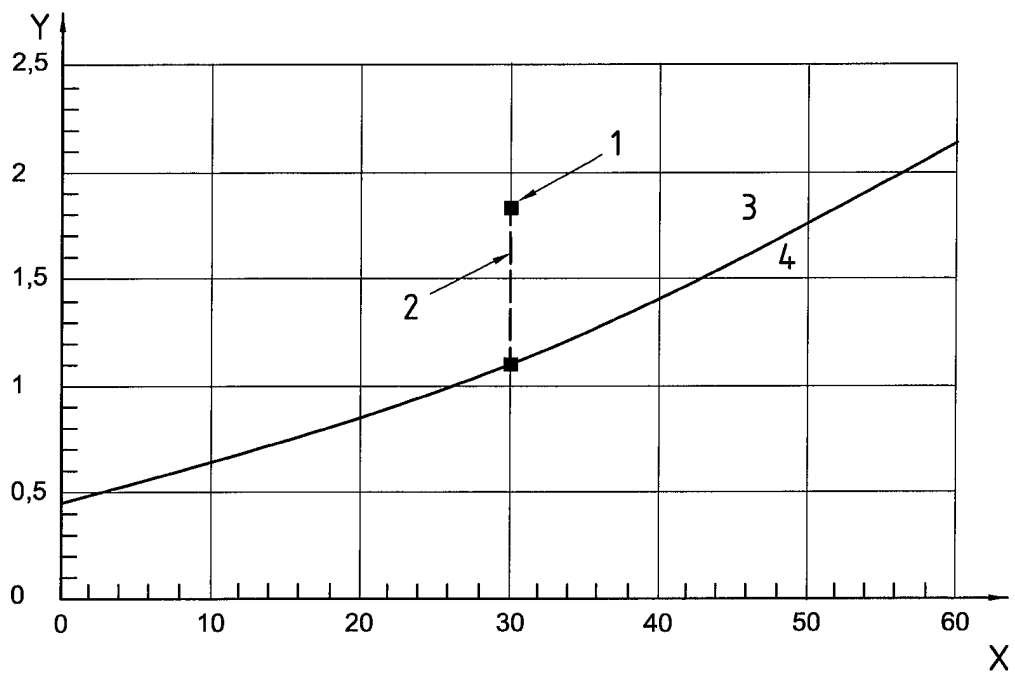
NOTE These phases were selected to qualify the seal type for the operating ranges (temperatures and pressures) defined in each application group. Figures 28 to 32 show a graphical representation of the test operating parameters for all three phases and each test fluid. The test phases were selected to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



Key

- X temperature, °C
- Y absolute pressure, MPa
- 1 base-point conditions
- 2 temperature cycle
- 3 pressure cycle
- 4 liquid phase
- 5 vapour phase

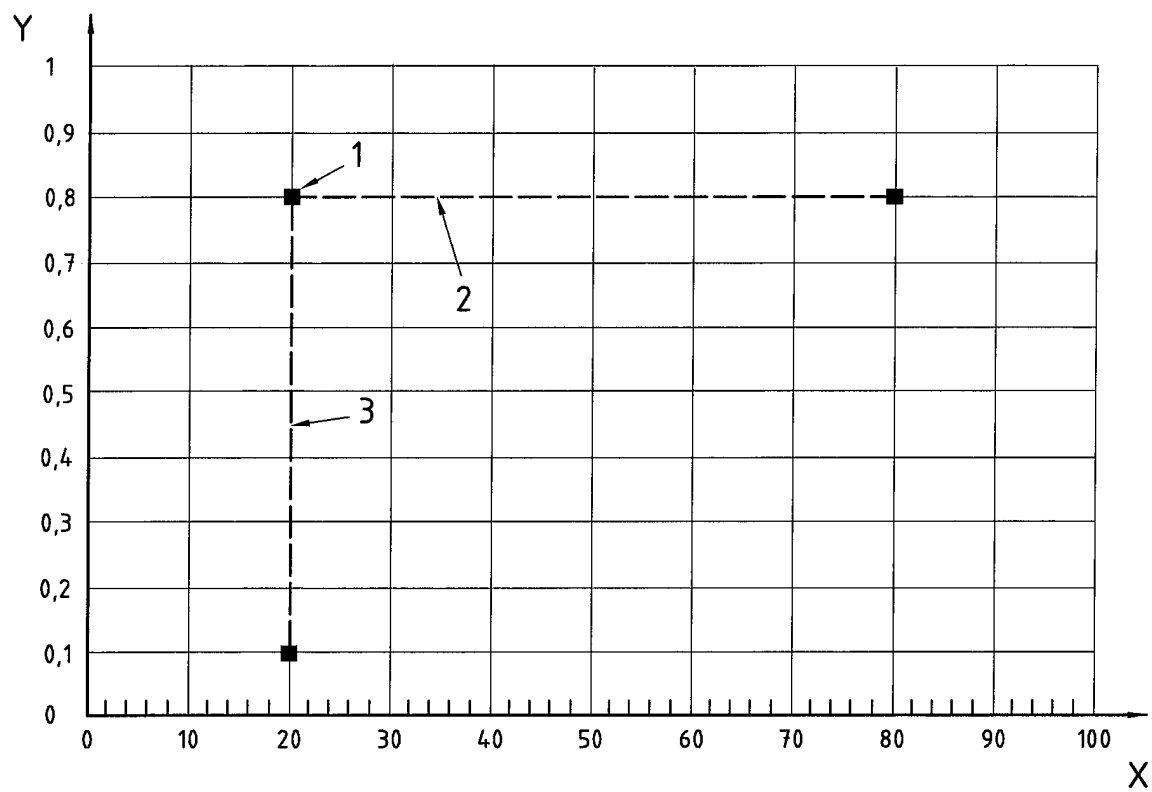
Figure 28 — Water test parameters



Key

- X temperature, °C
- Y absolute pressure, MPa
- 1 base-point conditions
- 2 pressure cycle
- 3 liquid phase
- 4 vapour phase

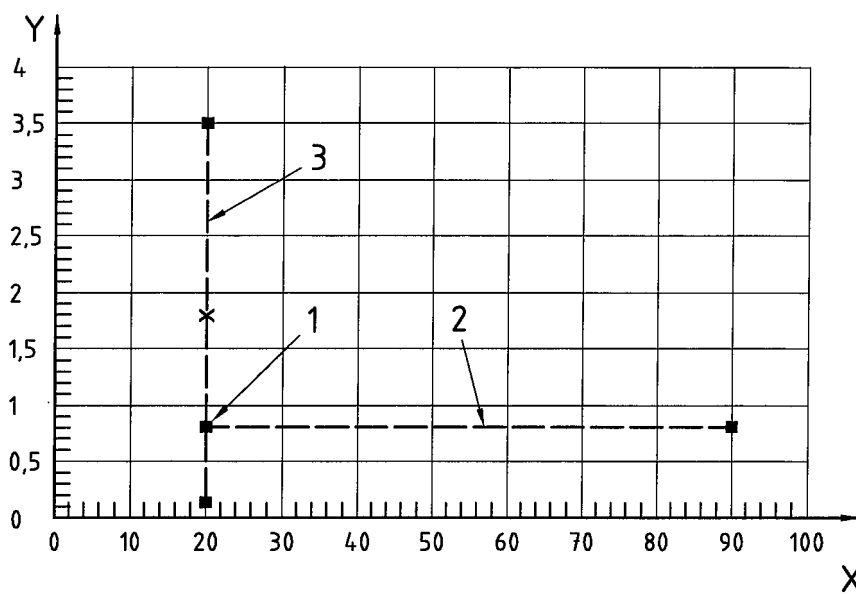
Figure 29 — Propane test parameters



Key

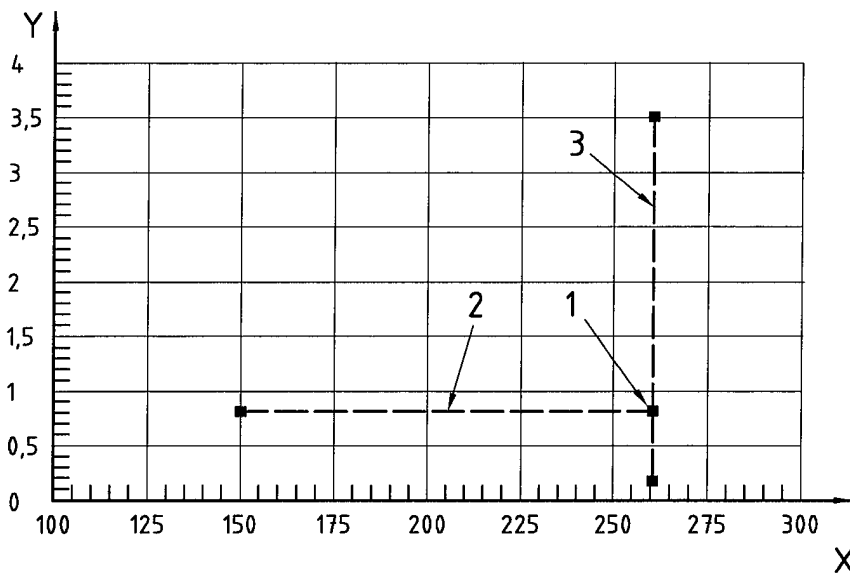
- X temperature, °C
- Y absolute pressure, MPa
- 1 base-point conditions
- 2 temperature cycle
- 3 pressure cycle

Figure 30 — Caustic (NaOH) test parameters

**Key**

- X temperature, °C
- Y absolute pressure, MPa
- 1 base-point conditions
- 2 temperature cycle
- 3 pressure cycle

Figure 31 — Mineral oil test parameters for applications between – 7 °C (20 °F) and 150 °C (300 °F)

**Key**

- X temperature, °C
- Y absolute pressure, MPa
- 1 base-point conditions
- 2 temperature cycle
- 3 pressure cycle

Figure 32 — Mineral oil test parameters for applications between 150 °C (300 °F) and 260 °C (500 °F)

10.3.1.2.7 For each seal type and test fluid, the nominal balance diameters of the seals to be tested shall be 50 mm (2 in) to 75 mm (3 in) and 100 mm (4 in) to 127 mm (5 in). For seals outside the scope of this International Standard, additional qualification testing should be considered.

NOTE Most seal applications are covered by this International Standard. The testing of these sizes is considered representative of the range of sizes identified. The performance of sizes between the test sizes is considered to be similar to the test sizes.

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

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

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

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

- a) for arrangements using contacting inner seals (2CW-CS) only, demonstrate the performance of the inner seal without the outer seal and the buffer-gas purge in accordance with 10.3.1.3;
- b) demonstrate the performance of the arrangement with the inner seal and outer seal, but without any buffer-gas purge, in accordance with 10.3.1.3;
- c) after completion of step b), demonstrate the performance of the containment seal in accordance with 10.3.1.3.5.

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

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

10.3.1.2.12 For Arrangement 3 seals using a gas barrier (3NC-BB, 3NC-FF, 3NC-FB):

- a) the barrier gas used during qualification testing shall be nitrogen;
- b) demonstrate the performance of the arrangement in accordance with 10.3.1.3;
- c) demonstrate the performance of the arrangement at variable barrier-gas pressures in accordance with 10.3.1.3.6.

10.3.1.3 Test procedure

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

10.3.1.3.2 The dynamic phase of the qualification test shall be operated continuously for a minimum of 100 h at 3 600 r/min under the base-point conditions, as specified in Table 8.

10.3.1.3.3 The static phase of the qualification test shall run for a minimum of 4 h at 0 r/min (shutdown) under the base-point conditions, as specified in Table 8. No rotation of the shaft is allowed during the static test.

10.3.1.3.4 The cyclic phase of the qualification test shall be at the temperatures and pressures specified in Table 8 and performed as follows:

- a) operate the seal at base-point pressure and temperature conditions and at 3 600 r/min until equilibrium has been established;
- b) drop the pressure to cause all fluid in the seal chamber to vaporize or drop to a gauge pressure of 0 MPa (0 bar) (0 psi) for non-flashing fluids (raise pressure for oil tests). Re-establish base pressure;
- c) drop the fluid temperature in the seal chamber to the minimum cyclic test temperature specified in Table 8. Re-establish base-point conditions;
- d) raise the fluid temperature in the seal chamber to the maximum cyclic test temperature specified in Table 8. Re-establish the base-point conditions. For the mineral oil tests, after the base condition is reached, raise the fluid pressure in the seal chamber to the maximum cyclic test pressure specified in Table 8. Re-establish the base-point conditions;
- e) turn off the seal flush for 1 min, if applicable;
- f) shut down the test (0 r/min) for at least 10 min;
- g) establish base-point conditions and operate at 3 600 r/min;
- h) repeat steps b) to g), three additional times;
- i) repeat steps b) to e);
- j) re-establish flush and allow test seal to reach equilibrium conditions (including emissions for hydrocarbons) at the base point; and
- k) shut down the test (0 r/min). Maintain base-point conditions for at least 10 min.

Table 8 — Seal qualification test parameters

Qualification test conditions					
Test fluids	Barrier/buffer test fluids for dual seals	Base point		Cyclic ranges	
		Dynamic and static		Pressure ^a MPa	Temperature ^b
		Pressure ^a MPa	Temperature ^b		
Water	glycol/water	0,4	80 °C (180 °F)	0,1 to 0,4	20 °C to 80 °C (70 °F to 180 °F)
Propane	diesel	1,8	30 °C (90 °F)	1,1 to 1,8	30 °C (90 °F)
20 % NaOH	glycol/water	0,8	20 °C (70 °F)	0,1 to 0,8	20 °C to 80 °C (70 °F to 180 °F)
Mineral oil 20 °C (70 °F) to 90 °C (200 °F) applications	diesel	0,8	20 °C (70 °F)	0,1 to 1,7 (Types B and C) 0,1 to 3,5 (Type A)	20 °C to 90 °C (70 °F to 200 °F)
Mineral oil 150 °C (300 °F) to 400 °C (750 °F) applications	mineral oil	0,8	400 °C (750 °F)	0,1 to 1,7 (Types B and C) 0,1 to 3,5 (Type A)	150 °C to 400 °C (300 °F to 750 °F)
^a The tolerance range for pressure shall be $\pm 2\%$.					
^b The tolerance range for temperature shall be $\pm 2,5\text{ °C}$ (4,5 °F).					

10.3.1.3.5 In addition to the requirements of 10.3.1.2.10, Arrangement 2 dry-running containment seals shall be tested, without disassembly, with the inner seal at the base-point conditions, as follows (see Figure 34).

- Continuously operate a gas-pressured phase for at least 100 h at 3 600 r/min in propane gas at a gauge pressure of 0,07 MPa (0,7 bar) (10 psi) and a supply temperature between 20 °C (68 °F) and 40 °C (104 °F). Emissions shall be measured using EPA Method 21.
- On completion of step a), pressurize the seal with nitrogen or air and test according to the air test procedure of 10.3.4. The pressure decay may exceed the requirements of 10.3.4 but shall be recorded every minute, and no rotation of the shaft is permitted during this test.
- On completion of step b), fill the containment seal chamber area with diesel at a temperature between 20 °C and 40 °C (68 °F and 104 °F) and pressurize to a gauge pressure of 0,28 MPa (2,8 bar) (40 psi). Restart, maintain pressure and operate for at least 100 h at 3 600 r/min Record the leakage rate.
- On completion of step c), test the seal statically in diesel fuel for at least 4 h at 0 r/min (shutdown) at a gauge pressure of 1,7 MPa (17 bar) (246 psi); no rotation of the shaft is permitted during the static test, and the leakage rate shall be reported.

NOTE During the qualification test of the Arrangement 2 seal, the containment seal runs at a low pressure and in the vapour or liquid leaked by the inner seal. The gauge pressure of 0,28 MPa (2,8 bar) (40 psi) is referenced to an assumed maximum flare-header pressure.

10.3.1.3.6 For Arrangement 3 seals using a gas barrier, the performance of the arrangement at variable barrier-gas pressure shall be demonstrated as follows (see Figure 35).

- Hold the barrier gas pressure at a gauge pressure of zero for at least 1 h (this is a static test).
- Restore barrier gas pressure, restart and run until equilibrium is established; record any process leakage as well as barrier gas consumption.

- c) While the seal is running, isolate the barrier gas supply immediately adjacent to the seal for a 1-min period.

NOTE The purpose of this is to simulate field conditions of varying buffer gas supply.

- d) Restore barrier gas pressure, run until equilibrium is established and record any process leakage as well as barrier-fluid consumption.
- e) Shut down the seal (0 r/min). With the gas control panel blocked in, maintain base-point conditions for the process (inner) seal for 10 min and record any pressure rise in the barrier system.

NOTE This clause continues the testing of the Arrangement 3 gas-pressurized seals after 10.3.1.3.4. It provides a test of the ability to survive upsets and startup problems.

10.3.1.3.7 Measurements shall be recorded on forms requesting at least the data presented in Annex I.

10.3.1.3.8 The temperature and pressure measurements are values taken to be representative of the majority of the seal chamber volume of fluid.

NOTE The seal chamber fluid temperature which is measured is an average between inlet and outlet temperatures.

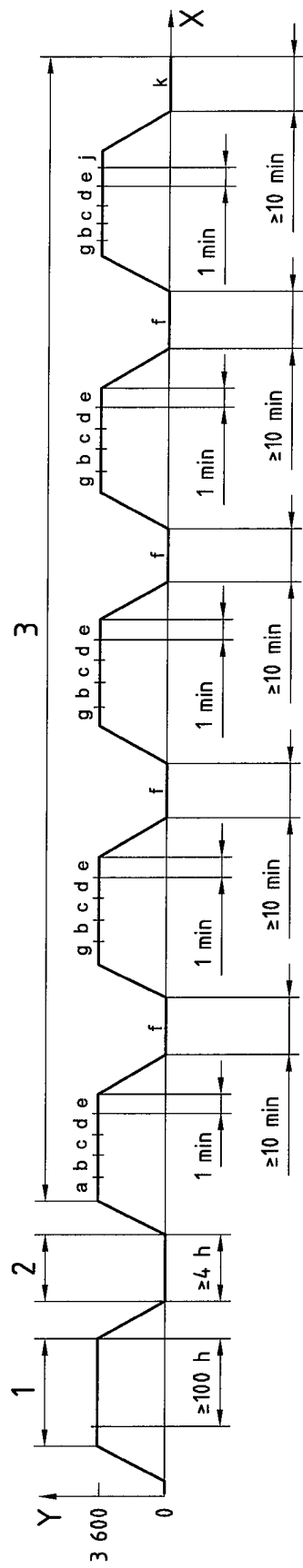
10.3.1.3.9 Leakage concentration of volatile organic compound (VOC) test fluids shall be measured with an organic vapour analyser in accordance with EPA Method 21 (Appendix A of Title 40, Part 60 of the US Code of Federal Regulations). Allow time for the analyser to complete measurements.

NOTE This method measures the concentration of VOC emission in the environment immediately surrounding the seal, not the VOC leakage rate.

10.3.1.3.10 All gauge ranges shall preferably be selected so that the normal operating point is at the middle of the gauge's range.

10.3.1.3.11 Instruments and methods of measurement shall be in accordance with ASME PTC 8.2.

10.3.1.3.12 Seal-face wear shall be computed based on the average change in length of the faces as measured before and after testing. Measurements shall be taken at four places approximately equally spaced around the circumference of the seal faces.

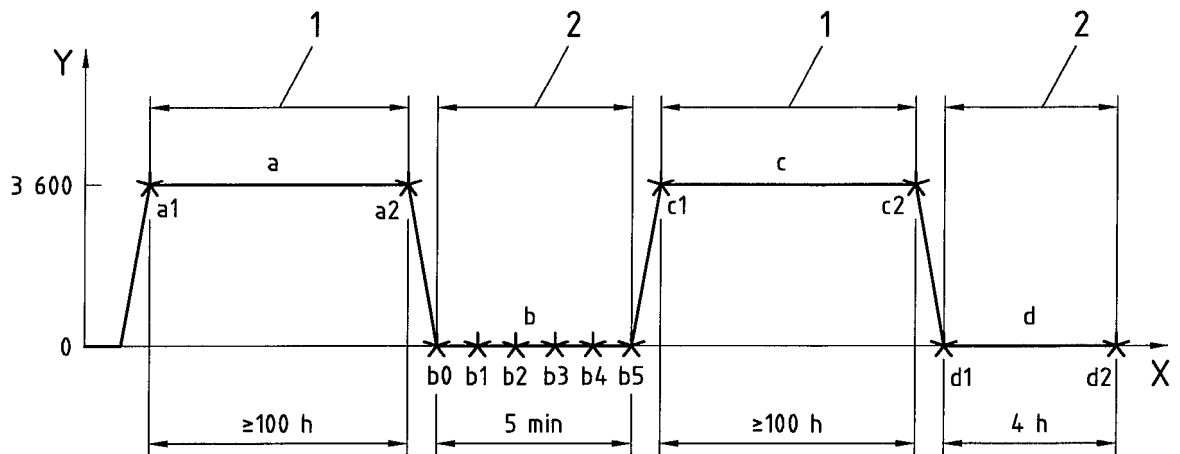


Key

- X time
- Y speed, r/min
- 1 dynamic test phase
- 2 static test phase
- 3 cyclic test phase

NOTE The points a, b, c, d, e, f, g, h, i, j and k relate to the steps in 10.3.1.3.4.

Figure 33 — Seal vendor qualification test procedure

**Key**

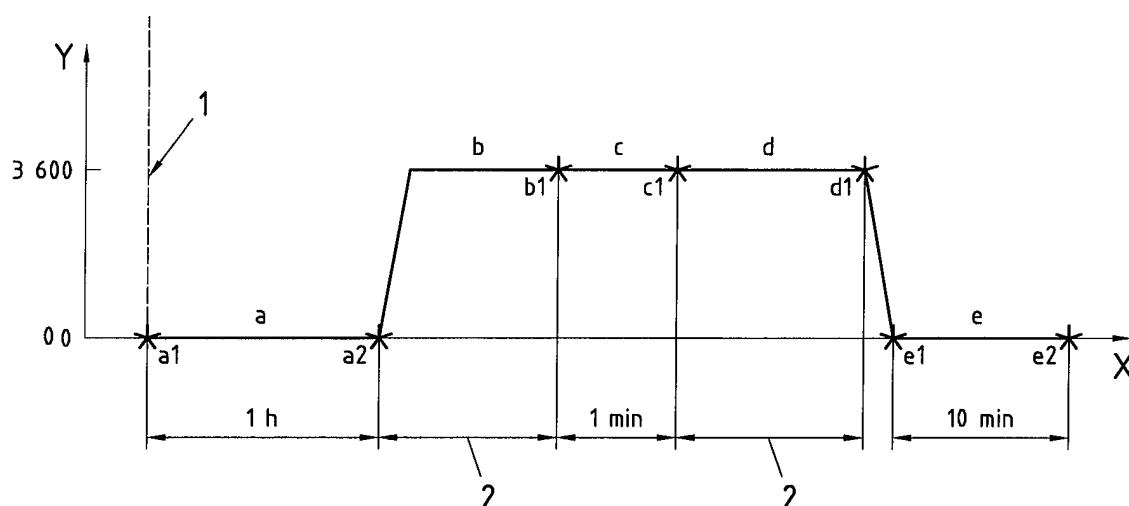
- X time
 Y speed, r/min
 1 dynamic test phase
 2 static test phase

NOTE 1 Test cycle refers to 10.3.1.3.5.

NOTE 2 Asterisks (★) indicate the timing and data-point designations for measurements that are taken in accordance with 10.3.1.3.5 and Annex I.

- a A gauge pressure of 0,07 MPa (0,7 bar) (10 psi) propane.
 b A gauge pressure of 0,17 MPa (1,7 bar) (25 psi) nitrogen.
 c A gauge pressure of 0,28 MPa (2,8 bar) (40 psi) diesel.
 d A gauge pressure of 1,7 MPa (17 bar) (250 psi) diesel.

Figure 34 — Seal vendor qualification test procedure for containment seals



Key

X time

Y speed, r/min

1 commences at end point of Figure 33

2 equilibrium

NOTE 1 Test cycle refers to 10.3.1.3.6.

NOTE 2 An asterisk (★) indicates the timing and data-point designations for measurements that are taken per 10.3.1.3.6 and Annex I.

- a Barrier at a gauge pressure of 0 MPa (0 bar) (0 psi), inner seal at normal test pressure.
- b Barrier at normal test pressure, inner seal at normal test pressure.
- c Isolate barrier pressure from supply pressure, inner seal at normal test pressure.
- d Barrier at normal test pressure, inner seal at normal test pressure.
- e Barrier blocked in, inner seal at normal test pressure.

Figure 35 — Seal vendor qualification test procedure for gas barrier seals

10.3.1.4 Minimum performance requirements

10.3.1.4.1 Unless otherwise specified to meet more stringent local emissions regulations, when single seals are tested in accordance with 10.3.1.3.2, 10.3.1.3.3 and 10.3.1.3.4, the permitted leakage shall be

- a) a concentration of vapours less than 1 000 ml/m³ (1 000 ppm vol) using EPA Method 21,
- b) an average liquid leakage rate of less than 5,6 g/h per pair of seal faces.

NOTE All mechanical seals require face lubrication to achieve reliability; this results in a minimal level of leakage. 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 (refer to A.1.3). Pressurized dual contacting wet seals (3CW), when used with a non-evaporative, lubricating-oil barrier fluid, can also produce visible leakage in the form of droplets, but at a rate less than 5,6 g/h (2 drops per minute).

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 3 may be required to meet the applicable limits.

10.3.1.4.2 Unless otherwise specified to meet more stringent local emissions regulations, when containment seals are tested in accordance with 10.3.1.3.5 a), the maximum permitted leakage concentration of vapours shall be 1 000 ml/m³ (1 000 ppm vol) using EPA Method 21.

NOTE Part a) of this test is considered to be normal operation, the remainder of the test is considered to be an upset condition.

10.3.1.4.3 After completion of the qualification test, the total wear of the primary 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 non-linear. Most seal-face wear occurs during startup or shortly thereafter.

10.3.1.4.4 For containment seals, the sum of the wear during testing according to 10.3.1.3.2 to 10.3.1.3.5 shall be less than 1 % of the available seal-face wear.

10.3.1.5 Results of test

The seal manufacturer shall provide the results of the qualification tests and certification in accordance with Table 9. The results of the tests shall include at least the information shown on the qualification test results forms (Annex I). Any conditions observed that would jeopardize the ability of the seal to meet the reliability and performance requirements of this International Standard shall be reported.

10.3.2 Hydrostatic test for pressure-containing mechanical seal parts and accessories

10.3.2.1 Pressure-casing seal components, except gland plates machined from a single piece of wrought material or bar stock, shall be tested hydrostatically with liquid at a minimum of 1,5 times the maximum allowable working pressure but not less than a gauge pressure of 0,14 MPa (1,4 bar) (20 psi). The test liquid shall be at a higher temperature than the nil ductility transition temperature of the material being tested.

10.3.2.2 If the part tested is to operate at a temperature at which the strength of a material is below the strength of that material at room temperature, the hydrostatic test pressure shall be multiplied by a factor obtained by dividing the allowable working stress for the material at room temperature by that at the operating temperature. The stress values used shall conform to those given in ISO 15649 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 data sheets shall list actual hydrostatic test pressures.

NOTE For the purpose of this provision, ASME B31.3 is equivalent to ISO 15649.

10.3.2.3 Where applicable, tests shall be in accordance with the EN 13445 or ASME VIII. In the event that a discrepancy exists between the code test pressure and the test pressure in this International Standard, the higher pressure shall govern.

10.3.2.4 The chloride content of liquids used to test austenitic stainless steel materials shall not exceed 50 mg/kg (50 ppm wt). To prevent deposition of chlorides as a result of evaporative drying, all residual liquid shall be removed from tested parts at the conclusion of the test.

10.3.2.5 Tests shall be maintained for a sufficient period of time to permit complete examination of parts under pressure. The hydrostatic test shall be considered satisfactory when neither leaks nor seepage through the chamber are observed for a minimum of 30 min.

10.3.3 Test of job seal by seal manufacturer

10.3.3.1 Each mechanical seal shall be tested with air by the seal manufacturer after final assembly in accordance with 10.3.4. Provisions for the test shall include the requirements in a) to 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 and Arrangement 3 seals shall have provisions to test each sealing section independently.

10.3.3.2 Following the successful completion of the air test, the tested seal cartridge shall not be disassembled. The cartridge assembly shall be tagged with the words "certified seal manufacturer air test acceptable", giving the test date and the inspector's name.

10.3.3.3 In the event that the seal assembly does not pass the air test, the entire test shall be repeated until a successful test has been accomplished.

10.3.4 Air test

10.3.4.1 Set-up

The set-up for the air test shall have a fill and pressurizing system capable of being isolated from the sealing section being tested. The gauge used for the test shall have a range so that the gauge pressure of 0,17 MPa (1,7 bar) (25 psi) is close to the midpoint.

10.3.4.2 Procedure

Each sealing section shall be independently pressurized with clean air to a gauge pressure of 0,17 MPa (1,7 bar) (25 psi). The volume of each test set-up shall be a maximum of 28 l (1 ft³). Isolate the test set-up from the pressurizing source and maintain the pressure for at least five minutes. The maximum pressure drop during the test shall be 0,014 MPa (0,14 bar) (2 psi).

10.3.4.3 Dual seal

Each sealing section of an Arrangement 2 or Arrangement 3 shall be independently pressurized. Connections shall be provided to test each section independently.

10.3.5 Test of job seal by pump manufacturer

● **10.3.5.1 Modified seal faces**

If specified, the air-tested seal shall be supplied to the pump manufacturer with modified seal faces for operation during the pump performance test. Following the pump performance test, the job seal faces shall be installed in the seal and air-tested in accordance with 10.3.4.

● **10.3.5.2 Seal not operated during pump performance test**

If specified, the seal being supplied shall not be operated in the pump during the pump performance test, in order to prevent damage. During the pump performance test, the pump shall utilize a seal supplied by the pump manufacturer. The seal being supplied, and the seal chamber (if applicable), shall be installed after the pump performance test and air tested in accordance with 10.3.4. It shall be specified if the seal is to be shipped uninstalled.

10.4 Preparation for shipment

10.4.1 Unless otherwise specified, the equipment shall be prepared for the type of shipment as described in 10.4.3.

10.4.2 The manufacturer shall provide the purchaser with the instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site and before start-up.

10.4.3 The equipment shall be prepared for shipment after all testing and inspection have been completed and the equipment has been released by the purchaser. The preparation shall include the following.

- a) Exterior surfaces, except for machined surfaces, shall be given at least one coat of the manufacturer's standard paint. The paint shall not contain lead or chromates. Stainless steel parts need not be painted.
- b) Carbon steel exterior machined surfaces shall be coated with a suitable rust preventive.
- c) The interior of the equipment shall be clean and free from scale, welding spatter and foreign objects.
- d) Internal steel areas of carbon steel systems 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 4,8 mm (3/16 in) thick, with elastomer gaskets and at least four full-diameter bolts. For studed openings, all nuts needed for the intended service shall be installed.
- f) Threaded openings shall be plugged in accordance with 6.1.2.18.
- g) Lifting points and the centre of gravity shall be clearly identified on the equipment package if the mass exceeds 23 kg (50 lb) or if required by local regulations. The manufacturer shall provide the recommended lifting arrangement.
- h) For Category 3 seals, the equipment shall be identified with item and serial numbers. Material shipped separately shall be identified with securely affixed, corrosion-resistant metal tags indicating the item and serial number of the equipment, and shall be shipped with duplicate packing lists, one inside and one on the outside of the shipping container.

10.4.4 Auxiliary piping connections shall be die-stamped or permanently tagged to agree with the manufacturer's connection table or general arrangement drawing. Service and connection designations shall be indicated.

10.4.5 One copy of the seal manufacturer's installation instructions shall be packed and shipped with the equipment.

11 Data transfer

11.1 General

11.1.1 Completion of the data sheets (Annex C) is the joint responsibility of the purchaser and the vendor. The purchaser may submit the data sheets to the vendor in a form other than that indicated herein. However, the alternative data sheets shall include 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.

11.1.2 The minimum information to be furnished by the manufacturer is specified in Table 9 and Table 10 and described in 11.2 and 11.3. It shall be sent to the address or addresses noted on the enquiry or order.

11.1.3 The following information shall be identified on cover letters, and on mechanical seal data sheets for Category 1 and Category 2 installations. Category 3 installations shall have the information on cover letters, mechanical seal data sheets, arrangement drawings, 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 enquiry or purchase order number;
- e) any other identification specified in the enquiry or purchase order; and
- f) the manufacturer's identifying proposal reference, shop order number, serial number, or other reference required to uniquely identify return correspondence.

- **11.1.4** If specified, the mechanical seal data requirements form (Annex J) shall be completed by the purchaser and the vendor. The purchaser may require this information in a form similar to or other than that indicated herein, provided it includes at least the information provided in Annex J.

11.2 Proposal data

11.2.1 The seal manufacturer's proposal shall include at least the information specified in Table 9.

11.2.2 The seal cross-sectional drawing (a modified typical drawing is acceptable) shall include the following information:

- a) sufficient dimensional information to check the fit of the installation in the equipment, including the seal chamber bore and depth, gland plate connections, and the distance to the nearest obstruction external to the seal chamber;
- b) overall seal dimensions and any relevant seal setting dimensions;
- c) seal axial tolerance to differential shaft/casing movement;
- d) material specifications; and
- e) a separate seal-chamber drawing clarifying any pump modifications required to fit the proposed seal. This drawing shall either show the seal assembly or include a cross-reference to it.

Table 9 — Proposal data

Information required	Seal category		
	1	2	3
Cross-sectional drawing (typical)	X	X	X
Auxiliary system schematic			X
Appropriate completed data sheets	X	X	X
Alternatives proposed	X	X	X
Exceptions to this International Standard	X	X	X
Detailed bill of materials for seal and auxiliary system			X
Estimated seal leakage of 2NC-CS at rated seal-chamber pressure	X	X	X
Seal qualification test results and certification			X
Seal design performance parameters			X
Seal axial thrust force on shaft			X
Data requirements form	X ^a	X ^a	X ^a
^a If specified.			

11.2.3 The seal design performance parameters shall include the following information specific to the liquid and pump information in the data sheet:

- a) dynamic sealing-pressure rating;
- b) static sealing-pressure rating;
- c) maximum reverse pressure (where appropriate);
- d) maximum and minimum operating temperatures.

11.2.4 Seal qualification test results shall include the following information:

- a) the information shown on the qualification test results forms (Annex I) plus any other relevant information;
- b) certification that the qualification test was properly conducted and has met the requirements of this International Standard;
- c) clarification of any design or specification differences between the test and the proposed seal; and
- d) any conditions observed that would jeopardize the ability of the seal to meet the reliability and performance requirements of this International Standard.

11.3 Contract data

11.3.1 The vendor shall supply to the purchaser at least the information specified in Table 10.

Table 10 — Contract data

Information required	Seal category		
	1	2	3
Cross-sectional drawing (typical)	X	X	
Cross-sectional drawing (specific)	a	a	X
Auxiliary system schematic	X	X	X
Detailed drawing of auxiliary system			X
Appropriate completed data sheets	X	X	X
Detailed bill of materials for seal and auxiliary system	X	X	X
Seal energy and heat-soak calculations			X
Seal axial thrust on shaft			X
Internal circulating device performance (test data)			X
Installation, operation and maintenance instructions (typical)	X	X	
Installation, operation and maintenance instructions (specific)			X
Hydrostatic test certification			X
Material safety data sheets	b	b	X
Data requirements form	X ^c	X ^c	X ^c
^a Shall be supplied if significant pump modifications are required. ^b If required by regulations. ^c If specified.			

11.3.2 The seal cross-sectional drawing specific to the equipment shall include at least the following:

- a) all seal components related to the order as well as pump components related to the seals;

- b) dimensions to properly verify the seal setting position;
- c) pump dimensions interfacing with the seal;
- d) seal boundary dimensions;
- e) seal chamber and gland-plate connection dimensions;
- f) auxiliary system and utility specifications;
- g) connecting dimensions for the auxiliary system and utilities;
- h) pump process and seal operating conditions;
- i) seal allowable axial movement from set point;
- j) seal category, type and arrangement as designated by this International Standard; and
- k) appropriate labelling and reference to the bill of materials, including materials of construction and item description.

11.3.3 The auxiliary system schematic drawing shall include:

- a) piping and instrumentation diagram;
- b) all external utility requirements and positions;
- c) appropriate labelling and reference to the bill of materials;
- d) barrier- or buffer-fluid specification;
- e) hydrotest pressure, if applicable;
- f) maximum design pressure and temperature;
- g) size and set pressure of relief valves.

11.3.4 The detailed drawing of the auxiliary system shall include:

- a) all mounting and overall boundary dimensions;
- b) all external utility requirements and positions;
- c) all connecting pipework locations, type and size;
- d) appropriate labelling and reference to the bill of materials;
- e) barrier or buffer-fluid specification;
- f) equipment and alarm set points;
- g) hydrotest pressure, if applicable;
- h) maximum design pressure and temperature;
- i) orifice size; and
- j) size and set pressure of relief valves.

11.3.5 The bill of materials for the seal shall also indicate the recommended spare parts.

11.3.6 Unless otherwise specified at the enquiry stage, the installation, operation and maintenance 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. The recommended torque values for all fasteners used in the seal, reservoir flange and level gauge shall be provided.

11.3.7 For Category 3 seals, the vendor shall provide sufficient written instructions and all necessary drawings to enable the purchaser to install, operate, and maintain all of the equipment covered by the purchase order. This information shall be compiled in a manual or manuals with a cover sheet showing the information listed in 11.1.3, an index sheet, and a complete list of the enclosed drawings by title and drawing number. The manual or manuals shall be prepared specifically for the equipment covered by the purchase order. "Typical" manuals are unacceptable.

11.3.8 Material safety data sheets shall be for the specific paints, preservatives, coatings and chemicals supplied with, or applied to, the seal or auxiliary system.

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Annex A **(informative)**

Recommended seal selection procedure

A.1 Assumptions and instructions

A.1.1 Application range

This selection procedure provides a recommended seal type, arrangement, flush plan and barrier/buffer fluid given the intended service condition, provided the conditions meet the seal operating envelope of Category 1 seals, Category 2 seals or Category 3 seals.

The fluids covered by this selection process include:

- a) water;
- b) sour water (containing H₂S);
- c) caustics;
- d) amines;
- e) some acids;
- f) most hydrocarbons.

A.1.2 Additional engineering required

This is a recommended procedure only. It is the responsibility of the purchaser or seal vendor using this procedure to ensure that the selected seal and auxiliaries are suitable for the intended service condition. The use of alternative selection criteria and more detailed engineering review is specifically recommended for the following service conditions:

- a) high temperatures above:
 - 1) for Category 1 seals: 260 °C (500 °F),
 - 2) for Category 2 and Category 3 seals: 400 °C (750 °F);
- b) low temperatures below – 40 °C (– 40 °F);
- c) high sealing pressure (gauge) above:
 - 1) for Category 1 seals: 2,1 MPa (21 bar) (300 psi),
 - 2) for Category 2 and Category 3 seals: 4,1 MPa (41 bar) (600 psi);
- d) surface speed above 23 m/s (4 500 ft/min);
- e) highly corrosive fluids for which the materials specified in this International Standard are not suitable;
- f) fluids with absolute vapour pressures in excess of 3,4 MPa (34 bar) (493 psi);

- g) unstable liquid properties, for example multiphase or non-Newtonian fluids, etc.;
- h) high solids concentration;
- i) shaft diameters above 110 mm (4,3 in) or below 20 mm (0,75 in);
- j) high viscosity or pour point above or within 20 °C (36 °F) of minimum ambient temperature.

A.1.3 Seal leakage

There is always a mass flowrate across the face of a mechanical seal, so all seals “leak” to some extent. Some seals, particularly non-contacting seals, are designed to have a certain flow between the faces. Nevertheless, for the vast majority of ISO 13709 pumps, there is no visible seal leakage depending on the state of the fluid being sealed. Leakage can occur regardless of seal category, type or arrangement; however, with dual seals, the leaked fluid may be buffer or barrier fluid instead of process fluid. Buffer and barrier fluids are often lubricating oils, which are not volatile, and visible droplets occur in these circumstances. Sometimes visible leakage is apparent only over time, as the non-volatile components of the process stream or buffer/barrier fluids accumulate.

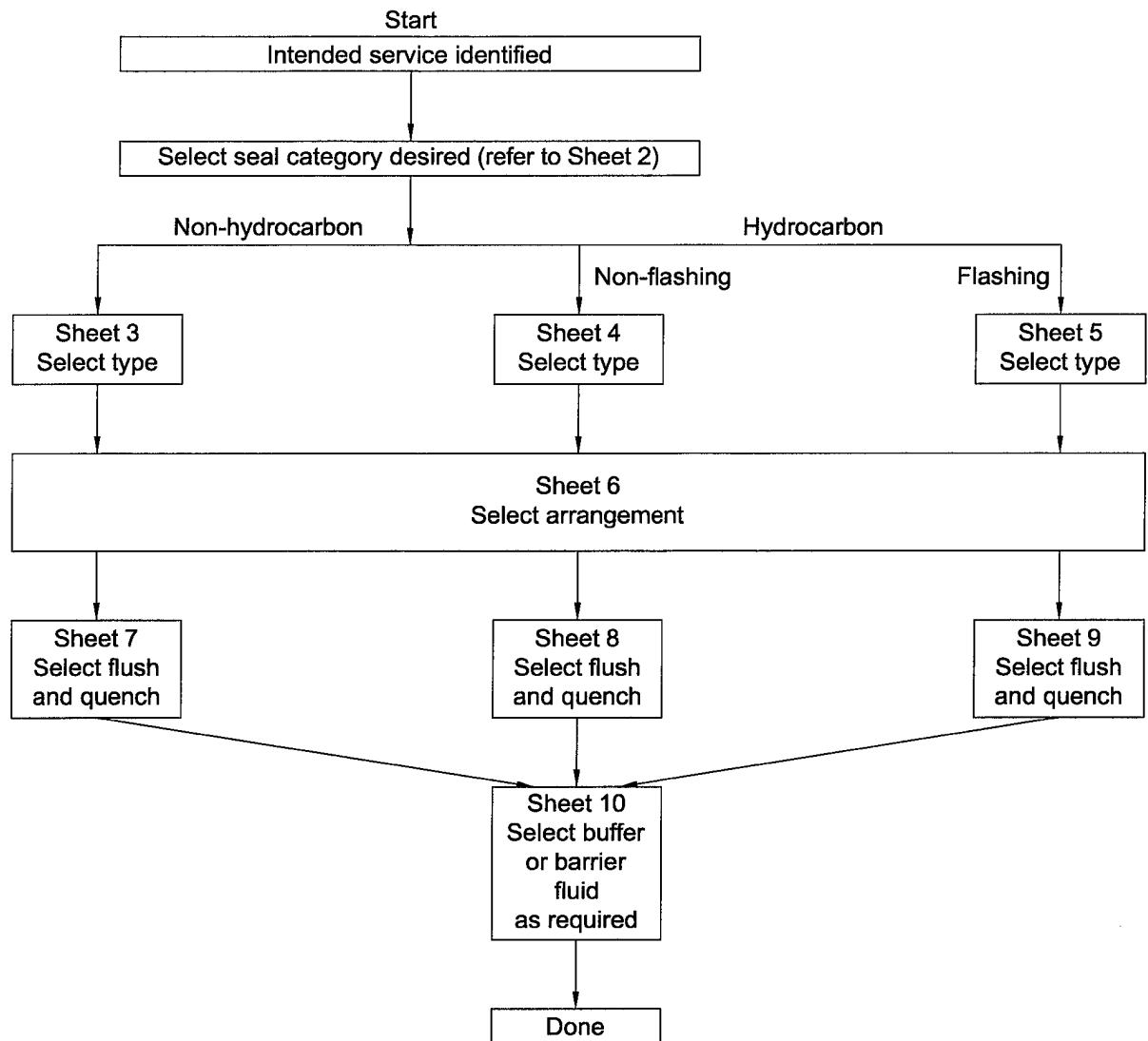
Contacting seals may use features such as variable or low seal balance ratio, or face enhancing features such as scallops, matte lapping or preferential lapping to reduce wear and extend the design envelope; however, leakage can be slightly higher than similar seals using plain faces under less difficult conditions. Seals designed for high pressures but actually used at low pressures may have unacceptable leakage. A single contacting wet seal (1CW) sealing water at a vendor pump test ordinarily leaks a fluid that is volatile and is not visible. The aforementioned design features, necessary for specific process reliability, can in a water-sealing environment alter leakage levels such that a slight visible leakage can occur at the vendor pump test.

Factors other than design features can result in increased leakage as well; however, these may be the result of aberrant system conditions. In particular, after a contacting seal has worn in to match a certain set of operating conditions, changing those conditions can result in increased leakage until the faces have worn to match the new conditions. Such changes include fluid type, viscosity or density in either the process or buffer/barrier fluid. Operating conditions such as temperature or pressure outside its design envelope can damage the seal and result in greater leakage rates. Other system factors that affect seal leakage rates, besides condition of the seal parts, include pump operation at off-design conditions, pipe strain, bearing problems, fitting leaks at the seal gland (often mistaken as seal leakage), impeller or sleeve gasket damage, etc.

A.1.4 Instructions and seal selection sheets

To use this procedure, begin on sheet 1 and consult each page given the service condition and fluid. Where alternative seal types are listed, they should be considered an acceptable equivalent to the standard (default) seal shown.

RECOMMENDED SEAL SELECTION PROCEDURE (SI UNITS)
SHEET 1 OF 10



RECOMMENDED SEAL SELECTION PROCEDURE (SI UNITS)
SEAL CATEGORY, TYPE, AND ARRANGEMENT SUMMARY
SHEET 2 OF 10

Seal category shall be Category 1, 2 or 3 as specified.

The major features of each category are summarized below. Options, where they exist for each feature, are listed in the text as "if specified". Clause numbers in parentheses indicate where the requirements are specified.

FEATURE	CATEGORY 1	CATEGORY 2	CATEGORY 3
Seal chamber size. (4.1.2)	ISO 3069-C, ASME B73.1 and ASME B73.2.	ISO 13709 and ISO 3069-H.	ISO 13709 and ISO 3069-H.
Temperature range. (4.1.2)	– 40 °C to 260 °C	– 40 °C to 400 °C	– 40 °C to 400 °C
Pressure range, absolute. (4.1.2)	2,2 MPa	4,2 MPa	4,2 MPa
Face materials. (6.1.6.2)	Premium blister-resistant carbon vs. self-sintered silicon carbide.	Premium blister-resistant carbon vs. reaction-bonded silicon carbide.	Premium blister-resistant carbon vs. reaction-bonded silicon carbide.
Distributed inlet flush requirements, Arrangements 1 and 2 with rotating flexible elements.	When required per 6.1.2.14 or if specified. (6.2.1.2.1)	When required per 6.1.2.14 or if specified. (6.2.2.2.1)	Required. (6.2.3.2)
Gland plate metal-to-metal contact requirement.	Required. (6.2.1.2.2)	Required inside and outside of the bolt circle diameter. (6.2.2.2.2)	Required inside and outside of the bolt circle diameter. (6.2.2.2.2)
Cartridge seal sleeve size increments required.	None	10 mm increments. (6.2.2.3.1)	10 mm increments. (6.2.2.3.1)
Throttle bushing design requirement for Arrangement 1 seals. (7.1.2.1)	Fixed carbon. Floating carbon option. (7.1.2.2)	Fixed, non-sparking metal. Floating carbon option. (7.1.2.2)	Floating carbon.
Dual-seal circulation device head flow curve provided.	If specified. (8.6.2.2)	If specified. (8.6.2.2)	Required. (8.6.2.2)
Scope of vendor qualification test.	Test as Category 1 unless faces interchangeable with Category 3. (10.3.1.2.3)	Test as Category 2 unless faces interchangeable with Category 3. (10.3.1.2.3)	Test as Category 3, entire seal assembly as a unit. (10.3.1.2.2)
Proposal data requirements.	Minimal. (11.2.1)	Minimal. (11.2.1)	Rigorous, including qualification test results. (11.2.1)
Contract data requirements.	Minimal. (11.3.1)	Minimal. (11.3.1)	Rigorous. (11.3.1)

SHEET 2 OF 10 (*continued*)

Seal type shall be Type A, B, or C as specified.

The major features of each type are summarized below. Options, where they exist for each feature, are listed in the text as "if specified". Clause numbers in parentheses indicate where the requirements are specified.

FEATURE	TYPE A	TYPE B	TYPE C
Standard temperature application range. (4.1.3)	– 40 °C to 176 °C	– 40 °C to 176 °C	– 40 °C to 400 °C
Hydraulic balance requirement. (4.1.3 and 6.1.1.7)	Balanced (e.g. hydraulic balance less than 1).	Balanced (e.g. hydraulic balance less than 1).	Balanced (e.g. hydraulic balance less than 1).
Mounting requirement. (4.1.3)	Inside the seal chamber.	Inside the seal chamber.	Inside the seal chamber.
Cartridge requirement. (4.1.3 and 6.1.1.1)	Cartridge design.	Cartridge design.	Cartridge design.
Flexible element style. (4.1.3)	Pusher (e.g. sliding elastomer).	Non-pusher (e.g. bellows).	Non-pusher (e.g. bellows).
Flexible element orientation. (4.1.3)	Rotating. Stationary option. (6.1.1.2)	Rotating. Stationary option. (6.1.1.2)	Stationary. Rotating option. (6.1.1.3)
Bellows material. (6.1.6.6)	Not applicable.	Alloy C-276	Alloy 718
Spring type. (4.1.3)	Multiple-coil springs. Single-spring option. (6.1.5.1)	Single bellows.	Single bellows.
Limit for stationary element application. (6.1.1.5)	23 m/s	23 m/s	Not applicable.
Secondary sealing element material. (4.1.3)	Elastomer.	Elastomer.	Flexible graphite.

SHEET 2 OF 10 (continued)

Seal arrangement shall be Arrangement 1, 2, or 3 as specified.

The major features of each arrangement are summarized below. Options, where they exist for each feature, are listed in the text as "if specified". Clause numbers in parentheses indicate where the requirements are specified.

FEATURE	ARRANGEMENT 1	ARRANGEMENT 2	ARRANGEMENT 3
Number of "seals" per cartridge, see definition of "seal" in 3.61. (4.1.4)	One (3.2 and 4.1.4)	Two (3.3 and 4.1.4)	Two (3.4 and 4.1.4)
Uses a barrier or buffer fluid. (4.1.4)	No	Sometimes, but not required. Liquid or gas buffer permitted.	Yes, barrier fluid required, liquid or gas permitted.
Allows non-contacting (wet or dry) seals. (4.1.4)	No	Yes, Figure 4.	Yes, Figure 6.
Arrangement 1 throttle bushing requirement. (7.1.2.1)	Category 1: Fixed carbon. Category 2: Fixed, non-sparking metallic. Category 3: Floating carbon.	Not applicable.	Not applicable.
Arrangement 2 & 3 throttle bushing requirement.	Not applicable.	Fixed carbon, if specified. (7.2.3)	Fixed carbon, if specified. (7.3.3.1)
Arrangement 2 containment seal chamber bushing requirement.	Not applicable.	Required with dry-running containment seal regardless of inner seal design. (7.2.5.1 and 7.2.6.1)	Not applicable.
Tangential buffer/barrier fluid outlet required ?	Not applicable.	If specified, for Categories 1 and 2. Required for Category 3. (7.2.4.2)	If specified, for Categories 1 and 2. Required for Category 3. (7.3.4.3)
Maximum buffer/barrier fluid temperature rise.	Not applicable.	8 °C aqueous or diesel, 16 °C mineral oils. (7.2.4.1)	8 °C aqueous or diesel, 16 °C mineral oils. (7.3.4.1)
Seal chamber pressure/flush design requirement. (6.1.2.14)	Minimum margin of 30 % of seal chamber pressure above fluid vapour pressure or 20 °C margin.	Minimum margin of 30 % of seal chamber pressure above fluid vapour pressure or 20 °C margin.	None
Minimum operating seal chamber pressure requirement. (6.1.2.14)	0,035 MPa above atmospheric.	0,035 MPa above atmospheric.	None
Minimum gland plate connection sizes and orientation.	See Table 1.	See Table 1.	See Table 1.
Minimum barrier/barrier fluid liquid reservoir.	Not applicable.	12 litres for shaft diameter 60 mm and smaller barrier; otherwise 20 litres. [8.5.4.3 a)]	12 litres for shaft diameter 60 mm and smaller; otherwise 20 litres. [8.5.4.3 a)]
Test requirements.	(10.3.1.2.8)	(10.3.1.2.9) and (10.3.1.2.10)	(10.3.1.2.11) and (10.3.1.2.12)

RECOMMENDED SEAL TYPE SELECTION PROCEDURE (SI UNITS)
SHEET 3 OF 10
Non-hydrocarbon services

	Fluids	Operating conditions, recommended seal types and special features							
		1	2	3	4	5	6	7	8
		Water	Water	Water	Sour water	Sour water	Caustic, amines crystallize	Caustic, amines crystallize	Acids ^a H ₂ SO ₄ , H ₃ PO ₄
	Pumping temp. °C	< 80	< 80	> 80	< 80	< 80	< 80	< 80	< 80
	Seal chamber gauge pressure, MPa, Category 1 seals	< 2,1		< 2,1	< 2,1		< 2,1		< 2,1
	Seal chamber gauge pressure, MPa, Category 2 and 3 seals	< 2,1	2,1 to 4,1	< 4,1	< 2,1	2,1 to 4,1	< 2,1	2,1 to 4,1	< 2,1
	Standard seal type	Type A	Type A	Type A	Type A	Type A	Type A	Type A	Type A
	Options when specified	Type B Type C	ES ^b	ES ^b	Type B Type C	ES ^b	Type B Type C	ES ^b	Type B Type C
	Required special features			Circulating device	Perfluoro-elastomer	Perfluoro-elastomer	Amine-resistant perfluoro-elastomer	Amine-resistant perfluoro-elastomer	Perfluoro-elastomer and single spring for Type A seals
Special features for contaminants ^c	Abrasive particulates	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface
This selection procedure chooses seal designs consistent with the default positions throughout this International Standard. Listed options meeting this International Standard might perform equally well.									
^a Up to 20 % H ₂ SO ₄ at 25 °C only. Up to 20 % H ₃ PO ₄ at 80 °C only. All other acids, including hydrofluoric acid, fuming nitric acid and hydrochloric acid, require special engineering agreed between purchaser and vendor.									
^b Totally engineered sealing system. Consult vendor to ensure special design considerations are accounted for.									
^c Special features listed apply only in mixtures having pH between 4 and 11.									

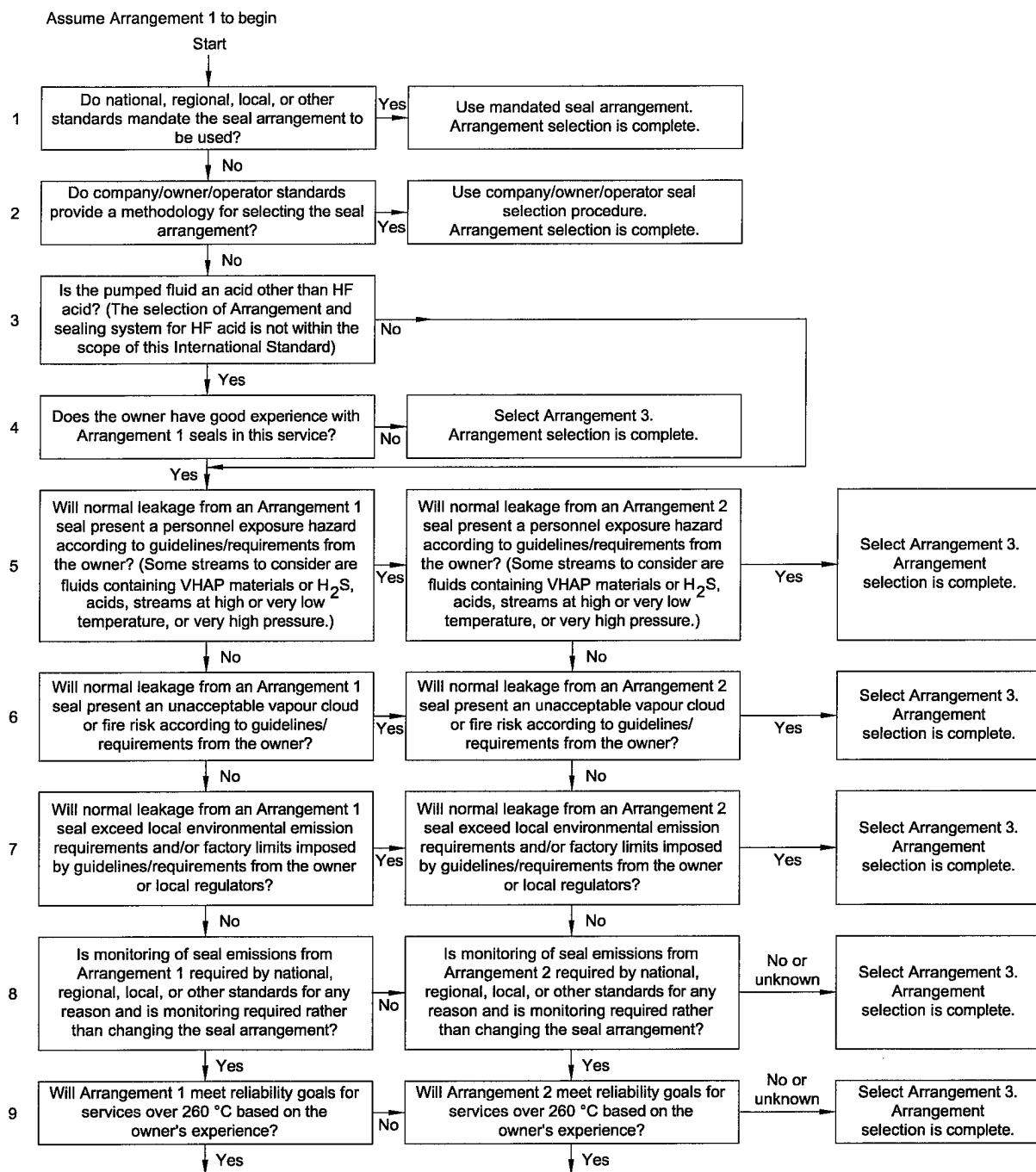
RECOMMENDED SEAL TYPE SELECTION PROCEDURE (SI UNITS)
SHEET 4 OF 10
Non-flashing hydrocarbons

		Operating conditions, recommended seal types and special features							
	Fluids	1	2	3	4	5	6	7	8
	Pumping temp. °C	– 40 to – 5	– 40 to – 5	– 5 to 176	– 5 to 176	176 to 260	176 to 260	260 to 400	260 to 400
	Seal chamber gauge pressure, MPa Category 1 seals	< 2,1		< 2,1		< 2,1		N/A	N/A
	Seal chamber gauge pressure, MPa Category 2 and 3 seals	< 2,1	2,1 to 4,1	< 2,1	2,1 to 4,1	< 2,1	2,1 to 4,2	< 2,1	2,1 to 4,1
	Standard seal type	Type A	Type A	Type A	Type A	Type C	ES ^a	Type C	ES ^a
	Option when specified	Type B	ES ^{a, b}	Type B	ES ^{a, b}	ES ^a		ES ^a	
	Option when specified	Type C		Type C					
	Required special features	Nitrile O-rings	Nitrile O-rings						
Special features for contaminants ^c	Caustic			Perfluoro-elastomer	Perfluoro-elastomer				
	Abrasive particulates	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface
	Aromatics and/or H ₂ S			Perfluoro-elastomer	Perfluoro-elastomer				
	Amines			Amine-resistant perfluoro-elastomer	Amine-resistant perfluoro-elastomer				
This selection procedure chooses seal designs consistent with the default positions throughout this International Standard. Listed options meeting this International Standard might perform equally well.									
^a Totally engineered sealing system. Consult vendor to ensure special design considerations are accounted for. ^b Engineered (high pressure) bellows. ^c Special features listed apply only in mixtures having pH between 4 and 11.									

RECOMMENDED SEAL TYPE SELECTION PROCEDURE (SI UNITS)
SHEET 5 OF 10
Flashing hydrocarbons

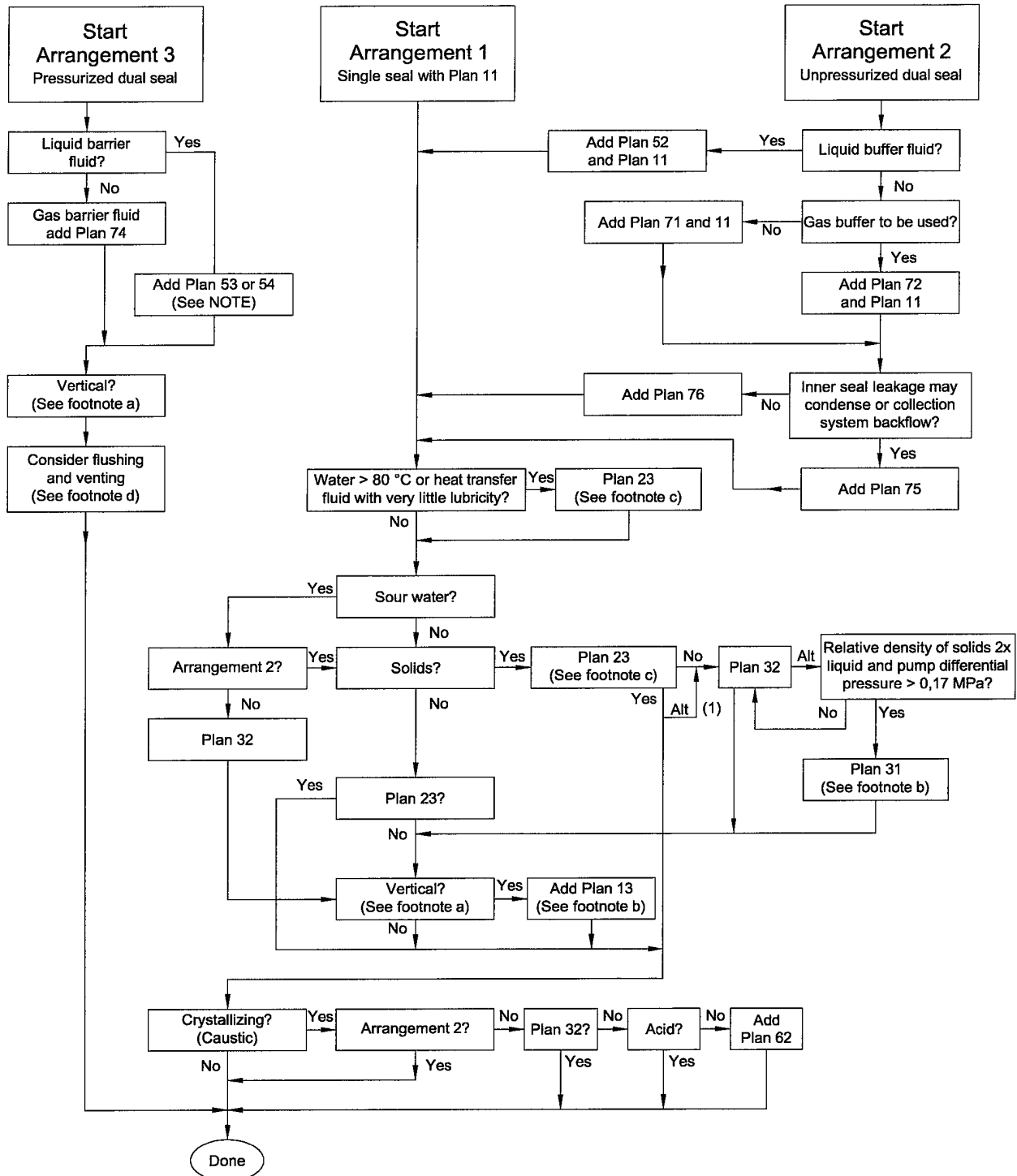
	Fluids	Operating conditions, recommended seal types and special features							
		1	2	3	4	5	6	7	8
	Pumping temp., °C	– 40 to – 5	– 40 to – 5	– 5 to 176	– 5 to 176	176 to 260	176 to 260	260 to 400	260 to 400
	Seal chamber gauge pressure, MPa Category 1 seals	< 2,1		< 2,1		< 2,1		N/A	N/A
	Seal chamber gauge pressure, MPa Category 2 and 3 seals	< 2,1	2,1 to 4,1	< 2,1	2,1 to 4,1	< 2,1	2,1 to 4,1	< 2,1	2,1 to 4,1
	Standard seal type	Type A	Type A	Type A ^d	Type A ^d	Type C	ES ^{a, b}	Type C	ES ^{a, b}
	Option when specified	ES ^a	ES ^{a, b}	ES ^a	ES ^{a, b}	ES ^a		ES ^a	
	Required special features	Nitrile O-rings	Nitrile O-rings						
Special features for contaminants^c	Caustic			Perfluoro-elastomer	Perfluoro-elastomer				
	Abrasive particulates	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface
	Aromatics and/or H ₂ S			Perfluoro-elastomer	Perfluoro-elastomer				
	Amines			Amine-resistant perfluoro-elastomer	Amine-resistant perfluoro-elastomer				
	Ammonia	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite
This selection procedure chooses seal designs consistent with the default positions throughout this International Standard. Listed options meeting this International Standard might perform equally well.									
^a Totally engineered sealing system. Consult vendor to ensure special design considerations are accounted for. ^b Engineered bellows. ^c Special features listed apply only in mixtures having pH between 4 and 11. ^d Requires special feature (circulating device) above 60 °C, and special feature (perfluoroelastomer) if pumping temperature is above 175 °C.									

RECOMMENDED SEAL ARRANGEMENT SELECTION PROCEDURE (SI UNITS) **SHEET 6 OF 10**





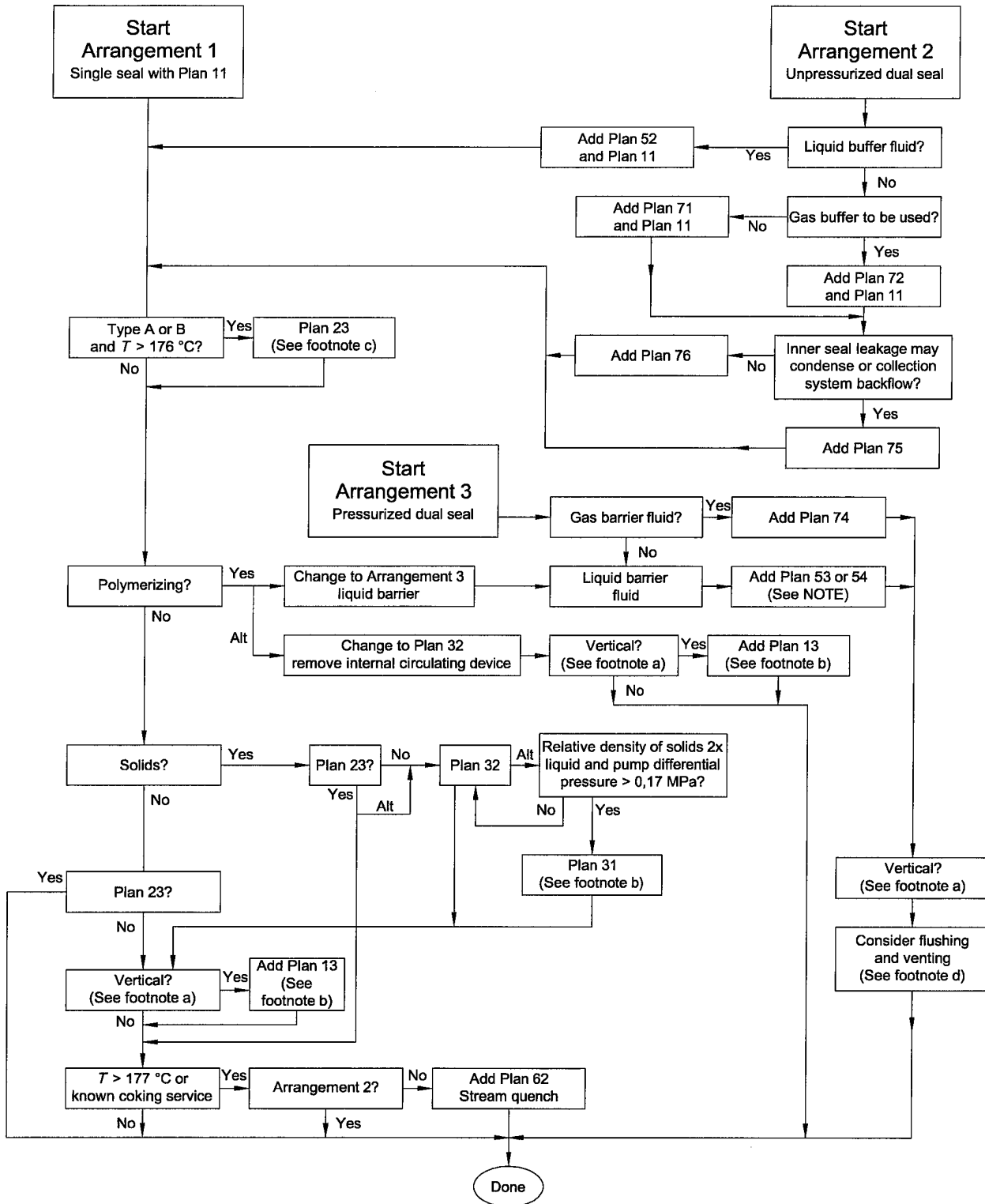
RECOMMENDED SEAL ARRANGEMENT SELECTION PROCEDURE (SI UNITS)
SHEET 7 OF 10
Non-hydrocarbon



NOTE See A.4.13 for guidance on selecting Plan 53A, 53B or 53C.

- ^a The user should evaluate whether to add Plan 13 or not, considering such factors as the inclusion of a bleed bushing, contamination of the seal chamber with pumped fluid, the need for venting of the seal chamber, and the need to reduce seal chamber pressure due to static or dynamic pressure rating of the seal versus the expected static and dynamic seal chamber pressure.
- ^b If Plan 31, 32 or 41 is selected and pump is vertical, Plan 13 is also recommended for venting. Users should consider installation of a "bleed bushing" design, in which an annulus and port cut into the throat bushing is connected to suction to keep solids out of the seal chamber. Ensure seal chamber is vented prior to start-up.
- ^c Cooling is needed due to low lubricity at elevated temperature. The recommended flush plan is 23 because field experience has shown that this plan is much less prone to plugging than Plan 21, due to recirculation of cooler fluid from the seal chamber. However, the user may wish to reconsider using Plan 21 due to the added seal complexity imposed by Plan 23 (size and cost), and other factors such as the use of an air cooler for Plan 21 in areas where water cannot be used or is not available. (An air cooler works better on Plan 21 due to the higher temperature difference between the pumped fluid and the cooling medium.) The user may also wish to consider the use of Plan 32 if a suitable fluid is available, especially if the fluid is normally injected into the process anyway (such as make-up water). See the flush descriptions later in this annex for additional detail.
- ^d Consider the need to add additional flushing to the process side of the inner seal. Flushing is sometimes needed for Arrangement 3 FB orientation to provide additional cooling, and Plan 11 or 13 may be a suitable choice. Other services may require a Plan 32 flush if the pumped fluid is extremely corrosive, aggressive or solids-laden. Consider the need for venting on vertical pumps. Special attention may be needed on Arrangement 3 NC configurations to ensure effective pump operation. Consult the pump vendor if the pump is vented through the seal chamber, and consider the effects listed in footnote ^a above.

RECOMMENDED SEAL ARRANGEMENT SELECTION PROCEDURE (SI UNITS)
SHEET 8 OF 10
Non-flashing hydrocarbon



NOTE See A.4.13 for guidance on selecting Plan 53A, 53B or 53C.

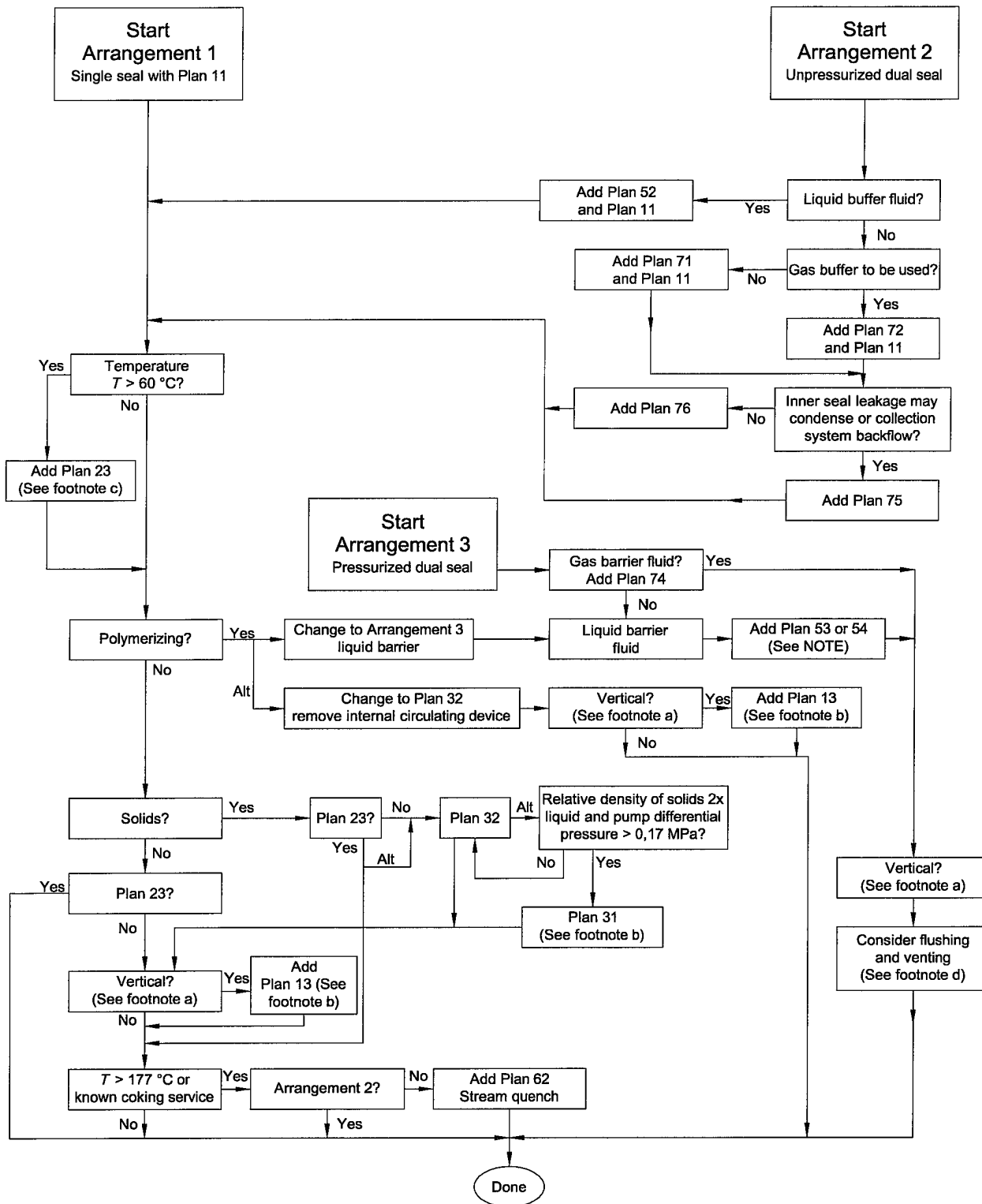
^a The user should evaluate whether to add Plan 13 or not, considering such factors as the inclusion of a bleed bushing, contamination of the seal chamber with pumped fluid, the need for venting of the seal chamber and the need to reduce seal chamber pressure due to static or dynamic pressure rating of the seal versus the expected static and dynamic seal chamber pressure.

^b If Plan 31, 32, or 41 is selected and pump is vertical, Plan 13 is also recommended for venting. Users should consider installation of a "bleed bushing" design, in which an annulus and port cut into the throat bushing is connected to suction to keep solids or polymerizing agents out of the seal chamber. Ensure seal chamber is vented prior to start-up.

^c Cooling is needed due to temperature limits of the standard secondary elastomers for Arrangement 1 and possibly for Arrangement 2 (consult the seal vendor). Consideration may be given to changing to perfluoroelastomer if cooling is not possible. The recommended flush plan is 23 because field experience has shown that this plan is much less prone to plugging than Plan 21, due to recirculation of cooler fluid from the seal chamber. However, the user may wish to reconsider using a Plan 21 due to the added seal complexity imposed by Plan 23 (size and cost) and other factors such as the use of an air cooler for Plan 21 in areas where water cannot be used or is not available. (An air cooler works better on Plan 21 due to the higher temperature difference between the pumped fluid and the cooling medium.) The user may also wish to consider the use of Plan 32 if a suitable fluid is available, especially if the fluid is normally injected into the process anyway (such as make-up water). See the flush descriptions later in this annex for additional detail.

^d Consider the need to add additional flushing to the process side of the inner seal. Flushing is sometimes needed for Arrangement 3 FB orientation to provide additional cooling and Plan 11 or 13 may be a suitable choice. Other services may require a Plan 32 flush if the pumped fluid is extremely corrosive, aggressive or solids-laden. Consider the need for venting on vertical pumps. Special attention may be needed on Arrangement 3 NC configurations to ensure effective pump operation. Consult the pump vendor if the pump is vented through the seal chamber, and consider the effects listed in footnote ^a above.

RECOMMENDED SEAL ARRANGEMENT SELECTION PROCEDURE (SI UNITS)
SHEET 9 OF 10
Flashing hydrocarbon



NOTE See A.4.13 for guidance on selecting Plan 53A, 53B or 53C.

^a The user should evaluate whether to add Plan 13 or not, considering such factors as the inclusion of a bleed bushing, contamination of the seal chamber with pumped fluid, the need for venting of the seal chamber, and the need to reduce seal chamber pressure due to static or dynamic pressure rating of the seal versus the expected static and dynamic seal chamber pressure.

^b If Plan 31, 32, or 41 is selected and pump is vertical, Plan 13 is also recommended for venting. Users should consider installation of a "bleed bushing" design, in which an annulus and port cut into the throat bushing is connected to suction to keep solids or polymerizing agents out of the seal chamber. Ensure seal chamber is vented prior to start-up.

^c Cooling is recommended to suppress flashing within the seal faces. Due to cooling-water temperatures, this is usually only effective above the temperature shown. Below this temperature, or as an alternative to adding cooling, the user may wish to use experience at their site or other alternatives such as high flushing rates, distributed flush systems, increased seal chamber pressure, or combinations thereof, to obtain satisfactory seal life. There may also be the opportunity to use Plan 32 if suitable flush fluid is available or, if experience is available, consideration of a change to Arrangement 3 may be appropriate.

^d Consider the need to add additional flushing to the process side of the inner seal. Flushing is sometimes needed for Arrangement 3 FB orientation to provide additional cooling, and Plan 11 or 13 may be a suitable choice. Other services may require a Plan 32 flush if the pumped fluid is extremely corrosive, aggressive or solids-laden. Consider the need for venting on vertical pumps. Special attention may be needed on Arrangement 3 NC configurations to ensure effective pump operation. Consult the pump vendor if the pump is vented through the seal chamber, and consider the effects listed in footnote ^a above.

RECOMMENDED SEAL ARRANGEMENT SELECTION PROCEDURE (SI UNITS)
Buffer/barrier fluid selection
SHEET 10 OF 10

The following should be considered when selecting a barrier/buffer fluid:

- compatibility of the fluid with the process pumpage being sealed, so as not to react with or form gels or sludge if leaked into the process fluid or the process fluid into the barrier/buffer fluid;
- compatibility of the fluid with the metallurgy, elastomers, and other materials of the seal/flush system construction;
- compatibility of the fluid assuming it reaches the process fluid temperature (high or low).

On pressurized barrier-fluid systems where the method of pressurization is a gas blanket, special attention shall be given to the application conditions and barrier-fluid selection. Gas solubility in a barrier fluid increases with increasing pressure and decreases with increasing barrier-fluid temperature. As pressure is relieved or temperatures rise, gas is released from solution and can result in foaming and loss of circulation of the barrier fluid. This problem is normally seen where higher viscosity barrier fluids, such as lubricating oils, are used at pressures above 1,0 MPa.

The viscosity of the barrier/buffer fluid should be checked over the entire operating-temperature range, with special attention being given to start-up conditions. The viscosity should be less than 500 mm²/s at the minimum temperature to which it is exposed.

The following barrier-fluid performance facts should be considered.

- a) For services above 10 °C, hydrocarbon barrier/buffer fluids having a viscosity below 100 mm²/s at 38 °C, and between 1 mm²/s and 10 mm²/s at 100 °C, have performed satisfactorily.
- b) For services below 10 °C, hydrocarbon barrier/buffer fluids having a viscosity between 5 mm²/s and 40 mm²/s at 38 °C, and between 1 mm²/s and 10 mm²/s at 100 °C, have performed satisfactorily.
- c) For aqueous streams, mixtures of water and ethylene glycol or propylene glycol are usually adequate. Commercially available automotive antifreeze should never be used. The additives in antifreeze tend to plate out on seal parts and cause failure as a result of gel formation.
- d) The fluid should not freeze at the minimum ambient temperature at the site.

Fluid volatility and toxicity of the fluid shall be such that leakage to the atmosphere or disposal does not impose an environmental problem. In addition:

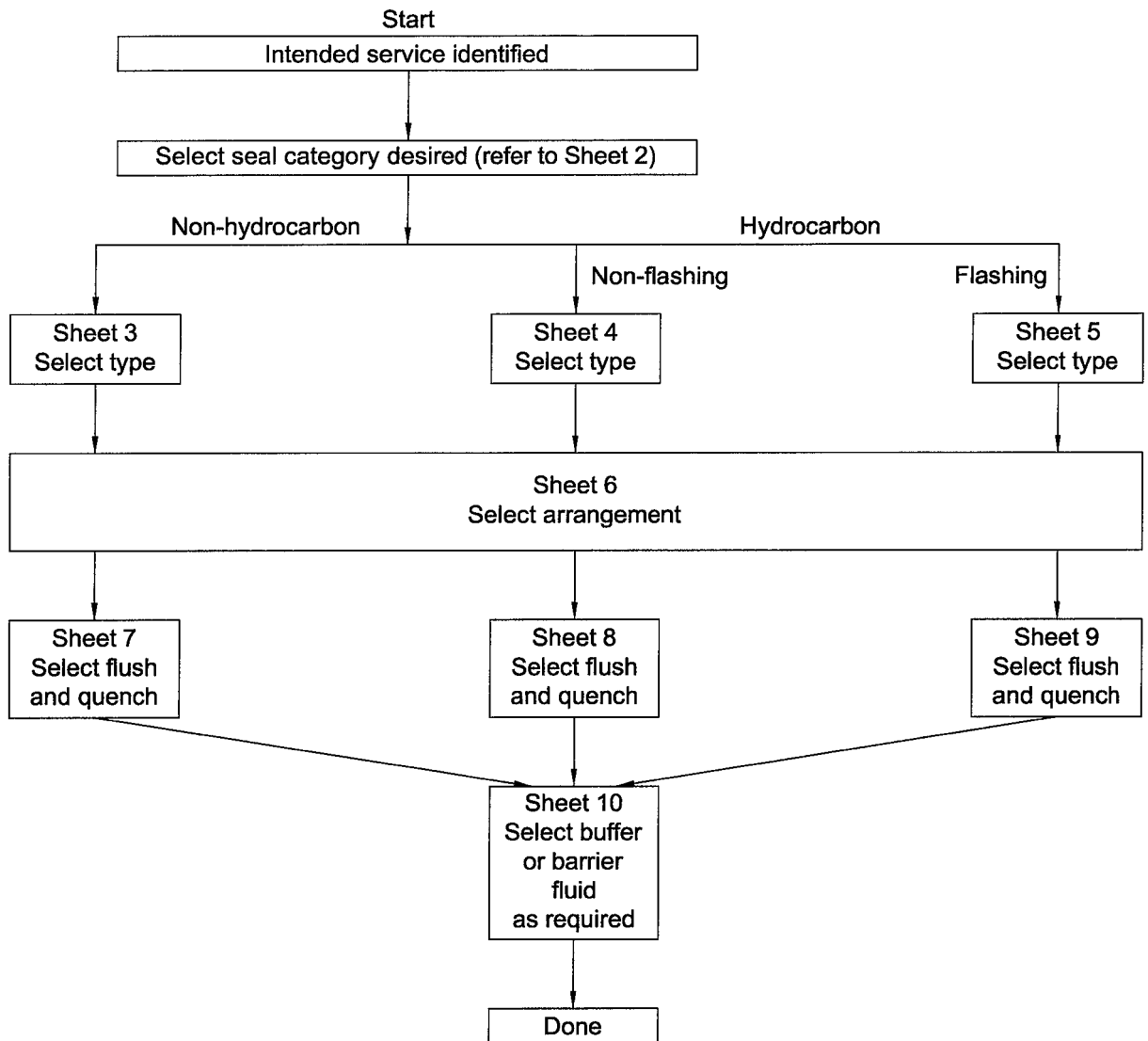
- the fluid should have an initial boiling point at least 28 °C above the temperature to which it will be exposed;
- the fluid should have a flash point higher than the service temperature if oxygen is present;
- ethylene glycol may be considered a hazardous material and/or hazardous waste when used as a barrier fluid.

The fluid should be able to meet the minimum 3-year continuous seal operation criteria without adverse deterioration. It should not form sludge, polymerize or coke after extended use.

For hydrocarbon streams, paraffin-based high purity oils having little or no additive for wear/oxidation resistance, or synthetic-based oils have been used successfully.

Anti-wear or oxidation-resistance additives in commercial turbine oils have been known to plate out on seal faces.

RECOMMENDED SEAL SELECTION PROCEDURE (US CUSTOMARY UNITS)
SHEET 1 OF 10



RECOMMENDED SEAL SELECTION PROCEDURE (US CUSTOMARY UNITS)
SEAL CATEGORY, TYPE, AND ARRANGEMENT SUMMARY
SHEET 2 OF 10

Seal category shall be Category 1, 2 or 3 as specified.

The major features of each category are summarized below. Options, where they exist for each feature, are listed in the text as "if specified". Clause numbers in parentheses indicate where the requirements are specified.

FEATURE	CATEGORY 1	CATEGORY 2	CATEGORY 3
Seal chamber size. (4.1.2)	ISO 3069 Type C, ASME B73.1 and ASME B73.2.	ISO 13709.	ISO 13709.
Temperature range. (4.1.2)	– 40 °F to 500 °F	– 40 °F to 750 °F	– 40 °F to 750 °F
Pressure range, absolute. (4.1.2)	315 psi	615 psi	615 psi
Face materials. (6.1.6.2)	Premium blister-resistant carbon vs. self-sintered silicon carbide.	Premium blister-resistant carbon vs. reaction-bonded silicon carbide.	Premium blister-resistant carbon vs. reaction-bonded silicon carbide.
Distributed inlet flush requirements, Arrangements 1 and 2 with rotating flexible elements.	When required per 6.1.2.14 or if specified. (6.2.1.2.1)	When required per 6.1.2.14 or if specified. (6.2.2.2.1)	Required. (6.2.3.2)
Gland plate metal-to-metal contact requirement.	Required. (6.2.1.2.2)	Required inside and outside of the bolt circle diameter. (6.2.2.2.2)	Required inside and outside of the bolt circle diameter. (6.2.2.2.2)
Cartridge seal sleeve size increments required.	None	10 mm increments. (6.2.2.3.1)	10 mm increments. (6.2.2.3.1)
Throttle bushing design requirement for Arrangement 1 seals. (7.1.2.1)	Fixed carbon. Floating carbon option. (7.1.2.2)	Fixed, non-sparking metal. Floating carbon option. (7.1.2.2)	Floating carbon.
Dual-seal circulation device head flow curve provided.	If specified. (8.6.2.2)	If specified. (8.6.2.2)	Required. (8.6.2.2)
Scope of vendor qualification test.	Test as Category 1 unless faces interchangeable with Category 3. (10.3.1.2.3)	Test as Category 2 unless faces interchangeable with Category 3. (10.3.1.2.3)	Test as Category 3, entire seal assembly as a unit. (10.3.1.2.2)
Proposal data requirements.	Minimal. (11.2.1)	Minimal. (11.2.1)	Rigorous, including qualification test results. (11.2.1)
Contract data requirements.	Minimal. (11.3.1)	Minimal. (11.3.1)	Rigorous. (11.3.1)

SHEET 2 OF 10 (continued)

Seal type shall be Type A, B, or C as specified.

The major features of each type are summarized below. Options, where they exist for each feature, are listed in the text as "if specified". Clause numbers in parentheses indicate where the requirements are specified.

FEATURE	TYPE A	TYPE B	TYPE C
Standard temperature application range. (4.1.3)	– 40 °F to 350 °F	– 40 °F to 350 °F	– 40 °F to 750 °F
Hydraulic balance requirement. (4.1.3 and 6.1.1.7)	Balanced (e.g. hydraulic balance less than 1).	Balanced (e.g. hydraulic balance less than 1).	Balanced (e.g. hydraulic balance less than 1).
Mounting requirement. (4.1.3)	Inside the seal chamber.	Inside the seal chamber.	Inside the seal chamber.
Cartridge requirement. (4.1.3 and 6.1.1.1)	Cartridge design.	Cartridge design.	Cartridge design.
Flexible element style. (4.1.3)	Pusher (e.g. sliding elastomer).	Non-pusher (e.g. bellows).	Non-pusher (e.g. bellows).
Flexible element orientation. (4.1.3)	Rotating. Stationary option. (6.1.1.2)	Rotating. Stationary option. (6.1.1.2)	Stationary. Rotating option. (6.1.1.3)
Bellows material. (6.1.6.6)	Not applicable.	Alloy C-276	Alloy 718
Spring type. (4.1.3)	Multiple-coil springs. Single spring option. (6.1.5.1)	Single bellows.	Single bellows.
Limit for stationary element application. (6.1.1.5)	4 500 ft/min	4 500 ft/min	4 500 ft/min
Secondary sealing element material. (4.1.3)	Elastomer.	Elastomer.	Flexible graphite.

SHEET 2 OF 10 (continued)

Seal arrangement shall be Arrangement 1, 2, or 3 as specified.

The major features of each arrangement are summarized below. Options, where they exist for each feature, are listed in the text as "if specified". Clause numbers in parentheses indicate where the requirements are specified.

FEATURE	ARRANGEMENT 1	ARRANGEMENT 2	ARRANGEMENT 3
Number of "seals" per cartridge, see definition of "seal" in 3.61. (4.1.4)	One (3.2 and 4.1.4)	Two (3.3 and 4.1.4)	Two (3.4 and 4.1.4)
Uses a barrier or buffer fluid. (4.1.4)	No	Sometimes but not required. Liquid or gas buffer permitted.	Yes, barrier fluid required, liquid or gas permitted.
Allows non-contacting (wet or dry) seals. (4.1.4)	No	Yes, Figure 4.	Yes, Figure 6.
Arrangement 1 throttle bushing requirement. (7.1.2.1)	Category 1: Fixed carbon. Category 2: Fixed, non-sparking metallic. Category 3: Floating carbon.	Not applicable.	Not applicable.
Arrangements 2 & 3 throttle bushing requirement.	Not applicable.	Fixed carbon, if specified. (7.2.3)	Fixed carbon, if specified. (7.3.3.1)
Arrangement 2 containment seal chamber bushing requirement.	Not applicable.	Required with dry-running containment seal regardless of inner seal design. (7.2.5.1 and 7.2.6.1)	Not applicable.
Tangential buffer/barrier fluid outlet required ?	Not applicable.	If specified, for Categories 1 and 2. Required for Category 3. (7.2.4.2)	If specified, for Categories 1 and 2. Required for Category 3. (7.3.4.3)
Maximum buffer/barrier fluid temperature rise.	Not applicable.	15 °F aqueous or diesel, 30 °F mineral oils. (7.2.4.1)	15 °F aqueous or diesel, 30 °F mineral oils. (7.3.4.1)
Seal chamber pressure/flush design requirement. (6.1.2.14)	Minimum margin of 30 % of seal chamber pressure above fluid vapour pressure or 36 °F margin.	Minimum margin of 30 % of seal chamber pressure above fluid vapour pressure or 36 °F margin.	None
Minimum operating seal chamber pressure requirement. (6.1.2.14)	5 psi above atmospheric.	5 psi above atmospheric.	None
Minimum gland plate connection sizes and orientation.	See Table 1.	See Table 1.	See Table 1.
Minimum barrier/barrier fluid liquid reservoir.	Not applicable.	3 U.S. gal for shaft diameter 2,5 in and smaller; otherwise 5 U.S. gal [8.5.4.3 a)]	3 U.S. gal for shaft diameter 2,5 in and smaller; otherwise 5 U.S. gal [8.5.4.3 a)]
Test requirements.	(10.3.1.2.8)	(10.3.1.2.9) and (10.3.1.2.10)	(10.3.1.2.11) and (10.3.1.2.12)

RECOMMENDED SEAL SELECTION PROCEDURE (US CUSTOMARY UNITS)
SHEET 3 OF 10
Non-hydrocarbon services

	Fluids	Operating conditions, recommended seal types and special features							
		1	2	3	4	5	6	7	8
		Water	Water	Water	Sour water	Sour water	Caustic, amines crystallize	Caustic, amines crystallize	Acids ^a H ₂ SO ₄ , H ₃ PO ₄
	Pumping temp., °F	< 180	< 180	> 180	< 180	< 180	< 180	< 180	< 180
	Seal chamber gauge pressure, psig Category 1 seals	< 300		< 300	< 300		< 300		< 300
	Seal chamber gauge pressure, psig Category 2 and 3 seals	< 300	300 to 600	< 600	< 300	300 to 600	< 300	300 to 600	< 300
	Standard seal type	Type A	Type A	Type A	Type A	Type A	Type A	Type A	Type A
	Options when specified	Type B Type C	ES ^b	ES ^b	Type B Type C	ES ^b	Type B Type C	ES ^b	Type B Type C
	Required special features			Circulating device	Perfluoro-elastomer	Perfluoro-elastomer	Amine-resistant perfluoro-elastomer	Amine-resistant perfluoro-elastomer	Perfluoro-elastomer and single spring for Type A seals
Special features for contaminants ^c	Abrasive particulates	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface
This selection procedure chooses seal designs consistent with the default positions throughout this International Standard. Listed options meeting this International Standard might perform equally well.									
^a Up to 20 % H ₂ SO ₄ at 77 °F only. Up to 20 % H ₃ PO ₄ at 176 °F only. All other acids, including hydrofluoric acid, fuming nitric acid and hydrochloric acid require special engineering agreed between purchaser and vendor.									
^b Totally engineered sealing system. Consult vendor to ensure special design considerations are accounted for.									
^c Special features listed apply only in mixtures having pH between 4 and 11.									

RECOMMENDED SEAL SELECTION PROCEDURE (US CUSTOMARY UNITS)
SHEET 4 OF 10
Non-flashing hydrocarbons

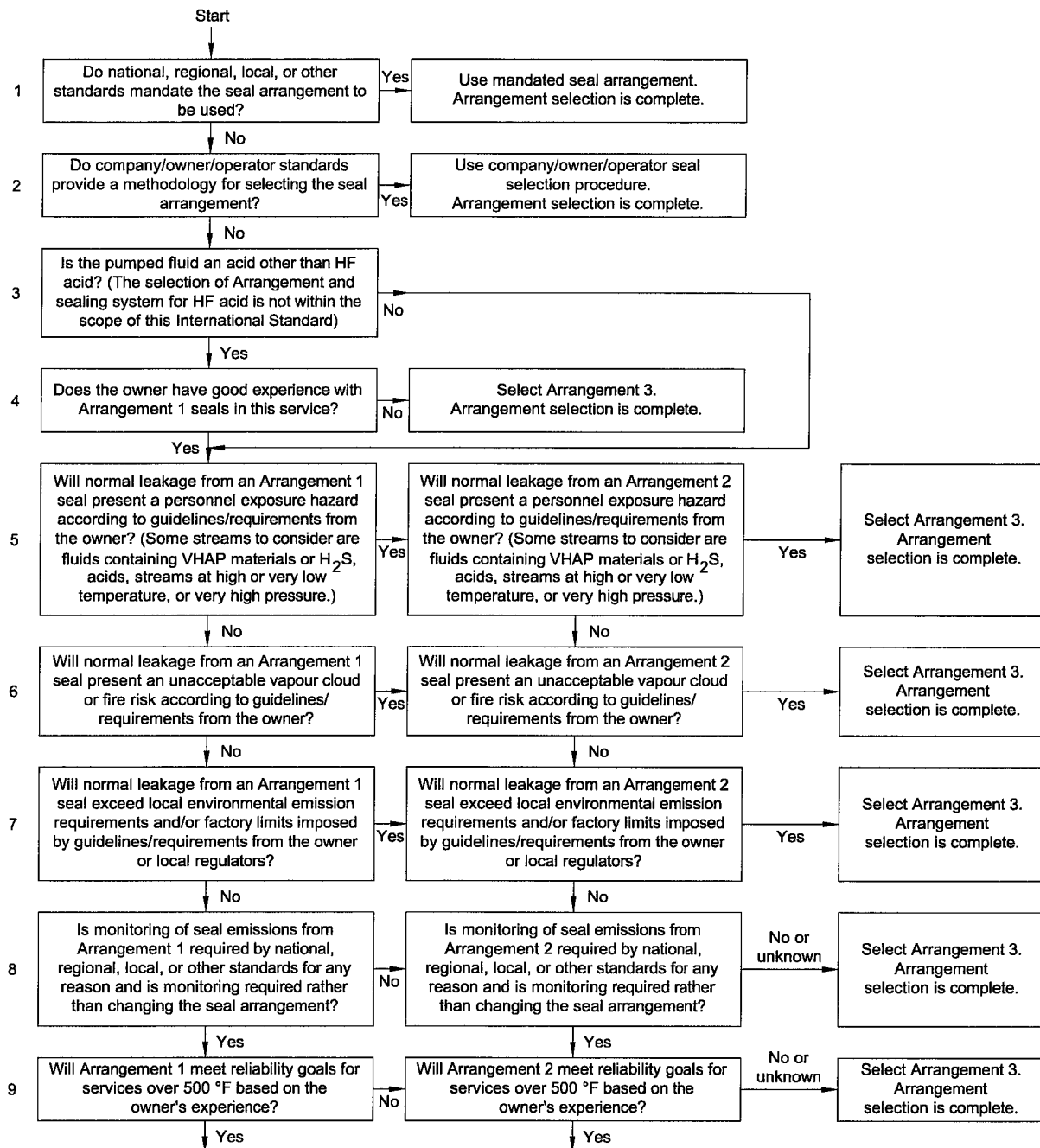
	Fluids	Operating conditions, recommended seal types and special features							
		1	2	3	4	5	6	7	8
	Pumping temp., °F	– 40 to 20	– 40 to 20	20 to 350	20 to 350	350 to 500	350 to 500	500 to 750	500 to 750
	Seal chamber gauge pressure, psig Category 1 seals	< 300		< 300		< 300		N/A	N/A
	Seal chamber gauge pressure, psig Category 2 and 3 seals	< 300	300 to 600	< 300	300 to 600	< 300	300 to 600	< 300	300 to 600
	Standard seal type	Type A	Type A	Type A	Type A	Type C	ES ^a	Type C	ES ^a
	Option when specified	Type B	ES ^{a, b}	Type B	ES ^{a, b}	ES ^a		ES ^a	
	Option when specified	Type C		Type C					
	Required special features	Nitrile O-rings	Nitrile O-rings						
Special features for contaminants ^c	Caustic			Perfluoro-elastomer	Perfluoro-elastomer				
	Abrasive particulates	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface
	Aromatics and/or H ₂ S			Perfluoro-elastomer	Perfluoro-elastomer				
	Amines			Amine-resistant perfluoro-elastomer	Amine-resistant perfluoro-elastomer				
This selection procedure chooses seal designs consistent with the default positions throughout this International Standard. Listed options meeting this International Standard might perform equally well.									
^a Totally engineered sealing system. Consult vendor to ensure special design considerations are accounted for. ^b Engineered (high pressure) bellows. ^c Special features listed apply only in mixtures having pH between 4 and 11.									

RECOMMENDED SEAL TYPE SELECTION PROCEDURE (US CUSTOMARY UNITS)
SHEET 5 OF 10
Flashing hydrocarbons

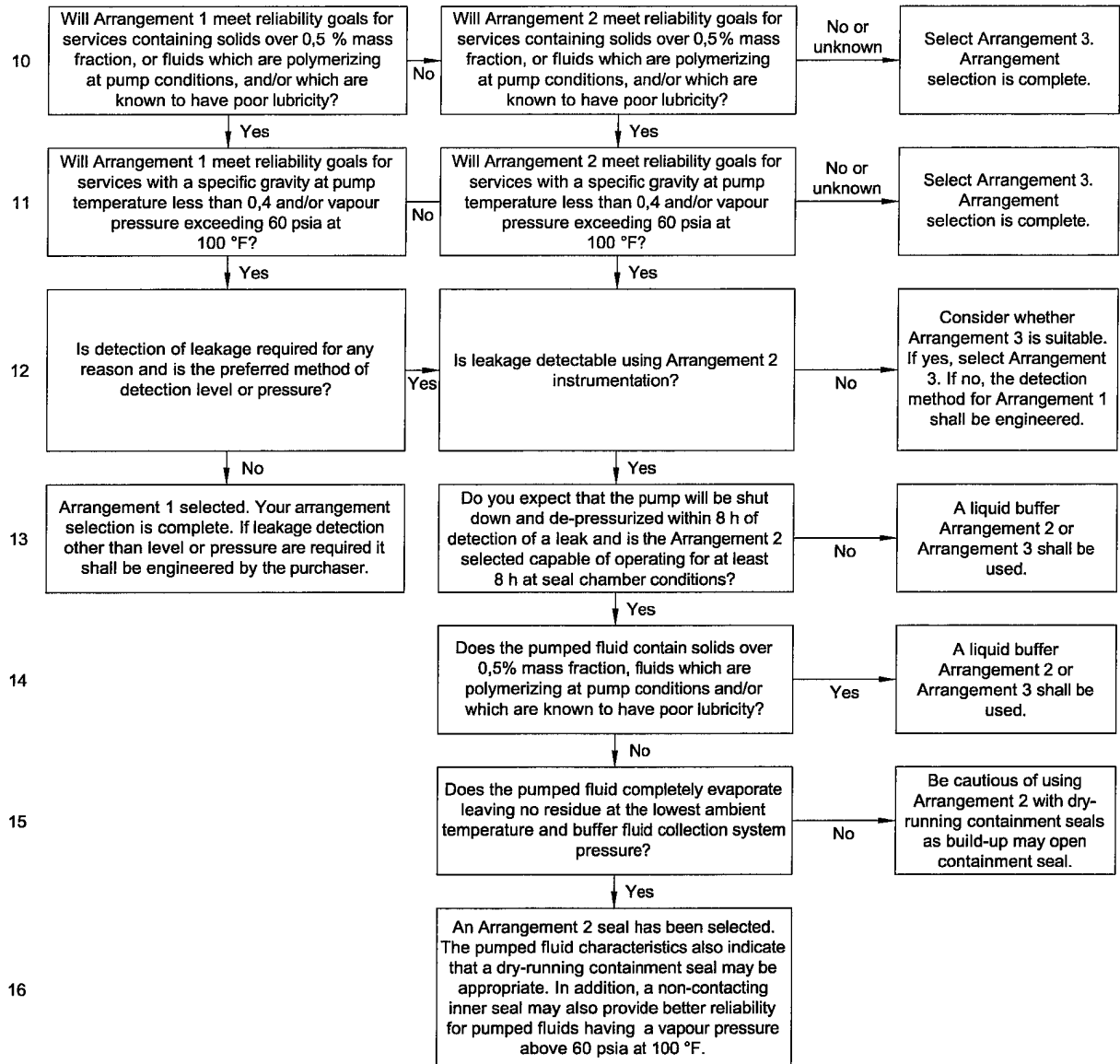
		Operating conditions, recommended seal types and special features							
	Fluids	1	2	3	4	5	6	7	8
	Pumping temp., °F	– 40 to 20	– 40 to 20	20 to 350	20 to 350	350 to 500	350 to 500	500 to 750	500 to 750
	Seal chamber gauge pressure, psig Category 1 seals	< 300		< 300		< 300		N/A	N/A
	Seal chamber gauge pressure, psig Category 2 and 3 seals	< 300	300 to 600	< 300	300 to 600	< 300	300 to 600	< 300	300 to 600
	Standard seal type	Type A	Type A	Type A ^d	Type A ^d	Type C	ES ^{a, b}	Type C	ES ^{a, b}
	Option when specified	ES ^a	ES ^{a, b}	ES ^a	ES ^{a, b}	ES ^a		ES ^a	
	Required special features	Nitrile O-rings	Nitrile O-rings						
Special features for contaminants^c	Caustic			Perfluoro-elastomer	Perfluoro-elastomer				
	Abrasive particulates	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface
	Aromatics and/or H ₂ S			Perfluoro-elastomer	Perfluoro-elastomer				
	Amines			Amine-resistant perfluoro-elastomer	Amine-resistant perfluoro-elastomer				
	Ammonia	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite
This selection procedure chooses seal designs consistent with the default positions throughout this International Standard. Listed options meeting this International Standard might perform equally well.									
^a Totally engineered sealing system. Consult vendor to ensure special design considerations are accounted for. ^b Engineered bellows. ^c Special features listed apply only in mixtures having pH between 4 and 11. ^d Requires special feature (circulating device) above 140 °F, and special feature (perfluoroelastomer) if pumping temperature is above 350 °F.									

RECOMMENDED SEAL ARRANGEMENT SELECTION PROCEDURE (US CUSTOMARY UNITS) **SHEET 6 OF 10**

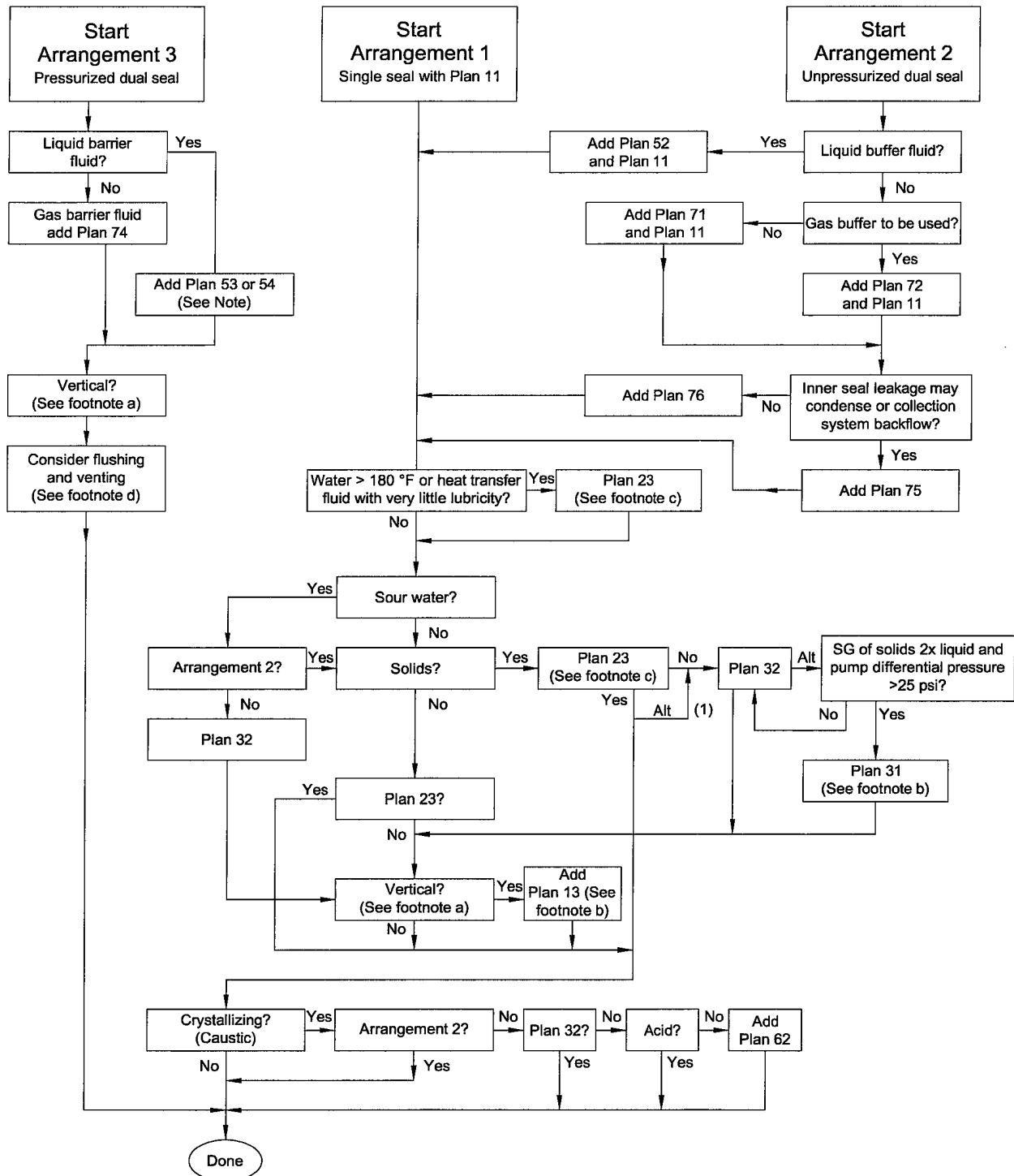
Assume Arrangement 1 to begin



SHEET 6 OF 10 (continued)



RECOMMENDED SEAL TYPE SELECTION PROCEDURE (US CUSTOMARY UNITS)
SHEET 7 of 10
Non-hydrocarbon



NOTE See A.4.13 for guidance on selecting Plan 53A, 53B or 53C.

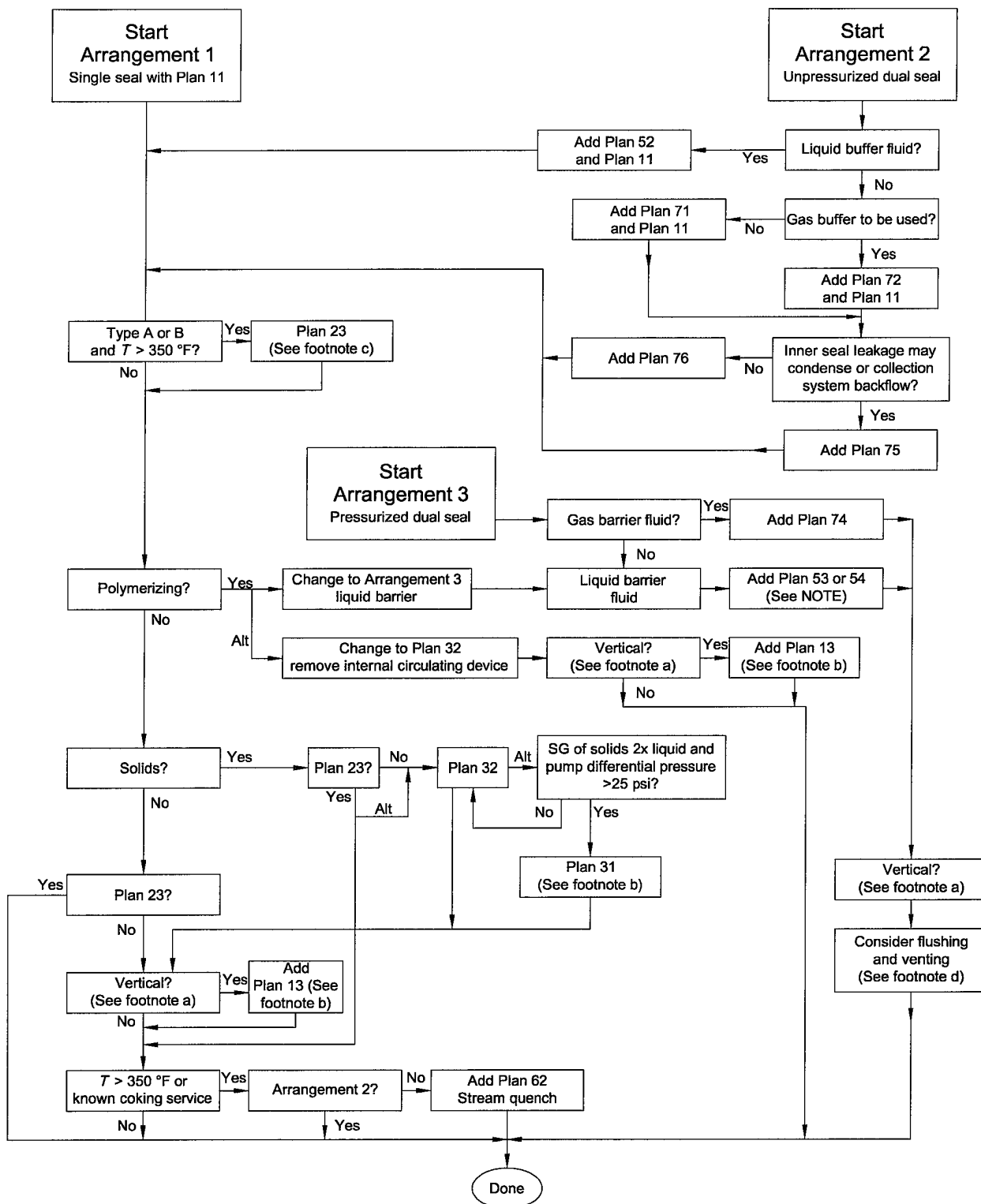
^a The user should evaluate whether to add Plan 13 or not, considering such factors as the inclusion of a bleed bushing, contamination of the seal chamber with pumped fluid, the need for venting of the seal chamber, and the need to reduce seal chamber pressure, due to static or dynamic pressure rating of the seal versus the expected static and dynamic seal chamber pressure.

^b If Plan 31, 32 or 41 is selected and pump is vertical, Plan 13 is also recommended for venting. Users should consider installation of a "bleed bushing" design, in which an annulus and port cut into the throat bushing is connected to suction to keep solids out of the seal chamber. Ensure seal chamber is vented prior to start-up.

^c Cooling is needed due to low lubricity at elevated temperature. The recommended flush plan is 23 because field experience has shown that this plan is much less prone to plugging than Plan 21 due to recirculation of cooler fluid from the seal chamber. However, the user may wish to reconsider using Plan 21 due to the added seal complexity imposed by Plan 23 (size and cost) and other factors such as the use of an air cooler for Plan 21 in areas where water cannot be used or is not available. (An air cooler works better on Plan 21 due to the higher temperature difference between the pumped fluid and the cooling medium.) The user may also wish to consider the use of Plan 32 if a suitable fluid is available, especially if the fluid is normally injected into the process anyway (such as make-up water). See the flush descriptions later in this annex for additional detail.

^d Consider the need to add additional flushing to the process side of the inner seal. Flushing is sometimes needed for Arrangement 3 FB orientation to provide additional cooling and Plan 11 or 13 may be a suitable choice. Other services may require a Plan 32 flush if the pumped fluid is extremely corrosive, aggressive or solids-laden. Consider the need for venting on vertical pumps. Special attention may be needed on Arrangement 3 NC configurations to ensure effective pump operation. Consult the pump vendor if the pump is vented through the seal chamber, and consider the effects listed in footnote ^a above.

RECOMMENDED SEAL SELECTION PROCEDURE (US CUSTOMARY UNITS)
SHEET 8 OF 10
Non-flashing hydrocarbon



NOTE See A.4.13 for guidance on selecting Plan 53A, 53B or 53C.

^a The user should evaluate whether to add Plan 13 or not, considering such factors as the inclusion of a bleed bushing, contamination of the seal chamber with pumped fluid, the need for venting of the seal chamber and the need to reduce seal chamber pressure, due to static or dynamic pressure rating of the seal versus the expected static and dynamic seal chamber pressure.

^b If Plan 31, 32 or 41 is selected and pump is vertical, Plan 13 is also recommended for venting. Users should consider installation of a "bleed bushing" design, in which an annulus and port cut into the throat bushing is connected to suction to keep solids or polymerizing agents out of the seal chamber. Ensure seal chamber is vented prior to start-up.

^c Cooling is needed due to temperature limits of the standard secondary elastomers for Arrangement 1 and possibly for Arrangement 2 (consult the seal vendor). Consideration may be given to changing to perfluoroelastomer if cooling is not possible. The recommended flush plan is 23 because field experience has shown that this plan is much less prone to plugging than Plan 21 due to recirculation of cooler fluid from the seal chamber. However, the user may wish to reconsider using Plan 21 due to the added seal complexity imposed by Plan 23 (size and cost) and other factors such as the use of an air cooler for Plan 21 in areas where water cannot be used or is not available. (An air cooler works better on Plan 21 due to the higher temperature difference between the pumped fluid and the cooling medium.) The user may also wish to consider the use of Plan 32 if a suitable fluid is available, especially if the fluid is normally injected into the process anyway (such as make-up water). See the flush descriptions later in this annex for additional detail.

^d Consider the need to add additional flushing to the process side of the inner seal. Flushing is sometimes needed for Arrangement 3 FB orientation to provide additional cooling, and Plan 11 or 13 may be a suitable choice. Other services may require a Plan 32 flush if the pumped fluid is extremely corrosive, aggressive or solids-laden. Consider the need for venting on vertical pumps. Special attention may be needed on Arrangement 3 NC configurations to ensure effective pump operation. Consult the pump vendor if the pump is vented through the seal chamber, and consider the effects listed in footnote ^a above.

NOTE See A.4.13 for guidance on selecting Plan 53A, 53B or 53C.

^a The user should evaluate whether to add Plan 13 or not, considering such factors as the inclusion of a bleed bushing, contamination of the seal chamber with pumped fluid, the need for venting of the seal chamber, and the need to reduce seal chamber pressure, due to static or dynamic pressure rating of the seal versus the expected static and dynamic seal chamber pressure.

^b If Plan 31, 32 or 41 is selected and pump is vertical, Plan 13 will also be recommended for venting. Users should consider installation of a "bleed bushing" design, in which an annulus and port cut into the throat bushing is connected to suction to keep solids or polymerizing agents out of the seal chamber. Ensure seal chamber is vented prior to start-up.

^c Cooling is recommended to suppress flashing within the seal faces. Due to cooling water temperatures, this is usually only effective above the temperature shown. Below this temperature, or as an alternative to adding cooling, the user may wish to use experience at their site or other alternatives such as high flushing rates, distributed flush systems, increased seal chamber pressure, or combinations thereof, to obtain satisfactory seal life. There may also be the opportunity to use Plan 32 if suitable flush fluid is available or, if experience is available, consideration of a change to Arrangement 3 may be appropriate.

^d Consider the need to add additional flushing to the process side of the inner seal. Flushing is sometimes needed for Arrangement 3 FB orientation to provide additional cooling, and Plan 11 or 13 may be a suitable choice. Other services may require a Plan 32 flush if the pumped fluid is extremely corrosive, aggressive or solids-laden. Consider the need for venting on vertical pumps. Special attention may be needed on Arrangement 3 NC configurations to ensure effective pump operation. Consult the pump vendor if the pump is vented through the seal chamber, and consider the effects listed in footnote ^a above.

RECOMMENDED SEAL ARRANGEMENT SELECTION PROCEDURE (US CUSTOMARY UNITS)
Buffer/barrier fluid selection
SHEET 10 OF 10

The following should be considered when selecting a barrier/buffer fluid:

- compatibility of the fluid with the process pumpage being sealed so as not to react with or form gels or sludge if leaked into the process fluid or the process fluid into the barrier/buffer fluid;
- compatibility of the fluid with the metallurgy, elastomers, and other materials of the seal/flush system construction;
- compatibility of the fluid assuming it reaches the process temperature (high or low).

On pressurized barrier fluid systems where the method of pressurization is a gas blanket, special attention shall be given to the application conditions and barrier fluid selection. Normally, gas solubility in a barrier fluid increases with increasing pressure and decreases with increasing barrier fluid temperature. As pressure is relieved or temperatures rise, the gas is released from solution, and may result in foaming and loss of circulation of the barrier fluid. This problem is normally seen where higher viscosity barrier fluids, such as lube oils, are used at gauge pressures above 150 psi.

The viscosity of the barrier/buffer fluid should be checked over the entire operating temperature range with special attention being given to start-up conditions. The viscosity should be less than 500 cSt at the minimum temperature to which it is exposed.

The following barrier-fluid performance facts should be considered.

- a) For services above 50 °F, hydrocarbon barrier/buffer fluids having a viscosity below 100 cSt at 100 °F and between 1 cSt and 10 cSt at 212 °F have performed satisfactorily.
- b) For services below 50 °F, hydrocarbon barrier/buffer fluids having a viscosity between 5 cSt and 40 cSt at 100 °F and between 1 cSt and 10 cSt at 212 °F have performed satisfactorily.
- c) For aqueous streams, mixtures of water and ethylene glycol or propylene glycol are usually adequate. Commercially available automotive antifreeze should never be used. The additives in antifreeze tend to plate out on seal parts and cause failure as a result of gel formation.
- d) The fluid should not freeze at the minimum ambient temperature at the site.

Fluid volatility and toxicity of the fluid shall be such that leakage to the atmosphere or disposal does not impose an environmental problem. In addition,

- the fluid should have an initial boiling point at least 50 °F above the temperature to which it will be exposed;
- the fluid should have a flash point higher than the service temperature if oxygen is present;
- ethylene glycol may be considered a hazardous material and/or hazardous waste when used as a barrier fluid.

The fluid should be able to meet the minimum 3-year continuous seal operation criteria without adverse deterioration. It should not form sludge, polymerize or coke after extended use.

For hydrocarbon streams, paraffin-based high purity oils having little or no additives for wear/oxidation resistance, or synthetic-based oils have been used successfully.

Anti-wear or oxidation-resistance additives in commercial turbine oils have been known to plate out on seal faces.

A.2 Tutorial clause

A.2.1 Seal selection justification

A.2.1.1 All seal selections by service were made with the following considerations in mind:

- a) to produce a reliable sealing system that has a high probability of operating 3 years of uninterrupted service, meeting or exceeding environmental emission regulations;
- b) personnel and plant safety in hazardous services; and
- c) to minimize spare parts inventory required for insurance stock.

A.2.1.2 All selections were made using experience of engineering, purchasing, operating, retrofitting and maintaining mechanical seals in various services and locations. The selections were made to ensure that the best seal for the service will be installed. Surely, a seal not specified by this International Standard is operating successfully in a given service somewhere. This International Standard does not attempt to prevent the selection of other seals. However, if a seal not specified by this International Standard is chosen, special engineering is recommended for successful operation.

Any seal operating with a seal chamber gauge pressure above a gauge pressure of 2,1 MPa (21 bar) (300 psi) for Category 1 seals or a gauge pressure of 4,1 MPa (41 bar) (600 psi) for Category 2 and Category 3 seals requires special engineering. Any product temperature above 260 °C (500 °F) for Category 1 seals and above 400 °C (750 °F) for Category 2 and 3 seals also requires special engineering design considerations. Therefore, the selection categories are limited to the above pressures and temperatures for this International Standard.

A.2.1.3 The seal references in this International Standard are:

- a) Type A, standard pusher seal;
- b) Type B, standard option for Type A, a non-pusher seal with rotating bellows and elastomeric secondary sealing elements; and
- c) Type C, standard non-pusher seal with stationary bellows and flexible graphite secondary sealing elements.

See Clause 3, Clause 4 and sheet 1 of this annex, for further description.

NOTE Pressure levels listed apply to Category 1, Category 2 or Category 3 as noted on the applicable sheet.

A.2.2 Non-hydrocarbon services — Sheet 3

A.2.2.1 Clean water below 80 °C (180 °F) and below a gauge pressure of 2,1 MPa (21 bar) (300 psi)

The standard seal is a Type A standard pusher with no special features required.

The standard options are either a Type B or Type C metal bellows with no special features required.

A.2.2.2 Clean water below 80 °C (180 °F) and a gauge pressure of between 2,1 MPa (21 bar) (300 psi) and 4,1 MPa (41 bar) (600 psi)

The standard seal is a Type A standard pusher with no special features required.

Any seal other than a Type A should be specially engineered for high pressure. Seal manufacturers normally rate their metal bellows designs for gauge pressures of less than 2,1 MPa (21 bar) (300 psi). The seal manufacturer should be consulted for specific performance data above this pressure.

A.2.2.3 Water above 80 °C (180 °F) and at a gauge pressure below 4,1 MPa (41 bar) (600 psi)

The standard seal is a Type A pusher with special features. The special features are a single-spring seal with an internal circulating device to circulate through a Plan 23 closed-loop system. As shown on sheet 7, a Plan 21 might also be used, especially if an air cooler is used. The elastomer configuration can be either O-ring or "U" cup.

The alternative seal is a Type A standard pusher with special features to include an internal circulating device to circulate through a Plan 23 closed-loop system, and a close-clearance bushing in the bottom of the sealing chamber.

A Plan 23 flushing arrangement is the most efficient way of providing a cool flush to the seal faces. Use of an internal circulating device to circulate the fluid through a closed-loop cooler allows the cooler to continuously cool a recirculated stream rather than a continuous (hot) stream from the discharge of the pump (Plan 21). The cooler now has to cool only that fluid in the loop, and the duty cycle is much less severe than a Plan 21.

A survey in one facility revealed that the average temperature of the inlet flush to the sealing chamber was 50 °C (122 °F). The average pumping temperature of the product was 219 °C (426,2 °F). The idle pump's average inlet temperature was 38 °C (100,4 °F). The idle pumps rely only on the thermosyphon through the cooler to cool the fluid. The cooler shall be mounted in accordance with this International Standard to ensure proper thermosyphoning.

A.2.2.4 Sour water below 80 °C (180 °F) up to a gauge pressure of 4,1 MPa (41 bar) (600 psi)

The standard seal is a Type A standard pusher with special features. The elastomers shall be changed to perfluoroelastomer to resist the H₂S, as H₂S is generally the agent that sours water.

The standard option up to a gauge pressure of 2,1 MPa (21 bar) (300 psi) is either the Type B or Type C seal with the special feature of perfluoroelastomer for the Type B.

The use of Type B or Type C seal above a gauge pressure of 2,1 MPa (21 bar) (300 psi) requires special engineering for the high pressure.

This selection is made to maximize the standardization process, as the Type A seal is recommended for all pressure ranges. Sour water may become flashing as the temperature and H₂S content increase.

A.2.2.5 Caustic, amines, and other crystallizing fluids below 80 °C (180 °F) and below a gauge pressure of 4,1 MPa (41 bar) (600 psi)

The standard seal is a Type A standard pusher with the special features of perfluoroelastomer.

The standard alternative is a Type B metal bellows seal up to a gauge pressure of 2,1 MPa (21 bar) (300 psi) with perfluoroelastomer.

The use of Type C seals up to a gauge pressure of 2,1 MPa (21 bar) (300 psi) with flexible graphite secondaries should be specially engineered, as graphite is not recommended for some caustic applications.

For gauge pressures above 2,1 MPa (21 bar) (300 psi) but below 4,1 MPa (41 bar) (600 psi), the use of Type B and Type C metal bellows seals require special engineering for the high pressure.

Any application in a crystallizing fluid requires the use of a Plan 62 quench or a Plan 32 flush to keep crystals from forming on the atmospheric side of the seal. Most facilities prohibit a quench from seals unless totally contained. A Plan 32 flush arrangement is generally not acceptable, as it dilutes the product and is sometimes expensive to operate. In these conditions an Arrangement 2 dual seal (un-pressurized buffer) should be considered, using clean water (or other compatible fluid) as a buffer to keep the crystals in solution. The same special features apply to both the dual seal and the single seals.

A.2.2.6 Acids: sulfuric, hydrochloric, phosphoric acids at less than 80 °C (180 °F) and below a gauge pressure of 2,1 MPa (21 bar) (300 psi)

The standard seal is a Type A standard pusher with special features. The special features are a single coil-spring.

The standard option is a Type B or Type C using flexible graphite as a secondary in the Type C.

Due to the thin cross-section of multiple-coil springs and bellows plates, select the most corrosion-resistant material for the application.

Hydrofluoric, fuming nitric, and other acids are not covered in this selection. Specially engineered designs agreed between the owner and the seal manufacturer should be used.

Seals for use with acids at temperatures over 80 °C (180 °F) require special engineering.

Seals for use with acids at a gauge pressure above 2,1 MPa (21 bar) (300 psi) require special engineering.

A.2.3 Non-flashing hydrocarbons [absolute vapour pressure less than 0,1 MPa (1 bar) (14,7 psi) at pumping temperature] — Sheet 4

A.2.3.1 From – 40 °C (– 40 °F) to – 5 °C (20 °F) and below a gauge pressure of 4,1 MPa (41 bar) (600 psi)

The standard seal is a Type A standard pusher with the special feature of NBR elastomers for the low temperature service. The NBR shall also be compatible with the pumped fluid.

The standard alternative up to a gauge pressure of 2,1 MPa (21 bar) (300 psi) is either a Type B with the special feature of NBR elastomers or a Type C with flexible graphite secondaries.

For gauge pressures over 2,1 MPa (21 bar) (300 psi), seal Types B and C require engineered bellows designed for the high pressure.

The special feature of NBR elastomers is due to the low temperature requirements. The standard fluoroelastomer is rated at – 17,7 °C (0 °F), but, for the applications of this International Standard, fluoroelastomer should not be used below – 5 °C (20 °F).

A.2.3.2 From – 5 °C (20 °F) to 176 °C (350 °F) and gauge pressures below 4,1 MPa (41 bar) (600 psi)

The standard seal is a Type A standard pusher with no special features required. (Check elastomer compatibility charts for pumped fluid).

The standard option for gauge pressures up to 2,1 MPa (21 bar) (300 psi) is a Type B or Type C standard non-pusher. The Type C seal should be used with flexible graphite secondaries.

The standard alternative for gauge pressures above 2,1 MPa (21 bar) (300 psi) is a Type B or Type C with engineered bellows for the high pressure.

The standard pusher seal elastomer is fluoroelastomer, which is rated at 204 °C (400 °F). A pumping temperature of 176 °C (350 °F) is realistic for fluoroelastomer, as the face friction will generate additional heat and raise the temperature the elastomer must endure.

A.2.3.3 From 176 °C (350 °F) to 260 °C (500 °F) and below a gauge pressure of 2,1 MPa (21 bar) (300 psi)

The standard seal is a Type C stationary non-pusher metal bellows seal using flexible graphite for secondaries.

The standard alternative is a Type A standard pusher with special features including an internal circulating device and perfluoroelastomer, circulating through a Plan 23 closed-loop system in accordance with the flush selection diagram.

The Type C seal is selected as the standard due to the temperature range, which is generally the range where coking occurs. The stationary bellows design easily accepts a steam baffle for anti-coking protection, whereas a rotating bellows does not.

A Type A seal with an internal circulating device and a Plan 23 closed-loop system maintains the product temperature below the range where coking occurs.

A.2.3.4 From 176 °C (350 °F) to 260 °C (500 °F) and from a gauge pressure of 2,1 MPa (21 bar) (300 psi) to 4,1 MPa (41 bar) (600 psi)

A totally engineered sealing system is required for hot high pressure services.

A.2.3.5 From 260 °C (500 °F) to 400 °C (750 °F) and below a gauge pressure of 2,1 MPa (21 bar) (300 psi)

The Type C seal is selected as the standard due to the temperature range, which is generally the range where coking occurs. The stationary bellows design easily accepts a steam baffle for anti-coking protection, whereas a rotating bellows does not.

The standard alternative is a totally engineered sealing system.

A.2.3.6 From 260 °C (500 °F) to 400 °C (750 °F) and from a gauge pressure of 2,1 MPa (21 bar) (300 psi) to 4,1 MPa (41 bar) (600 psi)

The only acceptable alternative is a totally engineered sealing system.

A.2.4 Flashing hydrocarbons [vapour pressure above 0,1 MPa (1 bar) (14,7 psi) at pumping temperature] — Sheet 5

A.2.4.1 From – 40 °C (– 40 °F) to – 5 °C (20 °F) and a gauge pressure below 4,1 MPa (41 bar) (600 psi)

The standard seal is a Type A standard pusher with special features. The special feature is an NBR elastomer. Ensure NBR is compatible with the pumped fluid.

The standard alternative is an engineered sealing system with an engineered metal bellows for the flashing service.

Metal bellows seals in flashing service are prone to fatigue failure, induced by “stick-slip” if marginal vapour suppression occurs. If metal bellows are desired, the seal should be a totally engineered sealing system with special attention to vapour suppression under all operating conditions of the pump, such as start-up, shutdown and plant upsets.

A.2.4.2 From – 5 °C (20 °F) to 176 °C (350 °F) and a gauge pressure below 4,1 MPa (41 bar) (600 psi)

The standard seal is a Type A standard pusher with special features to maintain adequate vapour suppression. If the temperature is above 60 °C (140 °F), an internal circulating device and Plan 23 closed-loop system should be considered as an alternative to help reduce flashing at the seal face. If the temperature is above 176 °C (350 °F), perfluoroelastomer should be used.

The standard alternative is a totally engineered sealing system with an engineered metal bellows.

Vapour suppression by cooling is always preferred over pressurization. Therefore, a Type A seal with internal circulating device and Plan 23 closed-loop system is selected if the temperature is above 60 °C (140 °F). The

60 °C (140 °F) limit is based on the cooling-water temperature in the hot months, where little cooling of a product below 60 °C (140 °F) will occur. Various locations may choose a higher or lower limit based on the maximum cooling-water temperature in that specific location.

A.2.4.3 From 176 °C (350 °F) to 400 °C (750 °F) and below a gauge pressure of 2,1 MPa (21 bar) (300 psi)

The standard seal is a Type C seal. The standard alternative is a totally engineered sealing system.

A.2.4.4 Above 176 °C (350 °F) and a gauge pressure from 2,1 MPa (21 bar) (300 psi) to 4,1 MPa (41 bar) (600 psi)

The seal should be a totally engineered sealing system.

A.3 Tutorial seal selection — Sheet 6

A.3.1 Sheet 6 is intended only as a guide to some of the aspects that might be considered in the selection of a seal arrangement. The user should evaluate the cost benefits and risk associated with any selection.

A.3.2 Question 1 is whether there are any regulations effective at the site of the equipment which require specific hardware. This hardware could include low-emission single seal or dual seals. The question is intended to alert the user so that he can investigate the possibility that specific designs might be required.

A.3.3 Question 2 alerts the user to examine the pumped stream to determine if any owner or operator standards exist that would dictate or help define the required arrangement from the owner or operator. These standards might deem the stream hazardous and require specific methods of control or limits of exposure on emissions, even if local regulations do not. Seal designs shall then employ the required hardware or be designed to meet the required emission limit.

A.3.4 Question 3 addresses selection of arrangement for acids. If the stream is not acid, question 3 will skip to question 5.

A.3.5 Question 4 selects the arrangement for an acid stream as either a single seal or a pressurized dual seal. Unpressurized dual seals are not recommended, due to the potential for build-up of acid in the buffer system or containment seal chamber.

A.3.6 Question 5 addresses materials which may pose a personnel hazard, such as rich (in H₂S) amine streams, to highlight the need for control beyond a single seal without external flush. The highlight is needed because specifications often overlook the need for added control measures on this type of stream.

A.3.7 Question 6 is similar to question 5, except it addresses streams for which an Arrangement 1 seal will not meet safety requirements of the owner concerning a potential vapour cloud or fire risk.

A.3.8 Question 7 addresses the need for additional sealing control on those streams which will not meet local emission requirements with an Arrangement 1 seal. Arrangement 2 or Arrangement 3 is chosen as needed instead.

A.3.9 Question 8 alerts the user to the fact that in certain countries, Arrangement 1 seals in specific services are required to be monitored (or “sniffed”) for emissions. If the user wishes to perform this monitoring then Arrangement 1 is suitable. However, the option is given to change the arrangement and possibly avoid monitoring.

A.3.10 Question 9 addresses reliability considerations for hot services. Experience has shown that Arrangement 2 or Arrangement 3 may provide better reliability.

A.3.11 Question 10 addresses reliability considerations for polymerizing agents, solids, and low-lubricity fluids out of the seal faces in order to help meet the goal of 3 years uninterrupted life.

A.3.12 Experience has shown Arrangement 1 and Arrangement 2 used in very light fluids often cannot meet the goal of a 3-year service. Special sealing arrangements involving the use of non-contacting inner seals in an Arrangement 2 have been known to provide very reliable service in fluids such as methane, ammonia, propane and other hydrocarbon mixtures of high vapour pressure.

A.3.13 Question 12 is intended to alert the user to the possible need for provision of an alarm of leakage. An arrangement other than Arrangement 1 is generally needed if leakage must be detected.

A.3.14 Question 13 determines how the user intends to use the containment feature of an unpressurized dual seal. Because of heat generation and face load, dry containment seals can have limited life at full seal chamber conditions.

A.3.15 This step changes to an Arrangement 3 or recommends a liquid buffer if the pumpage contains solids or polymerizing agents. These contaminants can reduce the reliability of dry containment seals.

A.3.16 An Arrangement 2 seal has been selected and further guidance is provided on the possible use of non-contacting inner seals

A.4 Tutorial on sheet 7 to sheet 9 of seal selection procedure

A.4.1 General

To aid in understanding the logic behind the flow/decision charts in sheet 7 to sheet 9 of the seal selection procedure, the following descriptions of the specified seal flush plans are given.

A.4.2 Plan 01

Plan 01 is similar to a Plan 11 except that internal porting is used to direct flow to the seal chamber from an area behind the impeller near the discharge. This plan is recommended for clean fluids only. Plan 01 may be useful with liquids that thicken or solidify at normal ambient temperatures to minimize the risk of freezing the fluid in flush piping. Special attention is needed to ensure that the recirculation supplied is sufficient for the seal operating requirements.

A.4.3 Plan 02

Plan 02 is a dead-ended seal chamber with no flush fluid circulation. Plan 02 is more common in the chemical industry in applications with low seal chamber pressures and process temperatures. Typically, the plan is used in conjunction with a taper bore seal chamber modified with flow enhancers. The process fluid should be relatively clean to avoid excessive erosion of the seal gland, seal chamber, or seal parts created by the swirling flow pattern. The vapour pressure sensitivity of the process fluid should also be taken into consideration to avoid flashing conditions in the seal chamber or at the seal faces. Plan 02 can be used with cool clean fluids with high specific heats, such as water, in relatively low-speed pumps. The product temperature margin should be carefully reviewed for any application where the selection of Plan 02 is being considered.

A.4.4 Plan 11

Plan 11 is the default seal flush plan for all single seals. In Plan 11, product is routed from the pump discharge to the seal chamber to provide cooling for the seal and to vent air or vapours from the seal chamber. Fluid then flows from the seal cavity back into the process stream. It is the most commonly used flush plan for clean general service equipment. For high-head applications, careful consideration should be given to calculation of the required flush flowrate. Calculations are required to determine the proper orifice and throat bushing dimensions to assure adequate seal flush flow.

A.4.5 Plan 13

Plan 13 is the standard flush plan selection for vertical pumps that are not provided with a bleed bushing below the seal chamber. The seal chamber pressure on vertical pumps supplied without a bleed bushing would normally operate at full discharge pressure. Due to this arrangement there is no pressure differential to allow a Plan 11 to work. In Plan 13, product is routed from the seal chamber back to the pump suction to provide cooling for the seal and to vent air or vapours from the seal chamber. Plans 1, 11, 12, 21, 22, 31 or 41 are used in conjunction with Plan 13 for vertical suspended pumps.

Plan 13 provides self venting on vertical in-line pumps provided differential pressure is sufficient to ensure circulation and seal chamber pressure is sufficient to prevent vaporization.

Plan 13 is also used in high-head pumps where the use of Plan 11 would require too small an orifice or would produce too high a flush flowrate. This plan will generally not work well in low-head pumps because of the low pressure differential between the seal chamber and the pump suction. The suitability of the service for Plan 13 can be determined by calculating the required flush flowrate and then calculating the required orifice size.

A.4.6 Plan 14

Plan 14 is the combination of a Plan 11, recirculation from pump discharge, and Plan 13, recirculation to pump suction. It allows a cooling flow to be supplied to the seal chamber (Plan 11) while providing complete venting of the seal chamber (Plan 13). Plan 14 is most commonly used on vertical pumps.

A.4.7 Plan 21

Plan 21 provides a cool flush to the seal. This may be needed to improve the margin to vapour formation, to meet secondary sealing element temperature limits, to reduce coking or polymerizing, or to improve lubricity (as in hot water). The benefit of Plan 21 is that it not only provides a cool flush but also has sufficient pressure differential to allow good flowrates. The drawback is that the cooler duty is high, leading to fouling and plugging on the water side and potential plugging on the process side if the fluid viscosity gets high quickly. Plan 21 works best in dry climates where an air fin cooler is used instead of a water cooler. Note that Plan 21 also uses more energy than Plan 23, because the pumped fluid that is used for the flush must be re-pumped from suction back to the discharge.

A.4.8 Plan 23

Plan 23 is the plan of choice for all hot water services, particularly boiler feed water, and many hydrocarbon services. This plan is the standard selection for hot water at 80 °C (180 °F) and above, and boiler feed water. Hot water has very low lubricity above 80 °C (180 °F), resulting in high seal face wear. This plan is also desirable in many hydrocarbon and chemical services where it is necessary to cool the fluid to establish the required margin between fluid vapour pressure (at the seal chamber temperature) and seal chamber pressure. In a Plan 23, the cooler only removes seal face-generated heat plus heat soak from the process. This duty is usually much less severe than that in Plan 21 or Plan 22.

Lessening the duty is very desirable because it extends the life of the cooler. The industry has considerable negative experience with Plan 21 and Plan 22 because of cooler plugging.

In Plan 23, product in the seal chamber is isolated from that in the impeller area of the pump by a throat bushing. The seal is equipped with an internal circulating device that circulates seal chamber fluid through a cooler and back to the seal chamber. In this arrangement, the cooler cools only that fluid in which the seal operates, and this cool fluid does not enter the process. This results in high energy efficiency.

High-freezing-point and viscous products should be considered when selecting a Plan 23 flush system. The cooler might cool the fluid below the point of circulation. In these applications, consider using steam as a cooling medium, or utilize a Plan 21 system.

A.4.9 Plan 31

Plan 31 is specified only for services containing solids with a specific gravity at least twice that of the process fluid. A typical use of this plan is water service to remove sand or pipe slag. In Plan 31, product is routed from the discharge of the pump into a cyclone separator. Solid particles are centrifuged from the stream and routed back to suction. The seal flush is routed from the cyclone separator into the flush connection on the seal plate. If the process stream is very dirty or is a slurry, Plan 31 typically is inadequate and is not recommended. The use of a pump throat bushing is recommended when a Plan 31 is specified.

A.4.10 Plan 32

Plan 32 is used in services containing solids or contaminants, in which a suitable cleaner or cooler external flush will improve the seal environment. It is also used to reduce flashing or air intrusion (in vacuum services) across the seal faces by providing a flush that has a lower vapour pressure or that will raise the seal chamber pressure to an acceptable level. The external flush should be continuous and reliable even during non-standard situations such as start-up or shutdown. The external flush should also be compatible with the process stream because it will flow from the seal chamber into the process fluid.

In Plan 32, the flushing product is brought from an external source to the seal. This plan is almost always used in conjunction with a close-clearance throat bushing. The bushing can function as a throttling device to maintain an elevated pressure in the stuffing box or as a barrier to isolate the pumped product from the seal chamber.

Plan 32 is not recommended for cooling only, as the energy costs can be very high. Product degradation costs should also be considered when using a Plan 32.

A.4.11 Plan 41

Plan 41 is a combination of Plans 21 and 31 and is specified only for hot services containing solids. Contained solids should have a specific gravity twice or more that of the process fluid. For this seal plan to be used, the seal should require a cool flush. This cool flush may be needed to improve the temperature margin over the fluid vapour pressure, or to meet secondary sealing element temperature limits, or to reduce coking or polymerizing, or to improve lubricity (as in hot water). A typical use of this plan is in a hot water service to remove sand or pipe slag.

In Plan 41, product is routed from the discharge of the pump into a cyclone separator. Solid particles are centrifuged from the stream and routed back to suction. The seal flush is then routed from the cyclone separator through an exchanger and into the flush connection on the seal plate.

If the process stream is very dirty or is a slurry, Plan 41 typically is inadequate and is not recommended. The benefits, detriments, and the best conditions for the use of the exchanger in the flush stream can be found in the write-up on Plan 21. The use of a pump throat bushing is recommended when a Plan 41 is specified.

A.4.12 Plan 52

Plan 52 is used with Arrangement 2 seals, with a contacting wet containment seal (configuration 2CW-CW) utilizing a liquid buffer system. It is normally used in services where process fluid leakage to atmosphere must be minimized and contained. The buffer liquid is contained in a seal pot which is vented to a vent system, thus maintaining the buffer system pressure close to atmospheric.

Plan 52 works best with clean, non-polymerizing, pure products that have a vapour pressure higher than the buffer system pressure. Leakage of higher vapour pressure process liquids into the buffer system will flash in the seal pot and the vapour can escape to the vent system.

Inner seal process liquid leakage will normally mix with the buffer fluid and contaminate the buffer liquid over time. Maintenance associated with seal repairs, filling, draining and flushing a contaminated buffer system can be considerable.

A.4.13 Plan 53A, Plan 53B, Plan 53C

Plan 53 or Arrangement 3 pressurized dual seal systems are used in services where no leakage to atmosphere can be tolerated. A Plan 53A system consists of dual mechanical seals with a barrier fluid between them. The barrier fluid is contained in a seal pot which is pressurized to approximately 0,14 MPa (1,4 bar) (20 psi) greater than the pump seal chamber. Inner seal leakage will be barrier fluid leakage into the product. There will always be some leakage. If seal chamber gauge pressures vary significantly, or are above 4,2 MPa (42 bar) (615 psi), the **inner and outer** seal stresses can be reduced by the application of a controlled differential pressure regulator set 0,14 MPa (1,4 bar) (20 psi) to 0,17 MPa (1,7 bar) (25 psi) higher than the pump seal chamber pressure.

Plan 53B is also a pressurized dual seal and differs from Plan 53A in that pressure is maintained in the seal circuit through the use of a bladder-type accumulator.

Plan 53C is a pressurized dual seal as well, but utilizes a piston-type accumulator to maintain pressure above seal chamber pressure.

Plan 53 is usually chosen over Plan 52 for dirty, abrasive or polymerizing products which would either damage the seal faces or cause problems with the buffer-fluid system if Plan 52 were used. There are two disadvantages to Plan 53 which should be considered. There will always be some leakage of barrier fluid into the product. The leakage rate can be monitored by monitoring the seal pot level. However, the product must be able to accommodate a small amount of contamination from the barrier fluid. Second, a Plan 53 system is dependent on having the seal pot pressure maintained at the proper level. If the seal pot pressure drops, the system will begin to operate like a Plan 52, or unpressurized dual seal, which does not offer the same level of sealing integrity. Specifically, the inner seal leakage direction will be reversed and the barrier fluid will, over time, become contaminated with the process fluid with the problems that result, including possible seal failure.

A.4.14 Plan 54

Plan 54 systems are also pressurized dual-seal systems with inner seal leakage into the pumped product. In a Plan 54, a cool clean product from an external source is supplied to the seal as a barrier fluid. The supply pressure of this product is at least 0,14 MPa (1,4 bar) (20 psi) greater than the pressure the inner seal is sealing against. This results in a small leakage of barrier fluid into the process. This arrangement should never be used where the barrier fluid pressure is less than the sealed pressure. If it were, the failure of one inner seal could contaminate the entire barrier fluid system and cause additional seal failures.

Plan 54 is often used in services where the pumped fluid is hot, contaminated with solids, or both. If Plan 54 is specified, carefully consider the reliability of the barrier fluid source. If the source is interrupted or contaminated, the resulting seal failures are very expensive to rectify. A properly engineered barrier-fluid system is typically complex and often expensive. Where these systems are properly engineered, they provide among the most reliable systems.

A.4.15 Plan 62

In Plan 62, a quench stream is brought from an external source to the atmospheric side of the seal faces. The quench stream can be low-pressure steam, nitrogen, or clean water. It is used in selected single seal applications to exclude the presence of oxygen to prevent coke formation (for example, hot hydrocarbon services) and to flush away undesirable material buildup around the dynamic seal components (for example, caustic and salt services).

A.4.16 Plan 65

Plan 65 is a seal leakage detection piping plan normally used with Arrangement 1 seals in services where seal leakage is expected to be mostly liquid (not gas). Piping is connected to the drain connection in the gland plate and directs any seal leakage past or through a reservoir/float chamber and then through an orifice, exiting into an oil and water sewer or liquid collection system. Excessive flowrates would be restricted by the orifice located downstream of the reservoir/float chamber and are redirected to it, causing the float to lift and activate an alarm. The orifice downstream of the level switch should be located in a vertical piping leg to avoid

accumulation of fluid in the drain piping. A connection at the top of the reservoir, connected to a pipe bypassing the orifice, will allow excessive leakage to be effectively drained.

A.4.17 Plan 71

Plan 71 is used on Arrangement 2, unpressurized dual seals, which utilize a dry containment seal and where no buffer gas is supplied but the provision to supply a buffer gas is desired. Buffer gas may be needed to sweep inner seal leakage away from the outer seal into a collection system or to dilute the leakage, but is not specified.

A.4.18 Plan 72

Plan 72 can be used on Arrangement 2 unpressurized dual seals that use a dry-running containment seal. The buffer gas can be used to sweep inner-seal leakage away from the outer seal to a collection system and/or dilute the leakage so the emissions from the containment seal are reduced.

The Plan 72 system is intended to function as follows.

The buffer gas first flows through an isolation block valve and check valve provided by the purchaser. It then enters a system, usually mounted on a plate or panel, provided by the seal vendor. A coalescing filter to remove any particles and liquid that might be present follows an inlet block valve on the panel. The gas then flows through a forward-pressure regulator which is set at the Plan 75 or Plan 76 alarm point, or at least 0,04 MPa (0,4 bar) (5 psi) above the normal flare pressure. Next comes a pressure indicator and low-pressure alarm switch ahead of an orifice; these are used to set the regulator. They also ensure the source pressure always maintains a flush flow over the operating range of the combined systems (when used with Plan 75 or Plan 76) and does not pressurize the seal chamber or affect the alarm settings of the exit flush plan. The orifice provides flow regulation and is followed by a flow meter to measure flow. (The use of a needle or globe valve for the orifice to allow flow regulation is optional.) The last elements on the panel are a check valve and a block valve. Buffer gas is then routed through tubing to the seal. A containment seal vent (CSV) and drain (CSD) are also located on the gland plate and are routed to a vent system, usually using Plan 75 or Plan 76.

A.4.19 Plan 74

Plan 74 systems are used on Arrangement 3, dual pressurized seals, where the barrier medium is a gas. They are the gas barrier equivalent to the traditional Plan 54 liquid barrier system. The most common barrier gas is plant nitrogen. The supply pressure to the seal is typically at least 0,17 MPa (1,7 bar) (25 psi) greater than the seal chamber pressure. This results in a small amount of gas leakage into the pump, with most of the gas barrier leaking to atmosphere. This arrangement should never be used where the barrier-gas pressure can be less than the sealed pressure. If this were to happen, the entire barrier gas system could become contaminated with the pumped fluid.

Plan 74 systems are typically used in services which are not too hot (within elastomer property limits) but which may contain toxic or hazardous materials whose leakage cannot be tolerated. Because they are pressurized dual seal systems, leakage to the atmosphere is eliminated under normal conditions. Plan 74 may also be used to obtain very high reliability, since solids or other materials which can lead to premature seal failure cannot enter the seal faces. For services containing sticky or polymerizing agents or where dehydration of the pumpage causes solids buildup, Plan 74 systems are not generally recommended.

The Plan 74 system is intended to function as follows: the barrier gas first flows through an isolation block valve and a check valve provided by the purchaser. It then enters a system, usually mounted on a plate or panel, provided by the seal vendor. An inlet block valve on the panel is followed by a 2 µm to 3 µm filter coalescer to remove any particles and liquid that might be present. The gas then flows through a back-pressure regulator which is set at least 0,17 MPa (1,7 bar) (25 psi) greater than the seal chamber pressure (In some cases, users prefer to install an orifice after the regulator to limit the amount of nitrogen that is used in the event of a seal that sticks open.) A flow meter follows the regulator and is used to measure the flow, while the pressure indicator is used to confirm adequate pressure. The low pressure switch is used to raise an alarm upon loss of barrier gas or excessive leakage of the seals. The last elements on the panel are a check valve and a block valve. Barrier gas is then routed to the seal using tubing. A drain is mounted on the gas barrier outlet to allow venting/draining for maintenance.

A.4.20 Plan 75

Plan 75 systems are typically used on Arrangement 2, unpressurized dual seals, which also utilize a dry containment seal and where the leakage from the inner seal may condense. They may be used with a buffer gas (Plan 72) or without a buffer gas (Plan 71).

If an unpressurized dual seal is installed, usually it is because leakage of the pumped fluid to the atmosphere must be restricted more than can be done with an Arrangement 1 seal. Therefore, a means is needed to collect the leakage and route it to a collection point. The Plan 75 system is intended to perform this collection function for pumped fluids that may form some liquid (condense) at ambient temperature. Note that even if the pumped liquid does not condense, users may wish to install this system due to the back-flow of condensation from the collection system.

Plan 75 is intended to work as follows. Leakage from the inner seal is restricted from escape by the containment seal and routed into the drain line. The collector accumulates any liquid, while vapour passes through into the collection system. A level indicator on the collector is used to determine when the collector needs to be drained. An orifice in the outlet line of the collector restricts flow such that high leakage of the inner seal will cause a pressure increase and trigger the PSH set at a gauge pressure of 0,07 MPa (0,7 bar) (10 psi). The block valve in the outlet of the collector serves to isolate the collector for maintenance. It may also be used to test the inner seal by closing while the pump is in operation and noting the time/pressure build-up relationship in the collector. If specified, a connection on the collector may be used to inject nitrogen or other gas for the purpose of testing the containment seal.

A.4.21 Plan 76

Plan 76 systems are typically used on Arrangement 2, unpressurized dual seals, which also utilize a dry containment seal and where leakage from the inner seal will not condense. They may be used with a buffer gas (Plan 72) or without a buffer gas (Plan 71).

If an unpressurized dual seal is installed, usually it is because leakage of the pumped fluid to the atmosphere must be restricted more than can be done with an Arrangement 1 seal. Therefore, a means is needed to route the leakage to a collection point. The Plan 76 system is intended for services where no condensation of the inner seal leakage or from the collection system will occur. Should liquid accumulate in the containment seal chamber, excessive heat could be generated, leading to hydrocarbon coking and possible seal failure.

Plan 76 is intended to work as follows. Leakage from the inner seal is restricted from escape by the containment seal and goes out the containment-seal vent. An orifice in the outlet line of the collector restricts flow such that high leakage of the inner seal will cause a pressure increase and trigger the PSH set at a gauge pressure of 0,07 MPa (0,7 bar) (10 psi). The block valve in the outlet serves to isolate the system for maintenance. It may also be used to test the inner seal by closing while the pump is in operation and noting the time/pressure buildup relationship in the collector. A drain connection on the piping harness may be used to inject nitrogen or other gas for the purpose of testing the containment seal as well as for checking for any liquid build-up.

Annex B (informative)

Typical materials standards for seal chamber and mechanical seal components

B.1 Materials standards

Table B.1 may be used for guidance regarding materials specifications. If this table is used, it should not be assumed that the material specifications are acceptable without taking full account of the service in which they will be applied. These materials might not be interchangeable for all applications.

Table B.1 — Materials standards

Material class	Applications	International ISO	USA		Europe		Japan JIS	
			ASTM	Grade	UNS	Standard	Symbol	Mat. No.
12 % Chromium steel	Casting: pressure application		A 217 A 487	Gr CA 15 Gr CA6NM	J 91150 J 91540	EN 10213-2 EN 10213-2	GX8CrNi12 GX4CrNi13-4	G 5121 G 5121
	Forging: pressure application	683-13-3 683-13-3	A 182 A 182	Gr F6a Cl 1 Gr F6 NM	S 41000 S 41500	EN 10250-4 EN 10222-5	X12Cr13 X3CrNi13-4	G 3214 G 3214
	Bar stock: General application	683-13-3 683-13-4	A 276 A 582	Type 410 Type 416	S 41000 S 41600	EN 10088-3 EN 10088-3 EN 10088-3	X12Cr13 X20CrS13 X39CrMo17-1	G 4303 G 4303 G 4303
	Bolts and studs	3506-1, C4-70	A 193	Gr B6	S 41000	EN 10269	X22CrMoV12-1	G 4303
	Nuts	3506-2, C4-70	A 194	Gr 6		EN 10269	X22CrMoV12-1	G 4303
Austenitic stainless steel	Casting: pressure application	683-13-10 683-13-19	A 351 A 351	Gr CF3 Gr CF3M	J 92500 J 92800	EN 10213-4 EN 10213-4	GX2CrNi19-11 GX2CrNiMo19-11-2	G 5121 G 5121
	Forging	9327-5, X2CrNi18-10 9327-5, X2CrNiMo17-12	A 182 A 182	Gr F 304L Gr F 316L	S 30403 S 31603	EN 10222-5 EN 10222-5	X2CrNi19-11 X2CrNiMo17-12-2	G 3214 G 3214
	Bar	683-13-19 683-13-19 683-13-19	A 276 A 276 A 276	Type 316 Type 316L Type 316Ti	S 31600 S 31603 S 31635	EN 10088-3 EN 10088-3 EN 10088-3	X5CrNiMo17-12-2 X2CrNiMo17-12-2 X6CrNiMoTi17-12-2	G 4303 G 4303 G 4303
	Bolts and studs	3506-1, A4-70	A 193	Gr B8M Cl2	S 31600	EN 10250-4	X6CrNiMoTi17-12-2	G 4303
	Nuts	3506-2, A4-70	A 194	Gr 8M	S 31600	EN 10250-4	X6CrNiMoTi17-12-2	G 4303

Table B.1 — Materials standards (continued)

Material class	Applications	International ISO	USA		UNS	Europe		Japan JIS
			ASTM	Grade		Standard	Symbol	Mat. No.
Duplex and super duplex stainless steel	Forging	9327-5, X2CrNiMoN22-5-3	A 182	Gr F 51	S 31803	EN 10222-5 EN 10250-4	X2CrNiMoN22-5-3 X2CrNiMoN22-5-3	1.4462 1.4462
			A 182	Gr 55	S 32760	EN 10250-4 EN 10250-4	X2CrNiMoCuWN25-7-4 X2CrNiMoCuWN25-7-4	1.4501 1.4501
	Bar	9327-5, X2CrNiMoN22-5-3	A 276		S 31803	EN 10088-3	X2CrNiMoN22-5-3	1.4462
			A 276 A 276		S 32550 S 32760	EN 10088-3 EN 10088-3	X2CrNiMoCuN25-6-3 X2CrNiMoCuWN25-7-4	1.4507 1.4501
Alloy 20	Casting		A 744	CN 7M	N 08007			G 5121
	Bar		B 473		N 08020		NiCr20CuMo	2.4660
	Forging		B 564		N 10276		NiMo16Cr15W	2.4819
	Bar and rod	9723, NW0276	B 574		N 10276		NiMo16Cr15W	2.4819
Low-carbon nickel molybdenum chromium alloy (Alloy C276)	Plate, sheet and strip	6208, NW0276	B 575		N 10276		NiMo16Cr15W	2.4819
	Weldable casting	12725, NC6455	A 494	Gr. CW2M				
	Forging	9725, NW4400	B 564		N 04400		NiCu30Fe	2.4360
	Bar and rod	9723, NW4400	B 164	Class A	N 04400		NiCu30Fe	2.4360
Nickel copper alloy ("Alloy 400")	Plate, sheet and strip	6208, NW4400	B 127		N 04400		NiCu30Fe	2.4360
	Weldable casting		A 494	Gr. M30C			G-NiCu30Nb	2.4365
	Forging and bar		B 637		N 07718		NiCr19NbMo	2.4668
	Plate, sheet and strip		B 670		N 07718		NiCr19NbMo	2.4668

Table B.1 — Materials standards (continued)

Material class	Applications	International ISO	USA			Europe			Japan JIS	
			ASTM	Grade	UNS	Standard	Symbol	Mat. No.		
Austenitic cast iron	Austenitic cast iron	2892, L-NiCuCr15-6-2	A 436	Type 1	F 41000					
		2892, L-NiCr20-2	A 436	Type 2	F 41002					
		2892, L-NiCr30-3	A 436	Type 3	F 41004					
Elastomer	Austenitic ductile cast iron	2892, SNI Cr20 2	A 439	Type D2	F 43000					
	Acrylonitrile butadiene	1629, NBR	D 1418	NBR						
	Ethylene- propylene- diene	1629, EPDM	D 1418	EPDM						
	Fluoro- elastomer	1629, FKM	D 1418	FKM						
	Perfluoro- elastomer	1629, FFKM	D 1418	FFKM						
	Pure graphite									
Gasket	Spiral-wound stainless steel with graphite									

B.2 Typical temperature limitations for seal materials in hydrocarbon service

Face material	Maximum temperature °C (°F)
Tungsten carbide	400 (750)
Silicon carbide (solid)	425 (800)
Carbon-graphite:	
Oxidizing	275 (525)
Non-oxidizing	425 (800)

B.3 Tutorial on silicon carbide

Silicon carbide is widely used as a material for seal rings. Its primary advantages are high hardness, excellent corrosion resistance, high thermal conductivity, and low coefficient of friction against carbon. Silicon carbides can be classified according to composition and manufacturing process. For mechanical seals, reaction-bonded silicon carbide and self-sintered silicon carbide are widely used. Reaction-bonded silicon carbide is manufactured by reacting silicon metal with carbon in a silicon carbide matrix. The resulting material contains free silicon metal usually in the range of 8 % to 12 %. Self-sintered silicon carbide, on the other hand, consists strictly of silicon carbide. In addition, within these classifications, there are various grades, grain structures, etc. As a result, the two classifications of silicon carbide have some variation in performance when used as a seal face material.

Although there are differences within the two classifications of silicon carbide, there are general characteristics as well. Reaction-bonded silicon carbide is regarded as having a marginally lower coefficient of friction against carbon under certain conditions. It is less brittle, and is not as hard as the self-sintered material. Although real, these differences are small. One substantial difference is in corrosion resistance. As a rough rule of thumb, reaction-bonded silicon carbide is recommended for service where the pH is between 4 and 11; outside this range, self-sintered silicon carbide should be used.

B.4 Tutorial on hard-face combinations

Although the preferred seal-face material combination is carbon versus a hard face, there are many services which require the use of two hard faces. Factors which dictate the use of two hard faces include:

- the presence of abrasive particles in the sealed fluid;
- the viscosity of the fluid;
- crystallization of the fluid;
- products which polymerize;
- presence of high vibration and shock.

The main material choices for hard faces are silicon carbide and tungsten carbide. As a general rule, silicon carbide will work satisfactorily against itself if there is sufficient liquid lubrication. However, tungsten carbide versus tungsten carbide can also be a very sensible combination.

There are general rules to consider.

- a) Tungsten carbide vs. silicon carbide has shown excellent performance where the medium sealed is oil. Even in less viscous liquid services, such as water with abrasives, tungsten carbide vs. silicon carbide is the most common selection if two hard faces are required.

- b) Tungsten carbide vs. tungsten carbide has shown excellent performance in heavy oils, tars and asphalts. It gives poor performance in water, but can give good performance in caustic solution. Special attention should be given to the (pressure × velocity) conditions, as the limits for this materials combination are low.
- c) Sintered silicon carbide vs. itself can give excellent results in corrosive service, and is the preferred combination of two hard faces for many chemical uses. However, this combination will experience irreversible damage if run under dry conditions and thus is not recommended in cases where there will be marginal lubricating conditions.
- d) Reaction-bonded silicon carbide vs. itself has also been used extensively in hydrocarbon processing. It provides good performance for services such as crude oil where abrasive particles are present.
- e) Note that, as a general rule, the science of tribology frowns on using two like materials in frictional contact. For this reason reaction-bonded silicon carbide, narrow face, has been used against a sintered silicon carbide, wide face. Practical concerns, such as corrosion resistance and increased inventory costs, make this a less popular combination.

Promising new materials and techniques are being developed for seal faces where hard-face combinations are required. As these are in the development or early stages of application, application guidelines are beyond the scope of this International Standard.

B.5 Typical temperature limitation guidelines for secondary seal materials

Material	Minimum temperature °C (°F)	Maximum temperature °C (°F)
Fluoroelastomer (FKM):		
Hydrocarbon service	– 7 (20)	175 (350)
Water-based service	– 7 (20)	120 (250)
Perfluoroelastomer (FFKM)	– 7 (20) ^a	290 (550)
Nitrile (NBR)	– 40 (– 40)	120 (250)
Flexible graphite	– 240 (– 400)	480 (900)
^a Some FFKM grades are not suitable below 20 °C (70 °F).		

B.6 Tutorial on selection of elastomers

Elastomers are a complex integration of polymer architecture, fillers, cure chemistries and design considerations. Properly selected, compounded, cured and designed elastomeric seals, such as O-rings, perform predictably in a defined service (medium, time, temperature, pressure, static/dynamic, etc.). However, if compromises are made then the elastomeric seal may perform inconsistently with shortened service life.

The proprietary nature of elastomers make writing a specification difficult. This International Standard provides only limited, general guidance for selection of elastomers and provides no specifics for selection of a particular compound, cure, filler, etc. The seal selection guide in Annex A recommends polymer families (such as fluoroelastomer, nitrile, etc.) based on general experience. The particulars of the compound must be suitable for that service.

Some considerations for selection of particular polymers and compounds include the following.

- a) The polymer should be identified by ISO or ASTM designation, and should not use reprocessed materials.
- b) It should be recognized that there are different compounds with different characteristics and performance within a specific polymer family.

- c) Although most elastomers use carbon black as a filler, there are other fillers that can be used.
- d) There are critical properties, such as compression set, that can be more important for some mechanical seal types than for others.
- e) Media compatibility can vary considerably with time, temperature and concentration — in particular, high temperature elastomers, such as perfluoroelastomers, can have reduced temperature ratings in some media.
- f) Dynamic secondary sealing elements can also have reduced temperature ratings.
- g) All polymers used in a compound should be indicated.

Annex C
(normative)

Mechanical seal data sheets

Category 1 & 2 Seals MECHANICAL SEAL DATA SHEET FOR CENTRIFUGAL & ROTARY PUMPS S.I. UNITS PAGE 1 OF 2				REQUIRED FOR: _____ SITE: _____ UNIT: _____	
				JOB/PROJECT NO. _____ ITEM NO. _____	
				REQUISITION / SPEC. NUMBER _____ / _____	
				INQUIRY NUMBER _____ BY _____	
				PURCH ORDER NUMBER _____ DATE _____	
				REVISION NO. 0 DATE _____	
1 DATA SUPPLIED ☐ CUSTOMARY UNITS ☐ SI UNITS				HARDWARE SUPPLIED ☐ CUSTOMARY UNITS ☐ SI UNITS	
2 ☐ INDICATES DATA COMPLETED BY PURCHASER ☐ BY SEAL VENDOR ☒ BY SEAL VENDOR OR PURCHASER					
3 ☒ ☐ DEFAULT SELECTION					
SEAL SPECIFICATION - (REF 4.1, FIGURES 1 TO 6)					
5 CATEGORY ☐ SEAL CATEGORY 1 (4.1.1) ☐ SEAL CATEGORY 2 (4.1.1) ☒ SEAL CODE (ANNEX D)					
6 TYPE ☒ TYPE A (3.72) ☐ TYPE B (3.73) ☐ ALTERNATIVE STATIONARY (TYPE A & B)					
7 (CODE-CW) ☒ TYPE C (3.74) ☐ ALTERNATIVE ROTATING (TYPE C) ☐ SINGLE SPRING (TYPE A)					
8 ARR'G'T	DEFAULT CONFIGURATION	ALTERNATIVE DESIGN		FLUSH PLANS (SEE ANNEX G)	
9 1 (3.2)	☒ 1CW-FX	☐ 1CW-FL ☐ DIST. FLUSH	☐ 01 ☐ 11 ☐ 14 ☐ 23 ☐ 32 ☐ 50 ☐ 61		
		☐ ALTERNATIVE BUSH	☐ 02 ☐ 13 ☐ 21 ☐ 31 ☐ 41 ☐ 51 ☐ 62		
10					
11 2 (3.3)	LIQUID ☒ 2CW-CW	☐ FX ☐ DIST. FLUSH	☐ 01 ☐ 13 ☐ 23 ☐ 41 ☐ 62 ☐ 75		
		☐ TANGENTIAL LBO CONN'N	☐ 02 ☐ 14 ☐ 31 ☐ 52 ☐ 71 ☐ 78		
12					
13	GAS ☒ 2CW-CS	☐ 2NC-CS ☐ FX ☐ DIST. FLUSH	☐ 11 ☐ 21 ☐ 32 ☐ 61 ☐ 72		
14					
15 3 (3.4)	LIQUID ☒ 3CW-FB	☐ 3CW-BB ☐ FX	☐ 01 ☐ 13 ☐ 53A ☐ 54 ☐ 74		
		☐ 3CW-FF ☐ TANG. LBO	☐ 02 ☐ 14 ☐ 53B ☐ 61		
16		☐ 3NC-BB ☐ 3NC-FF ☐ 3NC-FB	☐ 11 ☐ 32 ☐ 53C ☐ 62		
17	SLEEVE-SHAFT DRIVE ☒ SET-SCREW ONTO SHAFT ☐ ALTERNATIVE (6.1.3.13) - SPECIFY _____				
MATERIALS (REFERENCE 6.1.6 & ANNEX B)					
19 SECONDARY SEALS		SEAL FACES	METAL BELLOWS	SPRINGS	METAL PARTS
20 ☒ FKM ☐ FFKM		☐ CARBON VS SIC	☐ UNS N10276 (TYPE B)	☐ UNS N10276	☐ UNS S31600/ S31635
21 ☐ SPIRAL-W GASKET		☐ SIC VS SIC	☐ UNS N07718 (TYPE C)	OR N06455	☐ UNS N10276
22 ☐ NBR		☐ SS-SIC ☐ RB-SIC	☐ UNS N08020	☐ UNS S31600	☐ UNS N08020
23 ☐ OTHER: _____		☐ VS	☐ OTHER: _____	OR S31635	☐ OTHER: _____
MECHANICAL SEAL DATA					
25 ☐ SEAL VENDOR _____			☐ ALTERNATIVE SEAL FOR PUMP PERFORMANCE TEST		
26 ☐ DATA REQUIREMENTS FORM (ANNEX J)			☐ DYNAMIC SEALING PRESSURE RATING (3.19) _____ kPa (bar) [ga]		
27 ☐ SIZE/TYPE _____			☐ STATIC SEALING PRESSURE RATING (3.69) _____ kPa (bar) [ga]		
28 ☐ SEAL DRAWING NUMBER _____			☐ MAXIMUM ALLOWABLE TEMPERATURE (3.40) _____ °C		
29 ☐ VENDOR'S SEAL CODE _____			☐ MINIMUM DESIGN METAL TEMPERATURE (6.1.6.11.1) _____ °C		
30 ☐ MODIFIED FACES FOR PUMP PERFORMANCE TEST					
SEAL CHAMBER DATA (REFERENCE 6.1.2.4)					
32 ASME B73.1 & 2 ☒ CYLINDRICAL ☐ TAPERED ☐ ISO 13709 ☐ ISO 3069-C ☐ OTHER, SPECIFY _____					
33 ☐ BOLT-ON CHAMBER (6.1.2.5) ☐ SEAL CHAMBER FLUSH PORT REQ'D ☐ SEAL CHAMBER VENT REQ'D					
34 ☒ FLOATING THROAT BUSH ☐ FIXED THROAT BUSH ☐ CHAMBER HEATING REQ'D					
PUMP DATA					
36 PUMP DESIGN ☐ MANUFACTURER _____ ☐ MODEL _____ ☐ FRAME/SIZE _____ ☐ CASE MATERIAL _____					
37 PUMP OPERATING PRESSURE ☐ SUCTION PRESS. (RATED) _____ kPa (bar) [ga] ☐ DISCHARGE PRESSURE _____ kPa (bar) [ga]					
38 SEAL CHAMBER ☐ NORMAL _____ kPa (bar) [ga] ☐ MIN / MAX (3.42) _____ / _____ kPa (bar) [ga] ☐ MSSP (3.44) _____ kPa (bar) [ga]					
39 SHAFT ☐ HORIZONTAL ☐ VERTICAL ☐ DIA. _____ mm ☐ SHAFT SPEED _____ r/min					
40 SHAFT DIRECTION (FROM DRIVER): ☐ CW ☐ CCW					
FLUID DATA - (FOR QUENCH, BUFFER AND BARRIER FLUID DATA, SEE PAGE 2)					
42 PUMPED STREAM					
43 ☐ TYPE OR NAME _____ CONC'N _____ % ☐ HAZARDOUS ☐ FLAMMABLE ☐					
44 ☐ DISSOLVED CONTAMINANT ☐ H ₂ S _____ ml/m ³ ☐ WET ☐ FLUID SOLID @ AMBIENT					
45 ☐ Cl ₂ _____ ml/m ³ ☐ OTHER _____ @ _____ ml/m ³ ☐ SOLIDIFIES @ _____ °C POUR POINT _____ °C					
46 ☐ SOLID CONTAMINANT ☐ PUMPED STREAM SOLIDIFIES UNDER SHEAR					
47 ☐ CONCENTRATION (MASS FRACTION) _____ ☐ PUMPED STREAM CONTAINS AGENTS THAT POLYMERIZE					
48 ☐ PUMPING TEMPERATURE ☐ SPECIFY AGENTS _____ @ TEMP _____ °C					
49 MIN _____ °C NORMAL _____ °C MAX _____ °C ☐ PUMPED STREAM CAN PLATE OUT OR DECOMPOSE:					
50 ☐ RELATIVE DENSITY (TO WATER @ 25°C) AT REF. TEMP. ☐ SPECIFY CONDITIONS _____					
51 @ NORMAL TEMP _____ @ MAX TEMP _____ ☐ PUMPED STREAM IS REGULATED FOR FUGITIVE OR					
52 ☐ ABSOLUTE VAPOR PRESSURE AT REFERENCE TEMP. ☐ OTHER EMISSIONS. REGULATION LEVEL _____ ml/m ³					
53 NORMAL TEMP _____ kPa MAX TEMP _____ kPa ☐ SPECIAL PUMP CLEANING PROCEDURES					
54 ☐ ATMOSPHERIC BOILING POINT. _____ °C ☐ SPECIFY: _____					
55 ☐ VISCOSITY @ NORMAL PUMPING TEMP. _____ Pa.s ☐ ALTERNATIVE PROCESS FLUIDS & CONCENTRATION					
56 ☐ FLUSH FLUID (PLAN 32) If flush fluid is pumpage, then flush fluid data is not required. (INCL. COMMISSIONING)					
57 ☐ TYPE OR NAME _____ CONC'N _____ % ☐ ABSOLUTE VAPOR PRESSURE AT REFERENCE TEMP.					
58 ☐ SEAL VENDOR REVIEW REQUIRED ☐ NORMAL TEMP _____ kPa MAX TEMP _____ kPa					
59 ☐ FLUID TEMPERATURE ☐ ATMOSPHERIC BOILING POINT. _____ °C					
60 MIN _____ °C NORMAL _____ °C MAX _____ °C ☐ VISCOSITY @ NORMAL PUMPING TEMP. _____ Pa.s					
61 ☐ RELATIVE DENSITY (TO WATER @ 25°C) AT REF. TEMP. ☐ FLOW RATE REQ'D MAX/MIN _____ / _____ l/min					
62 ☐ @ NORMAL TEMP _____ @ MAX TEMP _____ ☐ PRESSURE REQ'D MAX/MIN _____ / _____ kPa (bar) [ga]					

Category 1 & 2 Seals		REQUIRED FOR: _____ SITE: _____ UNIT: _____	
MECHANICAL SEAL DATA SHEET FOR CENTRIFUGAL & ROTARY PUMPS S.I. UNITS PAGE 2 OF 2 (FLUID DATA, UTILITIES, ACCESSORIES, & INSP./TEST.)		JOB/PROJECT NO. _____ ITEM NO. _____	
		REQUISITION / SPEC. NUMBER _____ / _____	
		INQUIRY NUMBER _____ BY _____	
		PURCHASE ORDER NUMBER _____ DATE _____	
		REVISION NO. 0 DATE _____	
☐ INDICATES DATA COMPLETED BY PURCHASER ☒ ☐ DEFAULT SELECTION		☐ BY SEAL VENDOR ☒ BY SEAL VENDOR OR PURCHASER	
FLUID DATA - (QUENCH, BUFFER AND BARRIER FLUID DATA, LIQUID AND GAS)			
QUENCH MEDIUM (PLAN 51, 62) ☒ TYPE OR NAME _____		☒ SUPPLY TEMPERATURE MAX/MIN _____ / _____ °C ☐ FLOW RATE REQ'D MAX/MIN _____ / _____ l/min	
BUFFER/BARRIER MEDIUM ☒ TYPE OR NAME _____		☒ RELATIVE DENSITY (TO WATER @ 25°C) AT REF. TEMP. @ NORMAL TEMP _____ @ MAX TEMP _____	
☐ PURCHASER SELEC'N ☐ SEAL VENDOR SELEC'N ☐ SEAL VENDOR REVIEW ☐ PURCHASER REVIEW		☒ ABSOLUTE VAPOR PRESSURE AT REFERENCE TEMP. NORMAL TEMP _____ kPa MAX TEMP _____ kPa	
☐ FLOW RATE REQ'D MAX/MIN. _____ / _____ l/min ☐ COOLING/HEATING REQUIRED (+ OR -) _____ kW		☒ ATMOSPHERIC BOILING POINT (LIQUID) _____ °C ☒ VISCOSITY @ NORMAL TEMP (LIQUID) _____ Pa.s	
☒ SUPPLY PRESSURE MAX/MIN. _____ / _____ kPa (bar) [ga] ☒ FLUID OPERATING TEMPERATURE		☒ SPECIFIC HEAT CAPACITY @ CONSTANT PRESSURE FOR LIQUID @ NORMAL TEMPERATURE _____ J/kg.K	
MIN _____ °C: NORMAL _____ °C: MAX _____ °C			
SITE AND UTILITIES			
☐ CONTROL VOLTAGE _____ V PHASE _____ HERTZ _____ ☐ ELECTRICAL AREA CL _____ GR _____ DIV _____ ☐ DESIGN AMBIENT MIN./MAX. _____ / _____ °C		☐ COOLING H ₂ O SUPPLY TEMP. _____ °C ☐ Cl ₂ _____ m ³ /min ☐ COOLING H ₂ O PRESS. NORM./DES. _____ / _____ kPa (bar) [ga] ☐ ATEX (EC DIRECTIVE 94/9/EC) GR CAT. T CLASS _____	
ACCESSORIES (CLAUSES 8 AND 9)			
GENERAL ☐ JOINT USER/VENDOR LAYOUT OF EQUIPMENT (8.1.4) ☐ PIPE TAPER THREADS (8.1.9) ☐ ISO 7 ☐ ASME B1.20.1 ☐ SPECIAL REQUIREMENTS FOR HAZARDOUS SERVICE ☐ SPECIAL CLEANING AND DECONTAMINATION REQ'TS ☐ UTILITY MANIFOLD CONNECTIONS REQUIRED (8.4.4) ☐ TYPE AND SPEC. OF HEAT TRACING (8.6.5.8) ☐ THERMAL RELIEF VALVES REQUIRED (9.8.3)		PLAN 52 AND 53 SYSTEMS CONTINUED ☐ EQUIPMENT SUPPORT SUPPLIER _____ ☐ FILLING SYSTEM SUPPLIER _____ ☐ ASME CODE STAMP REQUIRED ☐ EN 13445 OR OTHER CODE APPLICABLE _____ ☒ RESERVOIR CAPACITY (8.5.4.3) _____ l ☒ NLL TO GLAND PLATE HEIGHT (8.5.4.2) _____ m ☐ RESERVOIR MAWP (3.41) _____ kPa (bar) [ga] @ _____ °C ☒ SET PRESSURE RANGE, MAX/MIN _____ / _____ kPa (bar) [ga] ☒ SYSTEM HOLD-UP PERIOD (PLANS 53B & 53C) _____ DAYS ☐ TEMPERATURE INDICATOR (PLAN 53B & 53C) PRESSURE SWITCH (8.5.4.2.h) TO ACTIVATE ON: ☒ RISING PRESSURE (ARR 2) SET @ _____ kPa (bar) [ga] ☒ FALLING PRESSURE (ARR 3) SET @ _____ kPa (bar) [ga] ☒ HIGH LEVEL ALARM REQUIRED (8.5.4.2.i) ☐ TEST BASED H/Q CURVE FOR INTERNAL CIRC. DEVICE ☐ EXTERNAL CIRCULATING PUMP (8.6.3.1)	
☐ COOLING SYSTEM (PLAN 21, 22, 23, 41, 53B, 53C) ☐ HEAT EXCHANGER SUPPLIER ☒ WATER COOLED ☒ AIR COOLED ☐ ISO 15649 ☒ EQUIPMENT REFERENCE/CODE _____ ☐ COOLING WATER LINES SUPPLIER _____ ☐ TUBING ☐ GALVANISED PIPING (8.4.2) ☒ COOLING WATER FLOW RATE _____ l/min ☐ SIGHT FLOW INDICATORS (8.4.3) ☐ OPEN ☐ CLOSED		PLAN 72 AND 74 SYSTEM ☐ EQUIPMENT SUPPLIER _____ ☐ HIGH FLOW ALARM SWITCH (8.6.6.5) PLAN 75 AND 76 SYSTEM ☐ EQUIPMENT SUPPLIER _____ ☐ HIGH LEVEL ALARM SWITCH FOR PLAN 75 (8.6.5.3) ☐ TEST CONNECTION (8.6.5.4)	
PLAN 11, 13, 14, 21, 23, 31, 32 AND 41 SYSTEMS ☐ CONNECTING LINES SUPPLIER _____ ☐ TUBING ☐ PIPING (8.5.2.2) _____ ☐ RESTRICTION ORIFICE NIPPLE IN FLUSH LINE (8.5.2.4) ☐ CYCLONE SEPARATOR SUPPLIER _____ ☐ PLAN 32 EQUIPMENT SUPPLIER _____ ☐ PLAN 32 FLOW IND'R ☐ PLAN 32 TEMPERATURE IND'R		INSTRUMENTATION ☐ USER SPECIFICATION REFERENCE FOR INSTRUMENTATION/CONTROLS _____ PRESSURE GAUGES (9.4); ☐ OIL FILLED PRESSURE GAUGES (9.4.3) PRESSURE SWITCHES (9.5.2); ☐ TRANSMITTER (9.5.2.3) LEVEL SWITCHES (9.5.3); ☐ TRANSMITTER (9.5.3.2) ☐ HYDROSTATIC ☐ CAPACITANCE ☐ ULTRASONIC LEVEL INDICATORS (9.6) ☐ WELD PAD ☐ EXTERNAL, REMOVABLE (9.6.2) FLOW INSTRUMENTS (9.7); ☐ TRANSMITTER (9.7.3)	
PLAN 52 AND 53 SYSTEMS ☒ STANDARD (FIG G.27) ☒ ALTERNATIVE (FIG G.28) ☐ DIMENSIONAL VARIATIONS TO STANDARD (FIG G.27) ☐ DIMENSIONAL VARIATIONS TO ALTERNATIVE (FIG G.28) ☒ ALTERNATIVE FABRICATION STANDARD _____ ☐ PRIMARY EQUIPMENT SUPPLIER _____ ☒ SUPPLIER REFERENCE/CODE _____ ☐ CONNECTING LINES SUPPLIER _____ ☐ TUBING ☐ SCH 80 PIPING (8.5.4.9)			
INSPECTION AND TESTING			
☐ PURCHASER PARTICIPATION IN INSPECTION & TEST SPECIFY: _____ ☐ INSPECTOR'S CHECK LIST (10.1.7 & ANNEX H) ☐ PURCHASER APPROVAL REQUIRED FOR WELDED CONNECTION DESIGNS, (6.1.6.10.5) ☐ HARDNESS TEST (10.2.3 k) REQUIRED FOR:		☐ 100% INSPECTION OF ALL WELDS (6.1.6.10.5) USING; ☐ MAGNETIC PARTICLE ☐ LIQUID PENETRANT ☐ RADIOGRAPHIC ☐ ULTRASONIC ☐ OPTIONAL QUALIFICATION TESTING REQ'D (10.3.1.1.2) ☒ MOD. FACES FOR PUMP TEST (10.3.5.1), SEE PG 1, LINE 30 ☒ ALTERNATIVE SEAL PUMP TEST (10.3.5.2), SEE PG 1, LINE 25	

Category 1 & 2 Seals MECHANICAL SEAL DATA SHEET FOR CENTRIFUGAL & ROTARY PUMPS U.S. CUSTOMARY UNITS PAGE 1 OF 2				REQUIRED FOR: _____ SITE: _____ UNIT: _____	
				JOB/PROJECT NO. _____ ITEM NO. _____	
				REQUISITION / SPEC. NUMBER _____ / _____	
				INQUIRY NUMBER _____ BY _____	
				PURCH ORDER NUMBER _____ DATE _____	
				REVISION NO. 0 DATE _____	
DATA SUPPLIED ☐ CUSTOMARY UNITS ☐ SI UNITS				HARDWARE SUPPLIED ☐ CUSTOMARY UNITS ☐ SI UNITS	
☐ INDICATES DATA COMPLETED BY PURCHASER ☐ BY SEAL VENDOR ☐ BY SEAL VENDOR OR PURCHASER					
☐ ☐ DEFAULT SELECTION					
SEAL SPECIFICATION - (REF 4.1, FIGURES 1 TO 6)					
CATEGORY		☐ SEAL CATEGORY 1 (4.1.1) ☐ SEAL CATEGORY 2 (4.1.1) ☐ SEAL CODE (ANNEX D)			
TYPE		☐ TYPE A (3.72) ☐ TYPE B (3.73) ☐ ALTERNATIVE STATIONARY (TYPE A & B)			
(CODE-CW)		☐ TYPE C (3.74) ☐ ALTERNATIVE ROTATING (TYPE C) ☐ SINGLE SPRING (TYPE A)			
ARR'G'T	DEFAULT CONFIGURATION	ALTERNATIVE DESIGN		FLUSH PLANS (SEE ANNEX G)	
1 (3.2)	☐ 1CW-FX	☐ 1CW-FL ☐ DIST. FLUSH		☐ 01 ☐ 11 ☐ 14 ☐ 23 ☐ 32 ☐ 50 ☐ 61	
		☐ ALTERNATIVE BUSH		☐ 02 ☐ 13 ☐ 21 ☐ 31 ☐ 41 ☐ 51 ☐ 62	
2 (3.3)	LIQUID ☐ 2CW-CW	☐ FX ☐ DIST. FLUSH		☐ 01 ☐ 13 ☐ 23 ☐ 41 ☐ 62 ☐ 75	
	GAS ☐ 2CW-CS	☐ TANGENTIAL LBO CONN'N		☐ 02 ☐ 14 ☐ 31 ☐ 52 ☐ 71 ☐ 76	
3 (3.4)	LIQUID ☐ 3CW-FB	☐ 2NC-CS ☐ FX ☐ DIST. FLUSH		☐ 11 ☐ 21 ☐ 32 ☐ 61 ☐ 72	
	GAS ☐ 3CW-BB	☐ 3CW-BB ☐ FX		☐ 01 ☐ 13 ☐ 53A ☐ 54 ☐ 74	
	☐ 3NC-BB	☐ 3CW-FF ☐ TANG. LBO		☐ 02 ☐ 14 ☐ 53B ☐ 61	
	☐ 3NC-BB	☐ 3NC-FF ☐ 3NC-FB		☐ 11 ☐ 32 ☐ 53C ☐ 62	
SLEEVE-SHAFT DRIVE		☐ SET-SCREW ONTO SHAFT ☐ ALTERNATIVE (6.1.3.13) - SPECIFY _____			
MATERIALS (REFERENCE 6.1.6 & ANNEX B)					
SECONDARY SEALS		SEAL FACES	METAL BELLOWS	SPRINGS	METAL PARTS
☐ FKM ☐ FFKM		☐ CARBON VS SIC	☐ UNS N10276 (TYPE B)	☐ UNS N10276	☐ UNS S31600/ S31635
☐ SPIRAL-W GASKET		☐ SIC VS SIC	☐ UNS N07718 (TYPE C)	OR N06455	☐ UNS N10276
☐ NBR		☐ SS-SIC ☐ RB-SIC	☐ UNS N08020	☐ UNS S31600	☐ UNS N08020
☐ OTHER: _____		☐ VS	☐ OTHER: _____	OR S31635	☐ OTHER: _____
MECHANICAL SEAL DATA					
☐ SEAL VENDOR _____			☐ ALTERNATIVE SEAL FOR PUMP PERFORMANCE TEST		
☐ DATA REQUIREMENTS FORM (ANNEX J)			☐ DYNAMIC SEALING PRESSURE RATING (3.19) _____ PSIG		
☐ SIZE/TYPE _____			☐ STATIC SEALING PRESSURE RATING (3.69) _____ PSIG		
☐ SEAL DRAWING NUMBER _____			☐ MAXIMUM ALLOWABLE TEMPERATURE (3.40) _____ °F		
☐ VENDOR'S SEAL CODE _____			☐ MINIMUM DESIGN METAL TEMPERATURE (6.1.6.11.1) _____ °F		
☐ MODIFIED FACES FOR PUMP PERFORMANCE TEST					
SEAL CHAMBER DATA (REFERENCE 6.1.2.4)					
ASME B73.1 & 2 ☐ CYLINDRICAL ☐ TAPERED ☐ ISO 13709 ☐ ISO 3069-C ☐ OTHER, SPECIFY _____					
☐ BOLT-ON CHAMBER (6.1.2.5) ☐ SEAL CHAMBER FLUSH PORT REQ'D		☐ SEAL CHAMBER VENT REQ'D			
☐ FLOATING THROAT BUSH ☐ FIXED THROAT BUSH		☐ CHAMBER HEATING REQ'D			
PUMP DATA					
PUMP DESIGN ☐ MANUFACTURER _____ ☐ MODEL _____ ☐ FRAME/SIZE _____ ☐ CASE MATERIAL _____					
PUMP OPERATING PRESSURE ☐ SUCTION PRESSURE (RATED) _____ PSIG ☐ DISCHARGE PRESSURE _____ PSIG					
SEAL CHAMBER ☐ NORMAL _____ PSIG ☐ MIN / MAX (MDSP, 3.42) _____ / _____ PSIG ☐ MSSP (3.44) _____ PSIG					
SHAFT ☐ HORIZONTAL ☐ VERTICAL ☐ DIA. _____ IN ☐ SHAFT SPEED _____ RPM					
SHAFT DIRECTION (FROM DRIVER): ☐ CW ☐ CCW					
FLUID DATA - (FOR QUENCH, BUFFER AND BARRIER FLUID DATA, SEE PAGE 2)					
PUMPED STREAM			☐ HAZARDOUS ☐ FLAMMABLE ☐ _____		
☐ TYPE OR NAME _____ CONC'N _____ %			☐ FLUID SOLID @ AMBIENT		
☐ DISSOLVED CONTAMINANT ☐ H ₂ S _____ PPM ☐ WET			☐ SOLIDIFIES @ _____ °F POUR POINT _____ °F		
☐ Cl ₂ _____ PPM ☐ OTHER _____ @ _____ PPM			☐ PUMPED STREAM SOLIDIFIES UNDER SHEAR		
☐ SOLID CONTAMINANT _____			☐ PUMPED STREAM CONTAINS AGENTS THAT POLYMERIZE		
☐ CONCENTRATION (% BY WT, OR PPM) _____			SPECIFY AGENTS _____ @ TEMP _____ °F		
☐ PUMPING TEMPERATURE			☐ PUMPED STREAM CAN PLATE OUT OR DECOMPOSE:		
MIN _____ °F NORMAL _____ °F MAX _____ °F			SPECIFY CONDITIONS _____		
☐ SPECIFIC GRAVITY AT TEMPERATURE INDICATED			☐ PUMPED STREAM IS REGULATED FOR FUGITIVE OR		
@ NORMAL TEMP _____ @ MAX TEMP _____			OTHER EMISSIONS. REGULATION LEVEL _____ PPMV		
☐ VAPOR PRESSURE AT TEMPERATURE INDICATED			☐ SPECIAL PUMP CLEANING PROCEDURES		
NORMAL TEMP _____ PSIA MAX TEMP _____ PSIA			SPECIFY: _____		
☐ ATMOSPHERIC BOILING POINT. _____ °F			☐ ALTERNATIVE PROCESS FLUIDS & CONCENTRATION		
☐ VISCOSITY @ NORMAL PUMPING TEMP. _____ cP			(INCL. COMMISSIONING)		
FLUSH FLUID (PLAN 32) If flush fluid is pumpage, then flush fluid data is not required.					
☐ TYPE OR NAME _____ CONC'N _____ %			☐ VAPOR PRESSURE AT TEMPERATURE INDICATED		
☐ SEAL VENDOR REVIEW REQUIRED			NORMAL TEMP _____ PSIA MAX TEMP _____ PSIA		
☐ FLUID TEMPERATURE			☐ ATMOSPHERIC BOILING POINT. _____ °F		
MIN _____ °F NORMAL _____ °F MAX _____ °F			☐ VISCOSITY @ NORMAL PUMPING TEMP. _____ cP		
☐ SPECIFIC GRAVITY AT TEMPERATURE INDICATED			☐ FLOW RATE REQ'D MAX/MIN _____ / _____ GPM		
@ NORMAL TEMP _____ @ MAX TEMP _____			☐ PRESSURE REQ'D MAX/MIN _____ / _____ PSIG		

Category 1 & 2 Seals MECHANICAL SEAL DATA SHEET FOR CENTRIFUGAL & ROTARY PUMPS U.S. CUSTOMARY UNITS PAGE 2 OF 2 (FLUID DATA, UTILITIES, ACCESSORIES, & INSP./TEST.)		REQUIRED FOR: _____ SITE: _____ UNIT: _____ JOB/PROJECT NO. _____ ITEM NO. _____ REQUISITION / SPEC. NUMBER _____ / _____ INQUIRY NUMBER _____ BY _____ PURCH ORDER NUMBER _____ DATE _____ REVISION NO. 0 DATE _____	
☐ INDICATES DATA COMPLETED BY PURCHASER ☒ ☐ DEFAULT SELECTION		☐ BY SEAL VENDOR ☒ BY SEAL VENDOR OR PURCHASER	
FLUID DATA - (QUENCH, BUFFER AND BARRIER FLUID DATA, LIQUID AND GAS)			
QUENCH MEDIUM (PLAN 51, 62) ☒ TYPE OR NAME _____ BUFFER/BARRIER MEDIUM ☒ TYPE OR NAME _____ ☐ PURCHASER SELEC'N ☐ SEAL VENDOR SELEC'N ☐ SEAL VENDOR REVIEW ☐ PURCHASER REVIEW ☐ FLOW RATE REQ'D MAX/MIN. _____ / _____ GPM/SCFH ☒ SUPPLY PRESSURE MAX/MIN. _____ / _____ PSIG ☒ FLUID OPERATING TEMPERATURE MIN _____ °F; NORMAL _____ °F; MAX _____ °F		☒ SUPPLY TEMPERATURE MAX/MIN _____ / _____ °F ☐ FLOW RATE REQ'D MAX/MIN _____ / _____ GPM/SCFH ☐ SPECIFIC GRAVITY AT TEMP. INDICATED (LIQUID) @ NORMAL TEMP _____ @ MAX TEMP _____ ☒ VAPOR PRESSURE AT TEMPERATURE INDICATED (LIQUID) NORMAL TEMP _____ PSIA MAX TEMP _____ PSIA ☒ ATMOSPHERIC BOILING POINT (LIQUID) _____ °F ☐ VISCOSITY @ NORMAL TEMP (LIQUID) _____ cP ☒ SPECIFIC HEAT @ NORMAL TEMP _____ Btu/h.ft. °F ☐ COOLING/HEATING REQUIRED (+ OR -) _____ Btu/h	
SITE AND UTILITIES			
☐ CONTROL VOLTAGE _____ V PHASE _____ HERTZ _____ ☐ ELECTRICAL AREA CL _____ GR _____ DIV _____ ☐ DESIGN AMBIENT MIN./MAX. _____ / _____ °F		☐ COOLING H ₂ O SUPPLY TEMP. _____ °F ☐ Cl ₂ _____ PPM ☐ COOLING H ₂ O PRESS. NORM./DES. _____ / _____ PSIG ☐ ATEX (EC DIRECTIVE 94/9/EC) GR CAT. T CLASS	
ACCESSORIES (CLAUSES 8 AND 9)			
GENERAL ☐ JOINT USER/VENDOR LAYOUT OF EQUIPMENT (8.1.4) ☐ PIPE TAPER THREADS (8.1.9) ☐ ISO 7 ☐ ASME B1.20.1 ☐ SPECIAL REQUIREMENTS FOR HAZARDOUS SERVICE ☐ SPECIAL CLEANING AND DECONTAMINATION REQ'TS ☐ UTILITY MANIFOLD CONNECTIONS REQUIRED (8.4.4) ☐ TYPE AND SPEC. OF HEAT TRACING (8.6.5.8) ☐ THERMAL RELIEF VALVES REQUIRED (9.8.3)		PLAN 52 AND 53 SYSTEMS CONTINUED ☐ EQUIPMENT SUPPORT SUPPLIER ☐ FILLING SYSTEM SUPPLIER ☐ ASME CODE STAMP REQUIRED ☐ EN 13445 OR OTHER CODE APPLICABLE ☒ RESERVOIR CAPACITY (8.5.4.3) _____ GAL ☒ NLL TO GLAND PLATE HEIGHT (8.5.4.2) _____ FT ☐ RESERVOIR MAWP (3.4.1) _____ PSIG @ _____ °F ☒ SET PRESSURE RANGE, MAX/MIN _____ / _____ PSIG ☒ SYSTEM HOLD-UP PERIOD (PLANS 53B & 53C) _____ DAYS ☐ TEMPERATURE INDICATOR (PLAN 53B & 53C) PRESSURE SWITCH (8.5.4.2.h) TO ACTIVATE ON; ☒ RISING PRESSURE (ARR 2) SET @ _____ PSIG ☒ FALLING PRESSURE (ARR 3) SET @ _____ PSIG ☒ HIGH LEVEL ALARM REQUIRED (8.5.4.2.i) ☐ TEST BASED H/Q CURVE FOR INTERNAL CIRC. DEVICE ☐ EXTERNAL CIRCULATING PUMP (8.6.3.1)	
COOLING SYSTEM (PLAN 21, 22, 23, 41, 53B, 53C) ☐ HEAT EXCHANGER SUPPLIER ☒ WATER COOLED ☒ AIR COOLED ☐ ISO 15649 ☒ EQUIPMENT REFERENCE/CODE _____ ☐ COOLING WATER LINES SUPPLIER ☐ TUBING ☐ GALVANISED PIPING (8.4.2) ☒ COOLING WATER FLOW RATE _____ GPM ☐ SIGHT FLOW INDICATORS (8.4.3) ☐ OPEN ☐ CLOSED		PLAN 72 AND 74 SYSTEM ☐ EQUIPMENT SUPPLIER ☐ HIGH FLOW ALARM SWITCH (8.6.6.5)	
PLAN 11, 13, 14, 21, 23, 31, 32 AND 41 SYSTEMS ☐ CONNECTING LINES SUPPLIER ☐ TUBING ☐ PIPING (8.5.2.2) ☐ RESTRICTION ORIFICE NIPPLE IN FLUSH LINE (8.5.2.4) ☐ CYCLONE SEPARATOR SUPPLIER ☐ PLAN 32 EQUIPMENT SUPPLIER ☐ PLAN 32 FLOW IND'R ☐ PLAN 32 TEMPERATURE IND'R		PLAN 75 AND 76 SYSTEM ☐ EQUIPMENT SUPPLIER ☐ HIGH LEVEL ALARM SWITCH FOR PLAN 75 (8.6.5.3) ☐ TEST CONNECTION (8.6.5.4)	
PLAN 52 AND 53 SYSTEMS ☒ STANDARD (FIG G.27) ☒ ALTERNATIVE (FIG G.28) ☐ DIMENSIONAL VARIATIONS TO STANDARD (FIG G.27) ☐ DIMENSIONAL VARIATIONS TO ALTERNATIVE (FIG G.28) ☒ ALTERNATIVE FABRICATION STANDARD ☐ PRIMARY EQUIPMENT SUPPLIER ☒ SUPPLIER REFERENCE/CODE _____ ☐ CONNECTING LINES SUPPLIER ☐ TUBING ☐ SCH 80 PIPING (8.5.4.4.9)		INSTRUMENTATION ☐ USER SPECIFICATION REFERENCE FOR INSTRUMENTATION/CONTROLS _____ PRESSURE GAUGES (9.4); ☐ OIL FILLED PRESSURE GAUGES (9.4.3) PRESSURE SWITCHES (9.5.2); ☐ TRANSMITTER (9.5.2.3) LEVEL SWITCHES (9.5.3); ☐ TRANSMITTER (9.5.3.2) ☐ HYDROSTATIC ☐ CAPACITANCE ☐ ULTRASONIC LEVEL INDICATORS (9.6); ☐ WELD PAD ☐ EXTERNAL, REMOVABLE (9.6.2) FLOW INSTRUMENTS (9.7); ☐ TRANSMITTER (9.7.3)	
INSPECTION AND TESTING			
☐ PURCHASER PARTICIPATION IN INSPECTION & TEST SPECIFY; _____ ☐ INSPECTOR'S CHECK LIST (10.1.7 & ANNEX H) ☐ PURCHASER APPROVAL REQUIRED FOR WELDED CONNECTION DESIGNS, (6.1.6.10.5) ☐ HARDNESS TEST (10.2.3 k) REQUIRED FOR:		☐ 100% INSPECTION OF ALL WELDS (6.1.6.10.5) USING; ☐ MAGNETIC PARTICLE ☐ LIQUID PENETRANT ☐ RADIOGRAPHIC ☐ ULTRASONIC ☐ OPTIONAL QUALIFICATION TESTING REQ'D (10.3.1.1.2) ☒ MOD. FACES FOR PUMP TEST (10.3.5.1), SEE PG 1, LINE 30 ☒ ALTERNATIVE SEAL PUMP TEST (10.3.5.2), SEE PG 1, LINE 25	

Category 3 Seals MECHANICAL SEAL DATA SHEET FOR CENTRIFUGAL & ROTARY PUMPS S.I. UNITS PAGE 1 of 2				REQUIRED FOR: _____ SITE: _____ UNIT: _____	
				JOB/PROJECT NO. _____ ITEM NO. _____	
				REQUISITION / SPEC. NUMBER _____ / _____	
				INQUIRY NUMBER _____ BY _____	
				PURCH ORDER NUMBER _____ DATE _____	
				REVISION NO. 0 DATE _____	
1 DATA SUPPLIED ☐ CUSTOMARY UNITS ☐ SI UNITS				HARDWARE SUPPLIED ☐ CUSTOMARY UNITS ☐ SI UNITS	
2 ☐ INDICATES DATA COMPLETED BY PURCHASER ☐ BY SEAL VENDOR ☒ BY SEAL VENDOR OR PURCHASER					
3 ☒ ☐ DEFAULT SELECTION					
SEAL SPECIFICATION - (REF 4.1, FIGURES 1 TO 6)					
4 TYPE ☒ TYPE A (3.72) ☐ TYPE B (3.73) ☐ ALTERNATIVE STATIONARY (TYPE A & B)					
5 (CODE-CW) ☐ TYPE C (3.74) ☐ ALTERNATIVE ROTATING (TYPE C) ☐ SINGLE SPRING (TYPE A)					
6 ARR'G'T	DEFAULT CONFIGURATION	ALTERNATIVE DESIGN		FLUSH PLANS (SEE ANNEX G)	
7 1 (3.2)	☐ 1CW-FL	☐ ALTERNATIVE BUSH		☐ 01 ☐ 11 ☐ 14 ☐ 23 ☐ 32 ☐ 51 ☐ 62	
8				☐ 02 ☐ 13 ☐ 21 ☐ 31 ☐ 41 ☐ 61 ☐ 65	
9	10 BUFFER	LIQUID ☐ 2CW-CW ☐ FX		☐ 01 ☐ 13 ☐ 23 ☐ 41 ☐ 62 ☐ 75	
11		☐ DIST. FLUSH		☐ 02 ☐ 14 ☐ 31 ☐ 52 ☐ 71 ☐ 76	
12		GAS ☐ 2CW-CS ☐ 2NC-CS ☐ FX ☐ DIST. FLUSH		☐ 11 ☐ 21 ☐ 32 ☐ 61 ☐ 72	
13	14 BUFFER	LIQUID ☐ 3CW-FB ☐ 3CW-BB ☐ 3CW-FF ☐ FX		☐ 01 ☐ 11 ☐ 14 ☐ 53A ☐ 53C ☐ 61 ☐ 74	
14		GAS ☐ 3NC-BB ☐ 3NC-FF ☐ 3NC-FB		☐ 02 ☐ 13 ☐ 32 ☐ 53B ☐ 54 ☐ 62	
15 SLEEVE-SHAFT DRIVE		☐ SET-SCREW ONTO SHAFT ☐ ALTERNATIVE (6.1.3.13) - SPECIFY			
MATERIALS (REFERENCE 6.1.6 & ANNEX B)					
17 SECONDARY SEALS		SEAL FACES		METAL BELLOWS	
18 ☐ FKM ☐ FFKM		☐ CARBON VS SIC		☐ UNS N10276 (TYPE B)	
19 ☐ SPIRAL-W GASKET		☐ SIC VS SIC		☐ UNS N07718 (TYPE C)	
20 ☐ NBR		☐ SS-SIC ☐ RB-SIC		☐ UNS N08020	
21 ☐ OTHER:		☐ VS		☐ OTHER:	
				SPRINGS	
				☐ UNS N10276 ☐ UNS S31600/ S31635	
				OR N06455 ☐ UNS N10276	
				☐ UNS S31600 ☐ UNS N08020	
				OR S31635 ☐ OTHER:	
MECHANICAL SEAL DATA					
23 ☐ SEAL VENDOR _____					
24 ☐ DATA REQUIREMENTS FORM (ANNEX J) _____					
25 ☐ SIZE/TYPE _____					
26 ☐ SEAL DRAWING NUMBER _____					
27 ☒ SEAL CODE (ANNEX D) _____ C3					
28 ☐ VENDOR'S SEAL CODE _____					
29 ☐ MODIFIED FACES FOR PUMP PERFORMANCE TEST _____					
30 ☐ ALTERNATIVE SEAL FOR PUMP PERFORMANCE TEST _____					
31 ☐ DYNAMIC SEALING PRESSURE RATING (3.19) _____ kPa (bar) [ga]					
32 ☐ STATIC SEALING PRESSURE RATING (3.69) _____ kPa (bar) [ga]					
33 ☐ MAXIMUM ALLOWABLE TEMPERATURE (3.40) _____ °C					
34 ☐ MINIMUM DESIGN METAL TEMPERATURE (6.1.6.11.1) _____ °C					
35 ☐ GENERATED HEAT @ NORM. CONDITIONS _____ kW					
36 ☐ HEAT SOAK @ NORMAL CONDITIONS _____ kW					
37 ☐ TOTAL SEAL AXIAL THRUST ON SHAFT _____ N					
SEAL CHAMBER DATA (REFERENCE 6.1.2.4)					
38 ☒ ISO 13709 (ISO 3069-H) ☐ OTHER, SPECIFY _____					
39 ☒ SEAL CHAMBER FLUSH PORT REQ'D ☐ SEAL CHAMBER VENT REQ'D ☐ BOLT-ON CHAMBER (6.1.2.5)					
40 ☒ FLOATING THROAT BUSH ☐ FIXED THROAT BUSH ☐ CHAMBER HEATING REQ'D					
PUMP DATA					
41 PUMP DESIGN ☐ MANUFACTURER _____ ☐ MODEL _____ ☐ FRAME/SIZE _____ ☐ CASE MATERIAL _____					
42 PUMP OPERATING PRESSURE ☐ SUCTION PRESS. (RATED) _____ kPa (bar) [ga] ☐ DISCHARGE PRESSURE _____ kPa (bar) [ga]					
43 SEAL CHAMBER ☐ NORMAL _____ kPa (bar) [ga] ☐ MIN / MAX (3.42) _____ / _____ kPa (bar) [ga] ☐ MSSP (3.44) _____ kPa (bar) [ga]					
44 SHAFT ☐ HORIZONTAL ☐ VERTICAL ☐ DIA. _____ mm ☐ SHAFT SPEED _____ r/min					
45 SHAFT DIRECTION (FROM DRIVER): ☐ CW ☐ CCW					
FLUID DATA - (FOR QUENCH, BUFFER AND BARRIER FLUID DATA, SEE PAGE 2)					
46 PUMPED STREAM					
47 ☐ TYPE OR NAME _____ CONC'N _____ %					
48 ☐ DISSOLVED CONTAMINANT ☐ H ₂ S _____ ml/m ³ ☐ WET					
49 ☐ Cl ₂ _____ ml/m ³ ☐ OTHER _____ @ _____ ml/m ³					
50 ☐ SOLID CONTAMINANT _____					
51 ☐ CONCENTRATION (MASS FRACTION) _____					
52 ☐ PUMPING TEMPERATURE					
53 MIN _____ °C NORMAL _____ °C MAX _____ °C					
54 ☐ RELATIVE DENSITY (TO WATER @ 25°C) AT REF. TEMP.					
55 @ NORMAL TEMP _____ @ MAX TEMP _____					
56 ☐ ABSOLUTE VAPOR PRESSURE AT REFERENCE TEMP.					
57 NORMAL TEMP _____ kPa MAX TEMP _____ kPa					
58 ☐ ATMOSPHERIC BOILING POINT. _____ °C					
59 ☐ VISCOSITY @ NORMAL PUMPING TEMP. _____ Pa.s					
60 ☐ HAZARDOUS ☐ FLAMMABLE ☐ _____					
61 ☐ FLUID SOLID @ AMBIENT					
62 ☐ SOLIDIFIES @ _____ °C POUR POINT _____ °C					
63 ☐ PUMPED STREAM SOLIDIFIES UNDER SHEAR					
64 ☐ PUMPED STREAM CONTAINS AGENTS THAT POLYMERIZE					
65 SPECIFY AGENTS _____ @ TEMP _____ °C					
66 ☐ PUMPED STREAM CAN PLATE OUT OR DECOMPOSE:					
67 SPECIFY CONDITIONS _____					
68 ☐ PUMPED STREAM IS REGULATED FOR FUGITIVE OR					
69 OTHER EMISSIONS. REGULATION LEVEL _____ ml/m ³					
70 ☐ SPECIAL PUMP CLEANING PROCEDURES					
71 SPECIFY: _____					
72 ☐ ALTERNATIVE PROCESS FLUIDS & CONCENTRATION					
73 (INCL. COMMISSIONING)					
74 FLUSH FLUID (PLAN 32) If flush fluid is pumpage, then flush fluid data is not required.					
75 ☐ TYPE OR NAME _____ CONC'N _____ %					
76 ☐ SEAL VENDOR REVIEW REQUIRED					
77 ☐ FLUID TEMPERATURE					
78 MIN _____ °C NORMAL _____ °C MAX _____ °C					
79 ☐ RELATIVE DENSITY (TO WATER @ 25°C) AT REF. TEMP.					
80 @ NORMAL TEMP _____ @ MAX TEMP _____					
81 ☐ ABSOLUTE VAPOR PRESSURE AT REFERENCE TEMP.					
82 NORMAL TEMP _____ kPa MAX TEMP _____ kPa					
83 ☐ ATMOSPHERIC BOILING POINT. _____ °C					
84 ☐ VISCOSITY @ NORMAL PUMPING TEMP. _____ Pa.s					
85 ☐ FLOW RATE REQ'D MAX/MIN _____ / _____ l/min					
86 ☐ PRESSURE REQ'D MAX/MIN _____ / _____ kPa (bar) [ga]					

Category 3 Seals		REQUIRED FOR: _____ SITE: _____ UNIT: _____	
MECHANICAL SEAL DATA SHEET FOR CENTRIFUGAL & ROTARY PUMPS S.I. UNITS PAGE 2 OF 2 (FLUID DATA, UTILITIES, ACCESSORIES, & INSP./TEST.)		JOB/PROJECT NO. _____ ITEM NO. _____	
		REQUISITION /SPEC. NUMBER _____ / _____	
		INQUIRY NUMBER _____ BY _____	
		PURCH ORDER NUMBER _____ DATE _____	
		REVISION NO. 0 DATE _____	
☐ INDICATES DATA COMPLETED BY PURCHASER ☒ DEFAULT SELECTION		☐ BY SEAL VENDOR ☒ BY SEAL VENDOR OR PURCHASER	
FLUID DATA - (QUENCH, BUFFER, AND BARRIER FLUID DATA, LIQUID AND GAS)			
4 QUENCH MEDIUM (PLAN 51, 62) ☒ TYPE OR NAME _____		☒ SUPPLY TEMPERATURE MAX/MIN _____ / _____ °C ☐ FLOWRATE REQ'D MAX/MIN _____ / _____ l/min	
6 BUFFER AND BARRIER LIQUID/GAS ☒ TYPE OR NAME _____		☒ RELATIVE DENSITY (TO WATER @ 25°C) AT REF. TEMP. @ NORMAL TEMP _____ @ MAX TEMP _____	
8 ☐ PURCHASER SELEC'N ☐ SEAL VENDOR SELEC'N 9 ☐ SEAL VENDOR REVIEW ☐ PURCHASER REVIEW		☒ ABSOLUTE VAPOR PRESSURE AT REFERENCE TEMP. NORMAL TEMP _____ kPa MAX TEMP _____ kPa	
10 ☐ FLOW RATE REQ'D MAX/MIN. _____ / _____ l/min 11 ☐ COOLING/HEATING REQUIRED (+ OR -) _____ kW		☒ ATMOSPHERIC BOILING POINT (LIQUID) _____ °C ☒ VISCOSITY @ NORMAL TEMP (LIQUID) _____ Pa.s	
12 ☒ SUPPLY PRESSURE MAX/MIN. _____ / _____ kPa (bar) [ga] 13 ☒ FLUID OPERATING TEMPERATURE		☒ SPECIFIC HEAT CAPACITY @ CONSTANT PRESSURE FOR LIQUID @ NORMAL TEMPERATURE _____ J/Kg.K	
14 MIN _____ °C; NORMAL _____ °C; MAX _____ °C			
SITE AND UTILITIES			
16 ☐ CONTROL VOLTAGE _____ V PHASE _____ HERTZ _____ 17 ☐ ELECTRICAL AREA CL _____ GR _____ DIV _____ 18 ☐ DESIGN AMBIENT MIN./MAX. _____ / _____ °C		☐ COOLING H ₂ O SUPPLY TEMP. _____ °C ☐ Cl ₂ _____ m ³ /m ³ ☐ COOLING H ₂ O PRESS. NORM./DES. _____ / _____ kPa (bar) [ga] ☐ ATEX (EC DIRECTIVE 94/9/EC) GR CAT. T CLASS	
ACCESSORIES (CLAUSES 8 AND 9)			
20 GENERAL 21 ☐ JOINT USER/VENDOR LAYOUT OF EQUIPMENT (8.1.4) 22 ☐ PIPE TAPER THREADS (8.1.9) ☐ ISO 7 ☐ ASME B1.20.1 23 ☐ SPECIAL REQUIREMENTS FOR HAZARDOUS SERVICE 24 _____ 25 ☐ SPECIAL CLEANING AND DECONTAMINATION REQ'TS 26 ☐ UTILITY MANIFOLD CONNECTIONS REQUIRED (8.4.4) 27 ☐ TYPE AND SPEC. OF HEAT TRACING (8.6.5.8) 28 _____ 29 ☐ THERMAL RELIEF VALVES REQUIRED (9.8.3)		PLAN 52 AND 53 SYSTEMS CONTINUED ☐ ALTERNATIVE CODE/INSPECTION - SPECIFY _____ ☐ EQUIPMENT SUPPORT SUPPLIER ☒ RESERVOIR CAPACITY (8.5.4.3) _____ l ☒ NLL TO GLAND PLATE HEIGHT (8.5.4.2) _____ m ☐ RESERVOIR MAWP (3.4.1) _____ kPa (bar) [ga] @ _____ °C ☒ SET PRESSURE RANGE, MAX/MIN _____ / _____ kPa (bar) [ga] ☒ SYSTEM HOLD-UP PERIOD (PLANS 53B & 53C) _____ DAYS ☐ TEMPERATURE INDICATOR (PLAN 53B & 53C) PRESSURE SWITCH (8.5.4.2.h) TO ACTIVATE ON; ☒ RISING PRESSURE (ARR 2) SET @ _____ kPa (bar) [ga] ☒ FALLING PRESSURE (ARR 3) SET @ _____ kPa (bar) [ga] ☒ HIGH LEVEL ALARM REQUIRED (8.5.4.2.i) ☐ CONNECTING LINES SUPPLIER ☐ TUBING ☐ SCH 80 PIPING (8.5.4.4.9) ☐ FILLING SYSTEM SUPPLIER ☐ EXTERNAL CIRCULATING PUMP (8.6.3.1)	
30 COOLING SYSTEM (PLAN 21, 22, 23, 41, 53B & 53C) 31 ☐ HEAT EXCHANGER SUPPLIER 32 ☒ WATER COOLED ☒ AIR COOLED ☐ ISO 15649 33 ☒ EQUIPMENT REFERENCE/CODE _____ 34 ☐ COOLING WATER LINES SUPPLIER 35 ☐ TUBING ☐ GALVANISED PIPING (8.4.2) 36 ☒ COOLING WATER FLOW RATE _____ l/min 37 ☐ SIGHT FLOW INDICATORS (8.4.3) ☐ OPEN ☐ CLOSED		PLAN 72 AND 74 SYSTEM ☐ EQUIPMENT SUPPLIER ☐ HIGH FLOW ALARM SWITCH (8.6.6.5) PLAN 75 AND 76 SYSTEM ☐ EQUIPMENT SUPPLIER ☐ HIGH LEVEL ALARM SWITCH FOR PLAN 75 (8.6.5.3) ☐ TEST CONNECTION (8.6.5.4)	
38 PLAN 11, 13, 14, 23, 31, 32 AND 41 SYSTEMS 39 ☐ CONNECTING LINES SUPPLIER 40 ☐ TUBING ☐ PIPING (8.5.2.2) 41 ☐ RESTRICTION ORIFICE NIPPLE IN FLUSH LINE (8.5.2.4) 42 ☐ CYCLONE SEPARATOR SUPPLIER 43 ☐ PLAN 32 EQUIPMENT SUPPLIER 44 ☐ PLAN 32 FLOW IND'R ☐ PLAN 32 TEMPERATURE IND'R		INSTRUMENTATION ☐ USER SPECIFICATION REFERENCE FOR INSTRUMENTATION/CONTROLS _____ PRESSURE GAUGES (9.4); ☐ OIL FILLED PRESSURE GAUGES (9.4.3) PRESSURE SWITCHES (9.5.2); ☐ TRANSMITTER (9.5.2.3) LEVEL SWITCHES (9.5.3); ☐ TRANSMITTER (9.5.3.2) ☐ HYDROSTATIC ☐ CAPACITANCE ☐ ULTRASONIC LEVEL INDICATORS (9.6) ☐ WELD PAD ☐ EXTERNAL, REMOVABLE (9.6.2) FLOW INSTRUMENTS (9.7); ☐ TRANSMITTER (9.7.3)	
45 PLAN 52 AND 53 SYSTEMS 46 ☒ STANDARD (FIG G.27) ☒ ALTERNATIVE (FIG G.28) 47 ☐ DIMENSIONAL VARIATIONS TO STANDARD (FIG G.27) 48 _____ 49 ☐ DIMENSIONAL VARIATIONS TO ALTERNATIVE (FIG G.28) 50 _____ 51 ☒ ALTERNATIVE FABRICATION STANDARD _____ 52 ☐ PRIMARY EQUIPMENT SUPPLIER 53 ☒ SUPPLIER REFERENCE/CODE _____ 54 ☐ ASME CODE STAMP REQUIRED			
INSPECTION AND TESTING			
56 ☐ PURCHASER PARTICIPATION IN INSPECTION & TEST 57 SPECIFY; _____ 58 ☐ INSPECTOR'S CHECK LIST (10.1.7 & ANNEX H) 59 ☐ PURCHASER APPROVAL REQUIRED FOR WELDED 60 CONNECTION DESIGNS, (6.1.6.10.5) 61 ☐ HARDNESS TEST (10.2.3 k) REQUIRED FOR:		☐ 100% INSPECTION OF ALL WELDS (6.1.6.10.5) USING; ☐ MAGNETIC PARTICLE ☐ LIQUID PENETRANT ☐ RADIOGRAPHIC ☐ ULTRASONIC ☒ OPTIONAL QUALIFICATION TESTING REQ'D (10.3.1.1.2) ☒ MOD. FACES FOR PUMP TEST (10.3.5.1), SEE PG 1, LINE 29 ☒ ALTERNATIVE SEAL PUMP TEST (10.3.5.2), SEE PG 1, LINE 30	

Category 3 Seals MECHANICAL SEAL DATA SHEET FOR CENTRIFUGAL & ROTARY PUMPS U.S. CUSTOMARY UNITS PAGE 1 OF 2				REQUIRED FOR: _____ SITE: _____ UNIT: _____	
				JOB/PROJECT NO. _____ ITEM NO. _____	
				REQUISITION / SPEC. NUMBER _____ / _____	
				INQUIRY NUMBER _____ BY _____	
				PURCH ORDER NUMBER _____ DATE _____	
				REVISION NO. 0 DATE _____	
1 DATA SUPPLIED ☐ CUSTOMARY UNITS ☐ SI UNITS				☐ CUSTOMARY UNITS ☐ SI UNITS	
2 ☐ INDICATES DATA COMPLETED BY PURCHASER ☐ BY SEAL VENDOR ☒ BY SEAL VENDOR OR PURCHASER					
3 ☒ ☐ DEFAULT SELECTION					
SEAL SPECIFICATION - (REF 4.1, FIGURES 1 TO 6)					
5 TYPE ☐ TYPE A (3.72) ☒ TYPE B (3.73) ☐ ALTERNATIVE STATIONARY (TYPE A & B)					
6 (CODE-CW) ☐ TYPE C (3.74) ☒ ALTERNATIVE ROTATING (TYPE C) ☐ SINGLE SPRING (TYPE A)					
7 ARR'GT	DEFAULT CONFIGURATION	ALTERNATIVE DESIGN		FLUSH PLANS (SEE ANNEX G)	
8 1 (3.2)	☒ 1CW-FL	☒ ALTERNATIVE BUSH		☐ 01 ☐ 11 ☐ 14 ☐ 23 ☐ 32 ☐ 51 ☐ 62	
9				☐ 02 ☐ 13 ☐ 21 ☐ 31 ☐ 41 ☐ 61 ☐ 65	
10 2 (3.3)	LIQUID ☒ 2CW-CW ☐ FX	☐ DIST. FLUSH		☐ 01 ☐ 13 ☐ 23 ☐ 41 ☐ 62 ☐ 75	
11	GAS ☒ 2CW-CS ☐ 2NC-CS ☐ FX ☐ DIST. FLUSH			☐ 02 ☐ 14 ☐ 31 ☐ 52 ☐ 71 ☐ 76	
12				☐ 11 ☐ 21 ☐ 32 ☐ 61 ☐ 72	
13	LIQUID ☒ 3CW-FB ☐ 3CW-BB ☐ 3CW-FF ☐ FX			☐ 01 ☐ 11 ☐ 14 ☐ 53A ☐ 53C ☐ 61 ☐ 74	
14 3 (3.4)	GAS ☒ 3NC-BB ☐ 3NC-FF ☐ 3NC-FB			☐ 02 ☐ 13 ☐ 32 ☐ 53B ☐ 54 ☐ 62	
15 SLEEVE-SHAFT DRIVE ☒ SET-SCREW ONTO SHAFT ☐ ALTERNATIVE (6.1.3.13) - SPECIFY					
MATERIALS (REFERENCE 6.1.6 & ANNEX B)					
17 SECONDARY SEALS		SEAL FACES		METAL BELLOWS	
18 ☒ FKM ☐ FFKM ☐ CARBON VS SIC ☐ UNS N10276 (TYPE B) ☐ UNS N10276 ☐ UNS S31600/ S31635		19 ☒ SPIRAL-W GASKET ☐ SIC VS SIC ☐ UNS N07718 (TYPE C) ☐ OR N06455 ☐ UNS N10276			
20 ☒ NBR ☐ SS-SIC ☐ RB-SIC ☐ UNS N08020 ☐ UNS S31600 ☐ UNS N08020		21 ☐ OTHER: _____ ☐ VS ☐ OTHER: _____		☐ OR S31635 ☐ OTHER: _____	
MECHANICAL SEAL DATA					
22 ☐ SEAL VENDOR _____		☐ DYNAMIC SEALING PRESSURE RATING (3.19) _____ PSIG			
23 ☐ DATA REQUIREMENTS FORM (ANNEX J)		☐ STATIC SEALING PRESSURE RATING (3.69) _____ PSIG			
24 ☐ SIZE/TYPE _____		☐ MAXIMUM ALLOWABLE TEMPERATURE (3.40) _____ °F			
25 ☐ SEAL DRAWING NUMBER _____		☐ MINIMUM DESIGN METAL TEMPERATURE (6.1.6.11.1) _____ °F			
26 ☒ SEAL CODE (ANNEX D) _____ C3		☐ GENERATED HEAT @ NORM. CONDITIONS _____ BTU/HR			
27 ☐ VENDOR'S SEAL CODE _____		☐ HEAT SOAK @ NORM. CONDITIONS _____ BTU/HR			
28 ☐ MODIFIED FACES FOR PUMP PERFORMANCE TEST		☐ TOTAL SEAL AXIAL THRUST ON SHAFT _____ LBF			
29 ☐ ALTERNATIVE SEAL FOR PUMP PERFORMANCE TEST					
SEAL CHAMBER DATA (REFERENCE 6.1.2.4)					
30 ☒ ISO 13709 (ISO 3069-H)		☐ OTHER, SPECIFY _____		☐ BOLT-ON CHAMBER (6.1.2.5)	
31 ☒ SEAL CHAMBER FLUSH PORT REQ'D		☐ SEAL CHAMBER VENT REQ'D		☒ CHAMBER HEATING REQ'D	
32 ☒ FLOATING THROAT BUSH		☐ FIXED THROAT BUSH			
PUMP DATA					
33 PUMP DESIGN ☐ MANUFACTURER _____ ☐ MODEL _____ ☐ FRAME/SIZE _____ ☐ CASE MATERIAL _____					
34 PUMP OPERATING PRESSURE ☐ SUCTION PRESSURE (RATED) _____ PSIG ☐ DISCHARGE PRESSURE _____ PSIG					
35 SEAL CHAMBER ☐ NORMAL _____ PSIG ☐ MIN / MAX (MDSP, 3.42) _____ / _____ PSIG ☐ MSSP (3.44) _____ PSIG					
36 SHAFT ☐ HORIZONTAL ☐ VERTICAL ☐ DIA. _____ IN ☐ SHAFT SPEED _____ RPM					
37 SHAFT DIRECTION (FROM DRIVER): ☐ CW ☐ CCW					
FLUID DATA - (FOR QUENCH, BUFFER AND BARRIER FLUID DATA, SEE PAGE 2)					
38 PUMPED STREAM					
39 ☐ TYPE OR NAME _____ CONC'N _____ %		☐ HAZARDOUS ☐ FLAMMABLE ☐ _____			
40 ☐ DISSOLVED CONTAMINANT ☐ H ₂ S _____ PPM ☐ WET		☐ FLUID SOLID @ AMBIENT			
41 ☐ Cl ₂ _____ PPM ☐ OTHER _____ @ _____ PPM		☐ SOLIDIFIES @ _____ °F POUR POINT _____ °F			
42 ☐ SOLID CONTAMINANT		☐ PUMPED STREAM SOLIDIFIES UNDER SHEAR			
43 ☐ CONCENTRATION (% BY WT, OR PPM) _____		☐ PUMPED STREAM CONTAINS AGENTS THAT POLYMERIZE			
44 ☐ PUMPING TEMPERATURE		SPECIFY AGENTS _____ @ TEMP _____ °F			
45 MIN _____ °F NORMAL _____ °F MAX _____ °F		☐ PUMPED STREAM CAN PLATE OUT OR DECOMPOSE:			
46 ☐ SPECIFIC GRAVITY AT TEMPERATURE INDICATED		SPECIFY CONDITIONS _____			
47 @ NORMAL TEMP _____ @ MAX TEMP _____		☐ PUMPED STREAM IS REGULATED FOR FUGITIVE OR			
48 ☐ VAPOR PRESSURE AT TEMPERATURE INDICATED		OTHER EMISSIONS. REGULATION LEVEL _____ PPMV			
49 NORMAL TEMP _____ PSIA MAX TEMP _____ PSIA		☐ SPECIAL PUMP CLEANING PROCEDURES			
50 ☐ ATMOSPHERIC BOILING POINT. _____ °F		SPECIFY: _____			
51 ☐ VISCOSITY @ NORMAL PUMPING TEMP. _____ Cp		☐ ALTERNATIVE PROCESS FLUIDS & CONCENTRATION			
		(INCL. COMMISSIONING)			
52 FLUSH FLUID (PLAN 32) If flush fluid is pumpage, then flush fluid data is not required.					
53 ☐ TYPE OR NAME _____ CONC'N _____ %		☐ VAPOR PRESSURE AT TEMPERATURE INDICATED			
54 ☐ SEAL VENDOR REVIEW REQUIRED		NORMAL TEMP _____ PSIA MAX TEMP _____ PSIA			
55 ☐ FLUID TEMPERATURE		☐ ATMOSPHERIC BOILING POINT. _____ °F			
56 MIN _____ °F NORMAL _____ °F MAX _____ °F		☐ VISCOSITY @ NORMAL PUMPING TEMP. _____ Cp			
57 ☐ SPECIFIC GRAVITY AT TEMPERATURE INDICATED		☐ FLOW RATE REQ'D MAX/MIN _____ / _____ GPM			
58 @ NORMAL TEMP _____ @ MAX TEMP _____		☐ PRESSURE REQ'D MAX/MIN _____ / _____ PSIG			

Category 3 Seals MECHANICAL SEAL DATA SHEET FOR CENTRIFUGAL & ROTARY PUMPS U.S. CUSTOMARY UNITS PAGE 2 OF 2 (FLUID DATA, UTILITIES, ACCESSORIES, & INSP./TEST.)		REQUIRED FOR: _____ SITE: _____ UNIT: _____ JOB/PROJECT NO. _____ ITEM NO. _____ REQUISITION / SPEC. NUMBER _____ / _____ INQUIRY NUMBER _____ BY _____ PURCH ORDER NUMBER _____ DATE _____ REVISION NO. 0 DATE _____	
☐ INDICATES DATA COMPLETED BY PURCHASER ☒ ☐ DEFAULT SELECTION		☐ BY SEAL VENDOR ☒ BY SEAL VENDOR OR PURCHASER	
FLUID DATA - (QUENCH, BUFFER AND BARRIER FLUID DATA, LIQUID AND GAS)			
1 QUENCH MEDIUM (PLAN 51, 62) 2 ☒ TYPE OR NAME _____		☒ SUPPLY TEMPERATURE MAX/MIN _____ / _____ °F ☐ FLOW RATE REQ'D MAX/MIN _____ / _____ GPM/SCFH	
3 BUFFER AND BARRIER LIQUID/GAS 4 ☒ TYPE OR NAME _____ 5 ☐ PURCHASER SELEC'N ☐ SEAL VENDOR SELEC'N 6 ☐ SEAL VENDOR REVIEW ☐ PURCHASER REVIEW 7 ☐ FLOW RATE REQ'D MAX/MIN. _____ / _____ GPM/SCFH 8 ☐ COOLING/HEATING REQUIRED (+ OR -) _____ Btu/h 9 ☒ SUPPLY PRESSURE MAX/MIN. _____ / _____ PSIG 10 ☒ FLUID OPERATING TEMPERATURE 11 MIN _____ °F; NORMAL _____ °F; MAX _____ °F		☒ SPECIFIC GRAVITY AT TEMP. INDICATED (LIQUID) @ NORMAL TEMP _____ @ MAX TEMP _____ ☒ VAPOR PRESSURE AT TEMPERATURE INDICATED (LIQUID) NORMAL TEMP _____ PSIA MAX TEMP _____ PSIA ☒ ATMOSPHERIC BOILING POINT (LIQUID) _____ °F ☒ VISCOSITY @ NORMAL TEMP (LIQUID) _____ cP ☒ SPECIFIC HEAT @ NORMAL TEMP _____ Btu/h.ft.°F	
SITE AND UTILITIES			
12 ☐ CONTROL VOLTAGE _____ V PHASE _____ HERTZ _____ 13 ☐ ELECTRICAL AREA CL _____ GR _____ DIV _____ 14 ☐ DESIGN AMBIENT MIN./MAX. _____ / _____ °F		☐ COOLING H ₂ O SUPPLY TEMP. _____ °F ☐ Cl ₂ _____ PPM ☐ COOLING H ₂ O PRESS. NORM./DES. _____ / _____ PSIG ☐ ATEX (EC DIRECTIVE 94/9/EC) GR CAT. T CLASS	
ACCESSORIES (CLAUSES 8 AND 9)			
15 GENERAL 16 ☐ JOINT USER/VENDOR LAYOUT OF EQUIPMENT (8.1.4) 17 ☐ PIPE TAPER THREADS (8.1.9) ☐ ISO 7 ☐ ASME B1.20.1 18 ☐ SPECIAL REQUIREMENTS FOR HAZARDOUS SERVICE 19 ☐ SPECIAL CLEANING AND DECONTAMINATION REQ'TS 20 ☐ UTILITY MANIFOLD CONNECTIONS REQUIRED (8.4.4) 21 ☐ TYPE AND SPEC. OF HEAT TRACING (8.6.5.8) 22 ☐ THERMAL RELIEF VALVES REQUIRED (9.8.3)		PLAN 52 AND 53 SYSTEMS CONTINUED ☐ ALTERNATIVE CODE/INSPECTION - SPECIFY _____ ☐ EQUIPMENT SUPPORT SUPPLIER ☒ RESERVOIR CAPACITY (8.5.4.3) _____ GAL ☒ NLL TO GLAND PLATE HEIGHT (8.5.4.2) _____ FT ☐ RESERVOIR MAWP (3.41) _____ PSIG @ _____ °F ☒ SET PRESSURE RANGE, MAX/MIN _____ / _____ PSIG ☒ SYSTEM HOLD-UP PERIOD (PLANS 53B & 53C) _____ DAYS ☐ TEMPERATURE INDICATOR (PLAN 53B & 53C) PRESSURE SWITCH (8.5.4.2.h) TO ACTIVATE ON: ☒ RISING PRESSURE (ARR 2) SET @ _____ PSIG ☒ FALLING PRESSURE (ARR 3) SET @ _____ PSIG ☒ HIGH LEVEL ALARM REQUIRED (8.5.4.2.i) ☐ CONNECTING LINES SUPPLIER ☐ TUBING ☐ SCH 80 PIPING (8.5.4.4.9) ☐ FILLING SYSTEM SUPPLIER ☐ EXTERNAL CIRCULATING PUMP (8.6.3.1)	
23 COOLING SYSTEM (PLAN 21, 22, 23, 41, 53B & 53C) 24 ☐ HEAT EXCHANGER SUPPLIER 25 ☒ WATER COOLED ☒ AIR COOLED ☐ ISO 15649 26 ☒ EQUIPMENT REFERENCE/CODE _____ 27 ☐ COOLING WATER LINES SUPPLIER 28 ☐ TUBING ☐ GALVANISED PIPING (8.4.2) 29 ☒ COOLING WATER FLOW RATE _____ GPM 30 ☐ SIGHT FLOW INDICATORS (8.4.3) ☐ OPEN ☐ CLOSED 31 PLAN 11, 13, 14, 23, 31, 32 AND 41 SYSTEMS 32 ☐ CONNECTING LINES SUPPLIER 33 ☐ TUBING ☐ PIPING (8.5.2.2) 34 ☐ RESTRICTION ORIFICE NIPPLE IN FLUSH LINE (8.5.2.4) 35 ☐ CYCLONE SEPARATOR SUPPLIER 36 ☐ PLAN 32 EQUIPMENT SUPPLIER 37 ☐ PLAN 32 FLOW IND'R ☐ PLAN 32 TEMPERATURE IND'R 38 PLAN 52 AND 53 SYSTEMS 39 ☒ STANDARD (FIG G.27) ☒ ALTERNATIVE (FIG G.28) 40 ☐ DIMENSIONAL VARIATIONS TO STANDARD (FIG G.27) 41 ☐ DIMENSIONAL VARIATIONS TO ALTERNATIVE (FIG G.28) 42 ☒ ALTERNATIVE FABRICATION STANDARD 43 ☐ PRIMARY EQUIPMENT SUPPLIER 44 ☒ SUPPLIER REFERENCE/CODE _____ 45 ☐ ASME CODE STAMP REQUIRED		PLAN 72 AND 74 SYSTEM ☐ EQUIPMENT SUPPLIER ☐ HIGH FLOW ALARM SWITCH (8.6.6.5) PLAN 75 AND 76 SYSTEM ☐ EQUIPMENT SUPPLIER ☐ HIGH LEVEL ALARM SWITCH FOR PLAN 75 (8.6.5.3) ☐ TEST CONNECTION (8.6.5.4) INSTRUMENTATION ☐ USER SPECIFICATION REFERENCE FOR INSTRUMENTATION/CONTROLS _____ PRESSURE GAUGES (9.4); ☐ OIL FILLED PRESSURE GAUGES (9.4.3) PRESSURE SWITCHES (9.5.2); ☐ TRANSMITTER (9.5.2.3) LEVEL SWITCHES (9.5.3); ☐ TRANSMITTER (9.5.3.2) ☐ HYDROSTATIC ☐ CAPACITANCE ☐ ULTRASONIC LEVEL INDICATORS (9.6) ☐ WELD PAD ☐ EXTERNAL, REMOVABLE (9.6.2) FLOW INSTRUMENTS (9.7); ☐ TRANSMITTER (9.7.3)	
INSPECTION AND TESTING			
46 ☐ PURCHASER PARTICIPATION IN INSPECTION & TEST SPECIFY: _____ 47 ☐ INSPECTOR'S CHECK LIST (10.1.7 & ANNEX H) 48 ☐ PURCHASER APPROVAL REQUIRED FOR WELDED CONNECTION DESIGNS, (6.1.6.10.5) 49 ☐ HARDNESS TEST (10.2.3 k) REQUIRED FOR: _____		☐ 100% INSPECTION OF ALL WELDS (6.1.6.10.5) USING: ☐ MAGNETIC PARTICLE ☐ LIQUID PENETRANT ☐ RADIOGRAPHIC ☐ ULTRASONIC ☐ OPTIONAL QUALIFICATION TESTING REQ'D (10.3.1.1.2) ☒ MOD. FACES FOR PUMP TEST (10.3.5.1), SEE PG 1, LINE 29 ☒ ALTERNATIVE SEAL PUMP TEST (10.3.5.2), SEE PG 1, LINE 30	

Annex D **(informative)**

Mechanical seal codes

D.1 Mechanical seals

In accordance with this International Standard, mechanical seals can be described in a general manner by using the following simplified coding system.

D.2 First letter: seal category (1, 2, 3)

The category number is prefixed with a "C" for clarity.

Historical codes for Balanced (B) or Unbalanced (U) are unnecessary, because all the seals in this International Standard are balanced. See 4.1.2 and Annex A, Sheet 2, for seal category descriptions.

D.3 Second letter: seal arrangement (1, 2, 3)

The arrangement number is prefixed with an "A" for clarity.

Historical codes for Single (S), Tandem (T) or Double (D) are obsolete and may be misinterpreted. See 3.2, 3.3, 3.4, 4.1.4 and Annex A, Sheet 2 for seal arrangement descriptions.

D.4 Third letter: seal type (A, B, C)

There is no prefix with the seal type letter.

Historical codes for Plain (P), Throttle bushing with quench, leakage and/or drain connections (T), or Auxiliary (A) sealing devices are obsolete, as each seal type contains specific seal gland plate features. See 3.73, 3.74, 3.75, 4.1.3 and Annex A, Sheet 2, for seal type descriptions.

D.5 Fourth number(s): flush arrangement

One or more arrangement number from Annex G. The letter "X" may be used in any position, but shall always be explained.

D.6 Non-standard reference

Historical codes for gasket material have been eliminated, as it is not seen as a major cost issue at the time of early project development.

If a category or arrangement code is used in a seal code, then this International Standard is assumed to be invoked. Where there are conflicts in seal codes, the category and arrangement codes take precedence.

D.7 Summary

This coding system is a variation of the five-character code that has been used for many years to describe seals in ISO 13709. Seal codes are especially useful when working with new projects which may have many pumps and seals. This coding system is not intended to provide information about the details of the seal; always check the seal data sheet for details.

EXAMPLE 1 C1A1A11 is a Category 1, Arrangement 1 (single seal), Type A (pusher seal) seal which uses a Plan 11 flush. According to this International Standard, this seal has:

- a) a fixed, carbon throttle bushing in the seal gland (7.1.2.1);
- b) fluoroelastomer secondary seals (6.1.6.5.1);
- c) multiple springs (4.1.3);
- d) carbon vs. self-sintered silicon carbide faces (6.1.6.2.2 and 6.1.6.2.3); and
- e) a single inlet (non-distributed) flush port (6.2.1.2.1).

EXAMPLE 2 C3A2C1152 is a Category 3, Arrangement 2 (unpressurized), Type C (stationary metal bellows) seal which utilizes Plan 11 and Plan 52 flush. By definition, in this International Standard the seal has:

- a) two flexible metal bellows mounted in series (4.1);
- b) a contacting, wet inner seal with a reverse balance capability (7.2.1.1);
- c) a liquid buffer-fluid and contacting containment seal (7.2.1.3);
- d) flexible graphite for secondary sealing elements (4.1.3);
- e) carbon vs. reaction-bonded silicon carbide faces (6.1.6.2.2 and 6.1.6.2.3);
- f) a distributed inlet flush system (6.2.3.2);
- g) a tangential buffer-fluid outlet (7.2.4.2); and
- h) 3/4 in buffer-fluid connections if the sleeve bore is over 63,5 mm (2,5 in), where practical (Table 1).

Annex E (normative)

Seal and pump vendor interface responsibilities

CATEGORY 1, 2 and 3 SEALS		
Subclause	Topic	Responsibility
5.1	Define who has unit responsibility	Joint
6.1.1.8	Provide axial movement capability of the seal	Seal vendor
6.1.2.2	Define who shall supply seal chamber	Joint
6.1.2.4	Define seal chamber type	Seal vendor
6.1.2.5	Define who shall supply seal chamber	Joint
6.1.2.8 b)	Advise if register fit is outside or inside	Pump vendor
6.1.2.9	Provide maximum allowable working pressure of pump	Pump vendor
6.1.2.12	Provide gland or seal chamber bolting size	Pump vendor
6.1.2.14	Provide seal chamber pressure	Pump vendor
6.1.2.17	Define size and location of tapped connections in gland	Joint
6.1.2.17	Advise pump vendor if connections are required on the pump seal chamber	Seal vendor
6.1.2.20	Define how seal chamber shall be vented	Joint
6.1.2.24	Define heating or cooling requirements for pump	Seal vendor
6.1.2.25, 6.1.2.26	Define who shall provide flush tap and port connections	Joint
6.1.3.2	Provide shaft diameter for seal mounting	Pump vendor
6.1.3.5	Define impeller end of shaft and any threads requiring clearance for O-rings, etc.	Pump vendor
6.1.3.11	Provide shaft hardness to ensure set screws will imbed in shaft	Pump vendor
6.1.3.12	Advise if drive collar requires more than nine set screws	Seal vendor
6.1.3.13	Advise if devices other than set screws are required to drive and locate the seal	Seal vendor
6.1.6.2.4	Advise if seal cannot be operated during pump test	Seal vendor
6.1.6.7.1, 6.1.6.8.1	Advise pump construction if alloy higher than AISI Type 316 stainless steel	Pump vendor
6.1.6.7.2, 6.1.6.8.2	Advise if spiral-wound gasket is required	Seal vendor
6.2.1.2.2	Provide mating dimensions for seal chamber face	Pump vendor

CATEGORY 2 and 3 SEALS		
Subclause	Topic	Responsibility
6.2.2.2.2	Provide mating dimensions for seal chamber face	Pump vendor
6.2.2.3.1	Supply shaft dimensions for seal mounting	Pump vendor
6.2.2.3.2	Key drive requirements to be defined	Seal vendor

ACCESSORIES		
8.1.1	Define seal flush, quench and cooling systems required	Seal vendor
8.1.4	Develop arrangement of equipment, piping and auxiliaries	Joint
8.1.11	Provide maximum allowable working pressure of pump casing	Pump vendor
8.1.12	Provide pump construction for alloy pumps	Pump vendor
8.6.1	Define means of circulating barrier/buffer fluid	Seal vendor
8.6.2.3	Provide seal chamber bore diameter	Pump vendor
8.6.2.4	Provide location of seal chamber port(s)	Pump vendor

INSPECTION, TESTING, AND PREPARATION FOR SHIPMENT		
10.3.5.1	Advise if seal shall have modified seal faces for pump test	Seal vendor
10.3.5.2	Advise if seal cannot be operated during pump test	Seal vendor

DATA TRANSFER		
11.1.1	Provide completed seal datasheet to pump manufacturer	Seal vendor
11.1.4	Define data requirements for seal	Seal vendor
11.2.2	Provide seal cross-sectional drawing to pump manufacturer	Seal vendor
11.3	Define who is supplying what data	Joint

Annex F (informative)

Heat generation and heat soak calculations

F.1 Estimation of seal-generated heat

F.1.1 General

While the calculation of the heat generated by a mechanical seal appears to be a simple matter, several assumptions must be made which introduce potentially large variations in the results. Two variables that are particularly suspect are K , the pressure drop coefficient, and f , the effective coefficient of friction.

K is a number between 0,0 and 1,0 which represents the pressure drop as the sealed fluid migrates across the seal faces. For flat seal faces (parallel fluid film) and a non-flashing fluid, K is approximately equal to 0,5. For convex seal faces (converging fluid film) or flashing fluids, K is greater than 0,5. For concave seal faces (diverging fluid film), K is less than 0,5. Physically, K is the coefficient which is used to quantify the amount of differential pressure across the seal faces which is transmitted into opening forces. The opening force is expressed by the following equation:

$$F_{\text{opening}} = A \times \Delta p \times K \quad (\text{F.1})$$

where

- F_{opening} is the opening force, expressed in newtons;
- A is the area of the seal face, expressed in square millimetres;
- Δp is the differential pressure, expressed in megapascals;
- K is the pressure drop coefficient, dimensionless.

For practical purposes, K varies between 0,5 and 0,8. As a standard practice for non-flashing fluids though, a value of 0,5 is selected for K . Although K is known to vary depending upon seal fluid properties (including multi-phase properties) and film characteristics (including thickness and coning), this value is selected as a benchmark for consistent calculation. The engineer must be aware that this assumption has been made.

The effective coefficient of dynamic friction, f , is a number that is similar to the standard coefficient term that most engineers are familiar with. The standard coefficient of friction term is used to represent the ratio of parallel forces to normal forces. This is normally applied to the interaction between two surfaces moving relatively. These surfaces may be of the same material or different materials.

In a mechanical seal, the two relatively-moving surfaces are the seal faces. If the seal faces were operating dry, it would be a simple matter to determine the coefficient of friction. In actual operation, the seal faces operate under various lubrication regimes, and various types of friction are present.

If there is significant asperity contact, f is highly dependent on the materials and less dependent on the fluid viscosity. If there is a very thin fluid film (only a few molecules thick), friction may depend upon interaction between the fluid and the seal faces. With a full fluid film, there is no mechanical contact between the faces and f is solely a function of viscous shear in the fluid film. All of these types of friction can be present at the same time on the same seal face.

An effective coefficient of friction is used to represent the gross effects of the interaction between the two sliding faces and the fluid film. Actual testing has shown that normal seals operate with f between about 0,01 and 0,18. For normal seal applications, we have selected a value of 0,07 for f . This is reasonably accurate for most water and medium hydrocarbon applications. Viscous fluids (such as oils) will have a higher value, while less viscous fluids (such as LPG or light hydrocarbons) can have a lower value.

The combination of the assumption of K and the assumption of f can lead to a significant deviation between calculated heat generation results and actual results. Therefore, the engineer must keep in mind that these calculations are useful only as an order-of-magnitude approximation of the expected results. These results shall never be stated as a guarantee of performance.

F.1.2 Calculation method

Required inputs:

D_o is the seal face contact outer diameter, expressed in millimetres;

D_i is the seal face contact inner diameter, expressed in millimetres;

D_b is the effective seal balance diameter, expressed in millimetres;

F_{sp} is the spring force at working length, expressed in newtons;

Δp is the pressure across the seal face, expressed in megapascals;

n is the face rotational speed, expressed in revolutions per minute;

f is the coefficient of friction (assume 0,07);

K is the pressure drop coefficient (assume 0,5).

F.1.3 Formulas

F.1.3.1 Face area, A

$$A = \frac{\pi(D_o^2 - D_i^2)}{4} \quad (F.2)$$

F.1.3.2 Seal balance ratio, B

$$B = \left(\frac{D_o^2 - D_b^2}{D_o^2 - D_i^2} \right) \quad (F.3)$$

F.1.3.3 Spring pressure, p_{sp}

$$p_{sp} = \frac{F_{sp}}{A} \quad (F.4)$$

F.1.3.4 Total face pressure, p_{tot}

$$p_{tot} = \Delta p(B - K) + p_{sp} \quad (F.5)$$

F.1.3.5 Mean face diameter, D_m

$$D_m = \frac{(D_o + D_i)}{2} \quad (\text{F.6})$$

F.1.3.6 Running torque, T_r

$$T_r = p_{\text{tot}} \times A \times f \left(\frac{D_m}{2\,000} \right) \quad (\text{F.7})$$

F.1.3.7 Starting torque, T_s , estimated at 3 to 5 times running torque

$$T_s = T_r \times 4 \quad (\text{F.8})$$

F.1.3.8 Power, P

$$P = \frac{(T_r \times N)}{9\,550} \quad (\text{F.9})$$

F.1.4 Example of calculation**F.1.4.1 Application**

Fluid: Water

Pressure: 2 MPa (20 bar)

Speed: 3 000 r/min

Inputs:

$$D_o = 61,6 \text{ mm}$$

$$D_i = 48,9 \text{ mm}$$

$$D_b = 52,4 \text{ mm}$$

$$F_{\text{sp}} = 190 \text{ N}$$

$$\Delta p = 2 \text{ MPa (20 bar)}$$

$$n = 3\,000 \text{ r/min}$$

$$f = 0,07$$

$$K = 0,5$$

Equation (F.2) gives:

$$A = \left(\frac{\pi}{4} \right) \times (61,6^2 - 49,9^2) = 1\,102 \text{ mm}^2$$

Equation (F.3) gives:

$$B = \frac{(61,6^2 - 52,4^2)}{(61,6^2 - 48,9^2)} = 0,746$$

Equation (F.4) gives:

$$p_{sp} = \left(\frac{190}{1\,102} \right) = 0,172 \text{ N/mm}^2$$

Equation (F.5) gives:

$$p_{tot} = 2(0,746 - 0,5) + 0,172 = 0,664 \text{ N/mm}^2$$

Equation (F.6) gives:

$$D_m = \frac{(61,6 + 48,9)}{2} = 55,25 \text{ mm}$$

Equation (F.7) gives:

$$T_r = 0,664 \times 1\,102 \times 0,07 \left(\frac{55,25}{2\,000} \right) = 1,42 \text{ N} \cdot \text{m}$$

Equation (F.8) gives:

$$T_s = 1,42 \times 4 = 5,68 \text{ N} \cdot \text{m}$$

Equation (F.9) gives:

$$P = \frac{(1,42 \times 3\,000)}{9\,550} = 0,446 \text{ kW}$$

F.2 Temperature rise in the seal chamber

F.2.1 General

The steady-state temperature of the fluid in the seal chamber is a function of a simple thermodynamic balance. The heat flow into the seal chamber fluid minus the heat flow out of the seal chamber yields a net heat flow. The fluid temperature will either increase or decrease depending upon whether the net heat flow is positive or negative. This is deceptively simple. In actual applications, the heat flows into and out of the seal chamber fluids are extremely complex.

There are several sources of heat flow into the fluid. These include heat generated due to friction and fluid shear at the seal faces, heat generated due to windage (or turbulence) caused by the rotating seal components, and heat conducted from the pump through the seal chamber and shaft (or positive heat soak). There are also several sources of heat flow out of the seal chamber. These include heat conducted back into the pump through the seal chamber or shaft (or negative heat soak) and heat lost to the atmosphere through convection and radiation.

In some cases, assumptions can be made which simplify the model. For example, consider a single seal with Piping Plan 11, 12, 13, or 31. With these piping plans, the fluid injected into the seal chamber will be at pump

temperature and heat soak can be ignored. Unless the pump is at a very high temperature, heat loss to the atmosphere can also be ignored. Except in the case of large seals at high speeds, heat generation due to windage is usually insignificant and can be ignored. The increase in temperature can then be calculated if the following variables are known:

Q is the heat generation at the seal faces, expressed in kilowatts;

q_{inj} is the injection flowrate, expressed in litres per minute;

d is the relative density (specific gravity) of the injected fluid at pump temperature;

c_p is the specific heat capacity of the injected fluid at pump temperature, expressed in joules per kilogram kelvin.

The differential temperature, ΔT (in kelvin), can be calculated by the following equation:

$$\Delta T = \frac{(60\,000 \times Q)}{(d \times q_{inj} \times c_p)} \quad (F.10)$$

In applications that use a piping Plan 21, 22, 32, or 41, the fluid injected into the seal chamber may be at a significantly lower temperature than the pump temperature. If this is the case, there can be a significant heat flow or heat soak into the seal chamber from the pump. The calculation of heat soak is a complex matter, requiring detailed analysis or testing and a thorough knowledge of the specific pump construction and pumped product properties. If this data is not available, the heat soak [$Q_{heatsoak}$ (kW)] can be estimated by the equation:

$$Q_{heatsoak} = U \times A \times D_b \times \Delta T \quad (F.11)$$

where

U is the material property coefficient;

A is the heat transfer area;

D_b is the seal balance diameter, expressed in millimetres;

ΔT is the difference between pump temperature and desired seal chamber temperature, expressed in kelvin.

A typical value for ($U \times A$) which can be used for estimating purposes with stainless steel sleeve and gland construction and steel pump construction is 0,000 25. This value will generally provide a conservative estimate of heat soak.

F.2.2 Example of estimation of $Q_{heatsoak}$

$$U \times A = 0,000\,25$$

$$D_b = 55 \text{ mm (seal balance diameter)}$$

$$\text{pump temperature} = 175\,^{\circ}\text{C}$$

$$\text{desired seal chamber temperature} = 65\,^{\circ}\text{C}$$

$$\Delta T = 175 - 65 = 110 \text{ K}$$

$$Q_{heatsoak} = 0,000\,25 \times 55 \times 110 = 1,5 \text{ kW}$$

If the heat soak is known, the temperature rise (ΔT , in kelvin) can be calculated by the following equation:

$$\Delta T = 60\,000 \times \frac{(Q + Q_{\text{heatsoak}})}{(d \times q_{\text{inj}} \times c_p)} \quad (\text{F.12})$$

In the previous equations, the temperature rise is the average temperature rise of the fluid in the seal chamber. Within the seal chamber, there are areas that are much hotter and much cooler than the sealing chamber fluid temperature. An efficient seal injection is required to ensure that the area around the seal face is effectively cooled. For example, the injection should be directed at the sealing interface, or multiport injection may be used.

In some applications, it is necessary to specify the amount of injection required to maintain the seal chamber temperature below a certain level. In this case, the maximum allowable temperature rise would be calculated by subtracting the maximum allowable temperature in the seal chamber from the injection temperature. For good seal performance, the maximum temperature rise should be maintained at 2,8 K to 5,6 K. It is then a simple matter of rearranging Equations (F.10), (F.11) and (F.12) to solve for the injection flowrate.

For Piping Plan 11, 12, 13, or 31, the equation would be:

$$q_{\text{inj}} = \frac{(60\,000 \times Q)}{(d \times \Delta T \times c_p)} \quad (\text{F.13})$$

For Piping Plan 21, 22, 32, or 41, the equation would be:

$$q_{\text{inj}} = 60\,000 \times \frac{(Q + Q_{\text{heatsoak}})}{(d \times \Delta T \times c_p)} \quad (\text{F.14})$$

The temperature rise used in these calculations is the sealing chamber temperature rise. The temperature rise at the seal faces will be greater than the chamber temperature rise. If Equations (F.13) and (F.14) are used to calculate a minimum flowrate based on sealing chamber temperature, the seal faces can overheat and perform poorly. A design factor of at least two should be applied to the flowrate. The injection must also be directed at the seal interface to ensure proper cooling.

F.2.3 Example of calculation of ΔT

F.2.3.1 Given

$$Q = 0,9 \text{ kW}$$

$$q_{\text{inj}} = 11 \text{ l/min}$$

$$d = 0,75$$

$$c_p = 2\,300 \text{ J/kg} \cdot \text{K}$$

F.2.3.2 Calculation

Equation (F.10) gives:

$$\begin{aligned} \Delta T &= \frac{(60\,000 \times 0,9)}{(0,75 \times 11 \times 2\,300)} \\ &= 2,8 \text{ K} \end{aligned}$$

F.2.4 Example of calculation of q_{inj} **F.2.4.1 Given**

$$Q = 0,9 \text{ kW}$$

$$\Delta T_{\max} = 5 \text{ K}$$

$$d = 0,90$$

$$c_p = 2\,593 \text{ J/kg}\cdot\text{K}$$

F.2.4.2 Calculation

Equation (F.13) gives:

$$q_{inj} = \frac{(60\,000 \times 0,9)}{(0,9 \times 5 \times 2\,593)}$$

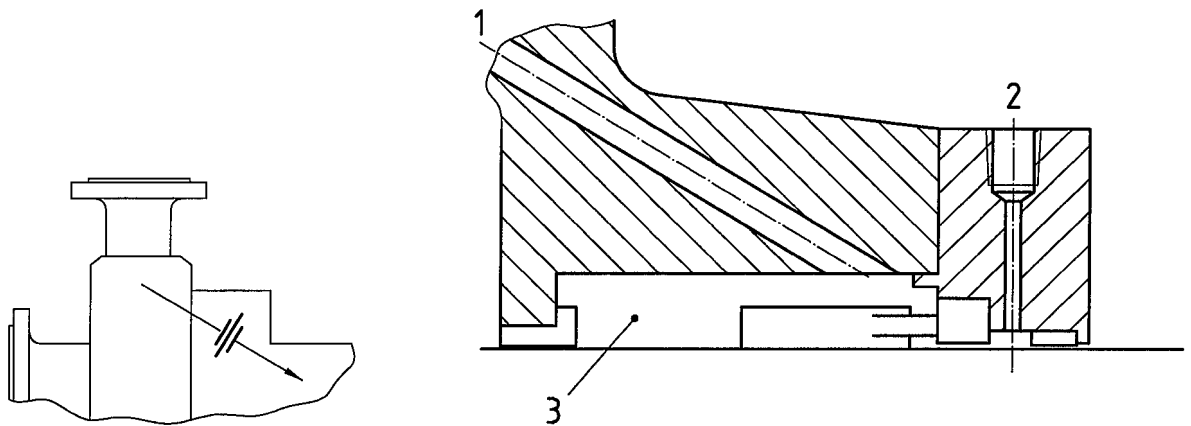
$$= 4,6 \text{ l/min}$$

With a design factor of two, the minimum injection flowrate should be 9,2 l/min.

Annex G (normative)

Standard flush plans and auxiliary hardware

This annex contains drawings (Figures G.1 to G.31) of standard flush plans and auxiliary hardware which have been used in industry. While not all of these plans are referenced in this International Standard, they may have applications in special cases with purchaser approval.



a) Piping and instrumentation schematic

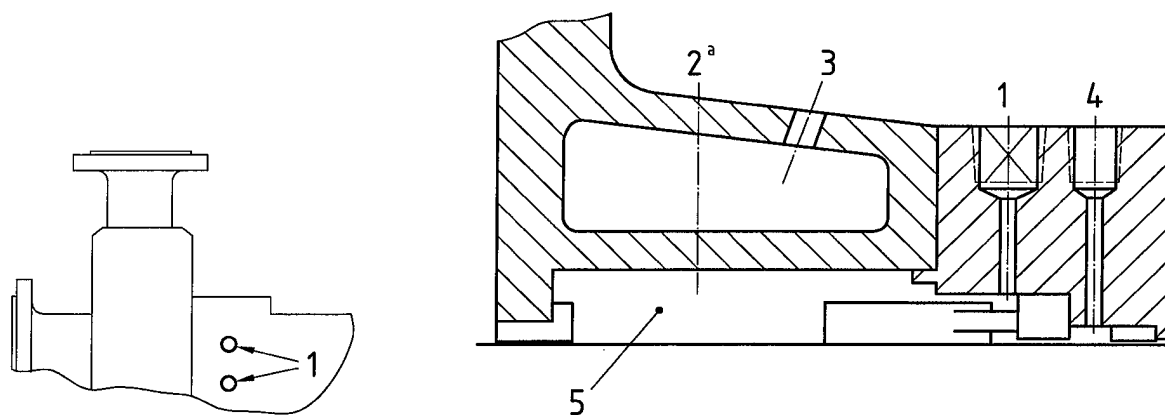
b) Seal chamber details

Key

- 1 inlet
- 2 quench/drain (Q/D)
- 3 seal chamber

Integral (internal) recirculation is from pump discharge to seal. Recommended for clean pumpage only. Care shall be taken to ensure that integral recirculation is sufficient to maintain stable face conditions.

Figure G.1 — Standard seal flush plan 01



a) Piping and instrumentation schematic

b) Seal chamber details

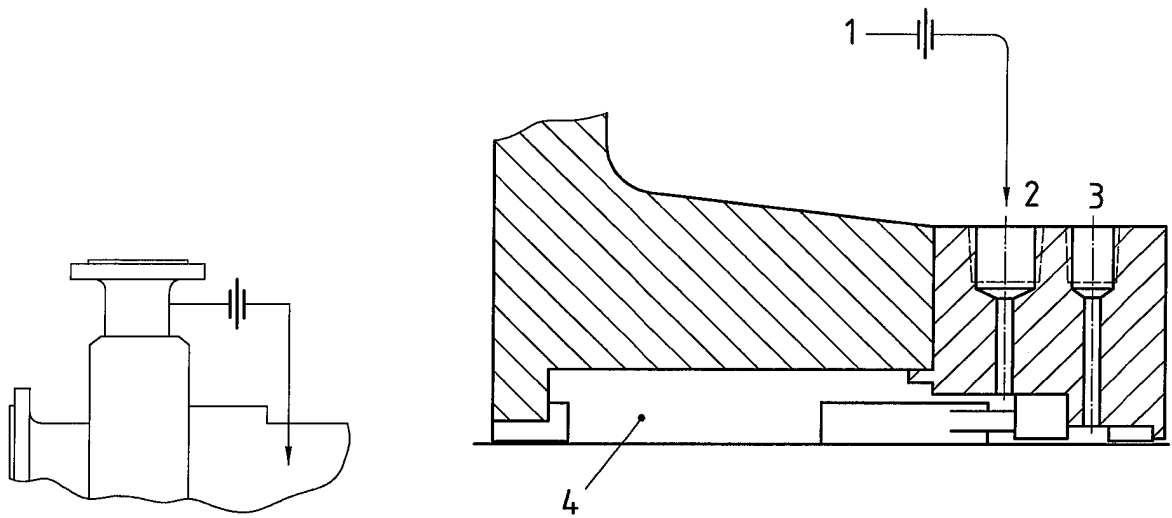
Key

- 1 plugged connections for possible future circulating fluid
- 2 vent (V), if required
- 3 heating/cooling inlet (HI or CI), heating/cooling outlet (HO or CO)
- 4 quench/drain (Q/D)
- 5 seal chamber

Dead-ended seal chamber with no recirculation of flushed fluid.

^a Self-venting arrangements preferred on horizontal pumps (see 6.1.2.20).

Figure G.2 — Standard seal flush plan 02



a) Piping and instrumentation schematic

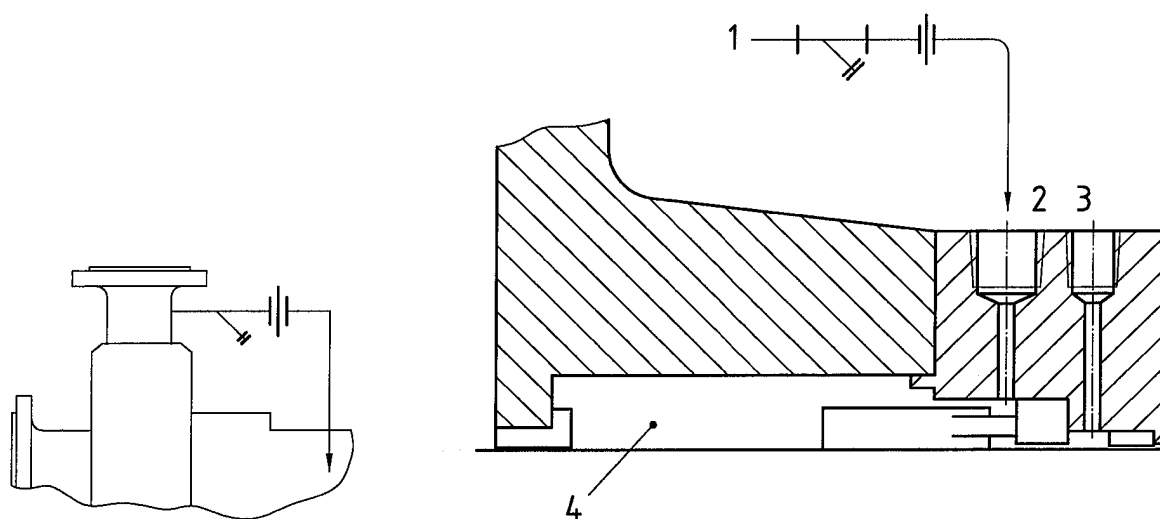
b) Seal chamber details

Key

- 1 from pump discharge
- 2 flush (F)
- 3 quench/drain (Q/D)
- 4 seal chamber

Recirculation from pump discharge through a flow control orifice to the seal. The flow enters the seal chamber adjacent to the mechanical seal faces, flushes the faces, and flows across the seal back into the pump.

Figure G.3 — Standard seal flush plan 11



a) Piping and instrumentation schematic

b) Seal chamber details

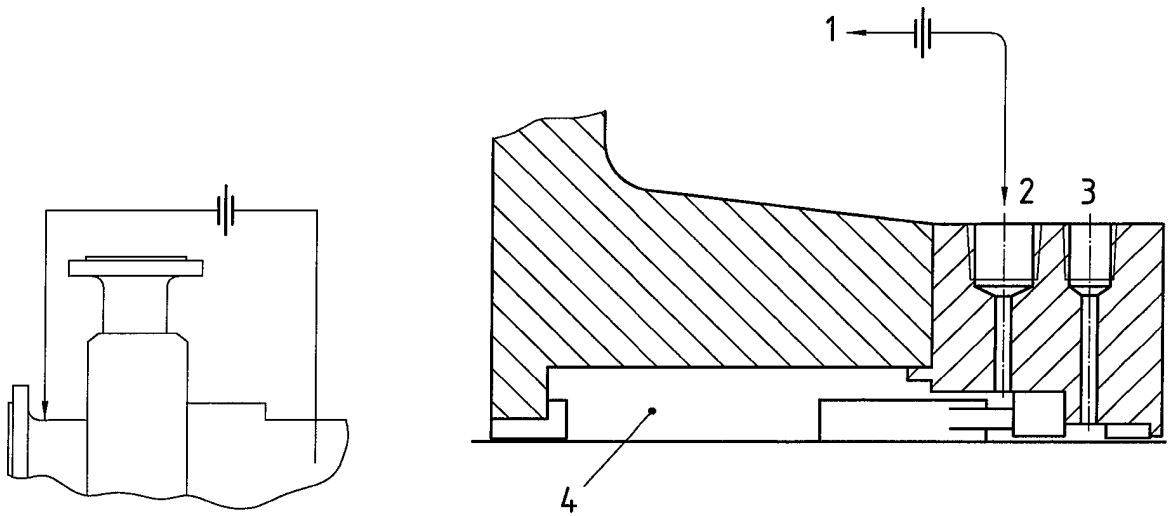
Key

- 1 from pump discharge
- 2 flush (F)
- 3 quench/drain (Q/D)
- 4 seal chamber

Recirculation from pump discharge through a strainer and flow control orifice to the seal. This plan is similar to Plan 11 but with the addition of a strainer to remove occasional particles. Strainers are not normally recommended because blockage of the strainer will cause seal failure.

NOTE This plan has not been proven to achieve a 3-year operating life.

Figure G.4 — Standard seal flush plan 12



a) Piping and instrumentation schematic

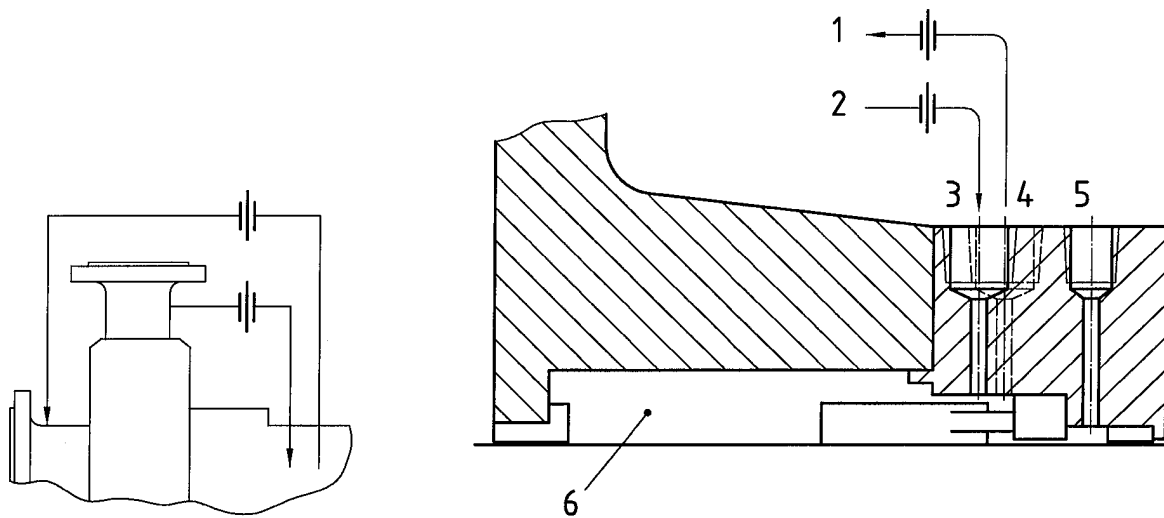
b) Seal chamber details

Key

- 1 to pump suction
- 2 flush (F)
- 3 quench/drain (Q/D)
- 4 seal chamber

Recirculation from pump seal chamber through a flow control orifice and back to the pump suction.

Figure G.5 — Standard seal flush plan 13



a) Piping and instrumentation schematic

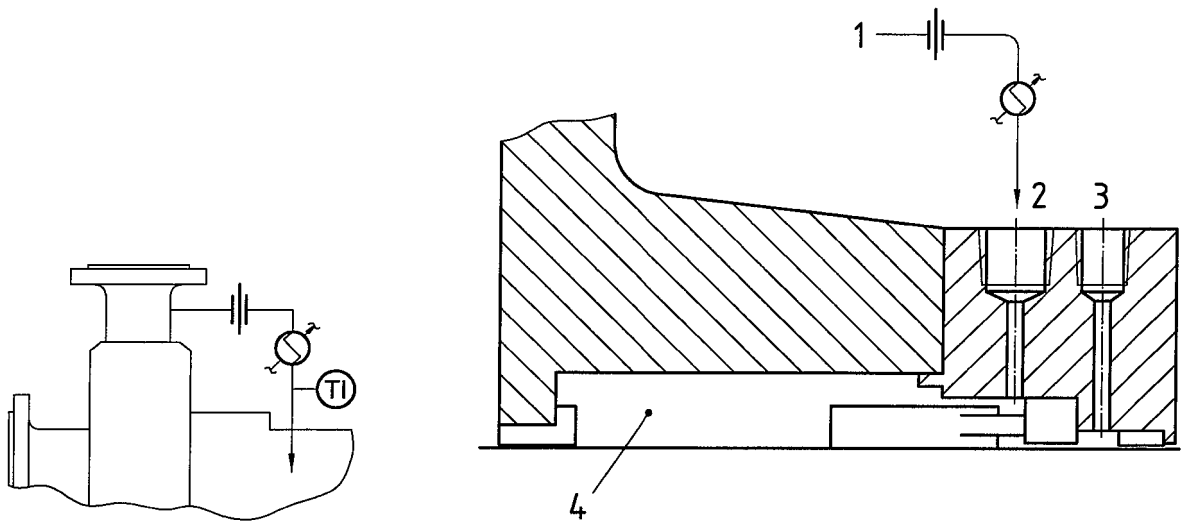
b) Seal chamber details

Key

- 1 to pump suction
- 2 from pump discharge
- 3 flush inlet (FI)
- 4 flush outlet (FO)
- 5 quench/drain (Q/D)
- 6 seal chamber

Recirculation from pump discharge through a flow control orifice to the seal and simultaneously from the seal chamber through a control orifice (if required) to pump suction. This allows fluid to enter the seal chamber and provide cooling while continually venting and reducing the pressure in the seal chamber. Plan 14 is a combination of Plan 11 and Plan 13.

Figure G.6 — Standard seal flush plan 14



a) Piping and instrumentation schematic

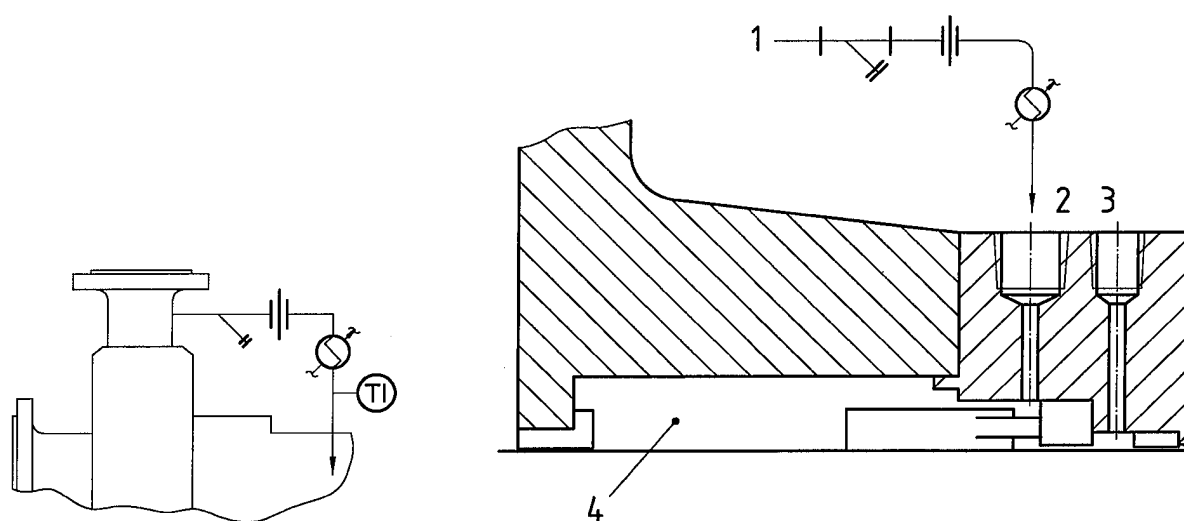
b) Seal chamber details

Key

- 1 from pump discharge
- 2 flush (F)
- 3 quench/drain (Q/D)
- 4 seal chamber
- TI temperature indicator

Recirculation from pump discharge through a flow control orifice and cooler, then into the seal chamber.

Figure G.7 — Standard seal flush plan 21



a) Piping and instrumentation schematic

b) Seal chamber details

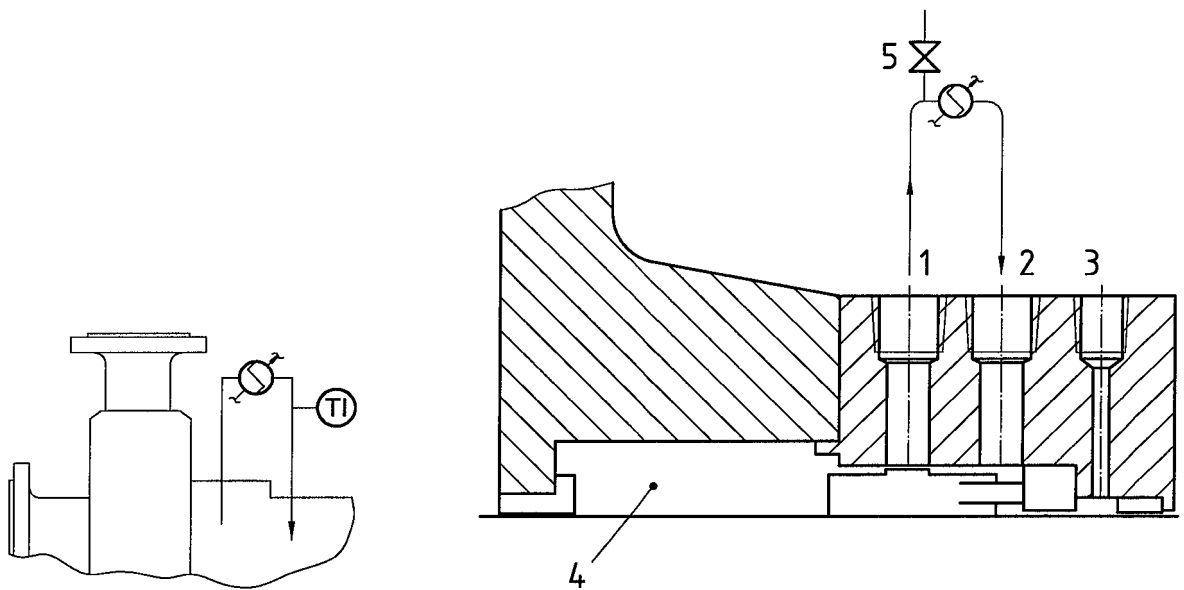
Key

- 1 from pump discharge
- 2 flush (F)
- 3 quench/drain (Q/D)
- 4 seal chamber
- TI temperature indicator

Recirculation from the pump discharge through a strainer, a flow control orifice, and a cooler and into the seal chamber. Strainers are not normally recommended because blockage of the strainer will cause seal failure.

NOTE This plan has not been proven to achieve a 3-year operating life.

Figure G.8 — Standard seal flush plan 22



a) Piping and instrumentation schematic

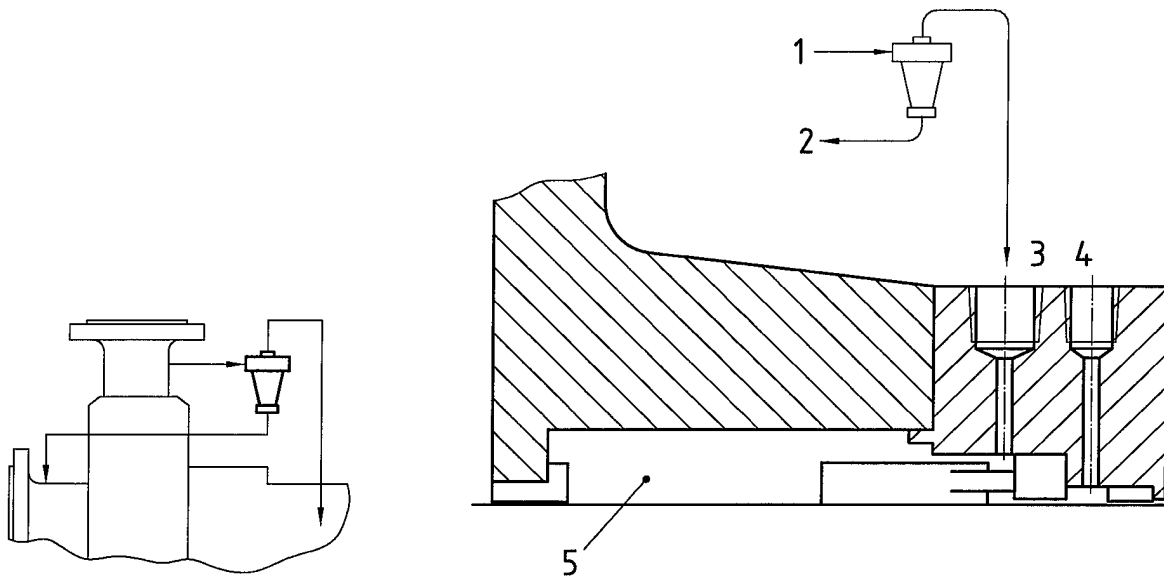
b) Seal chamber details

Key

- 1 flush outlet (FO)
- 2 flush inlet (FI)
- 3 quench/drain (Q/D)
- 4 seal chamber
- 5 vent
- TI temperature indicator

Recirculation from a pumping ring in the seal chamber through a cooler and back into the seal chamber. This plan can be used on hot applications to minimize the heat load on the cooler by cooling only the small amount of liquid that is recirculated.

Figure G.9 — Standard seal flush plan 23



a) Piping and instrumentation schematic

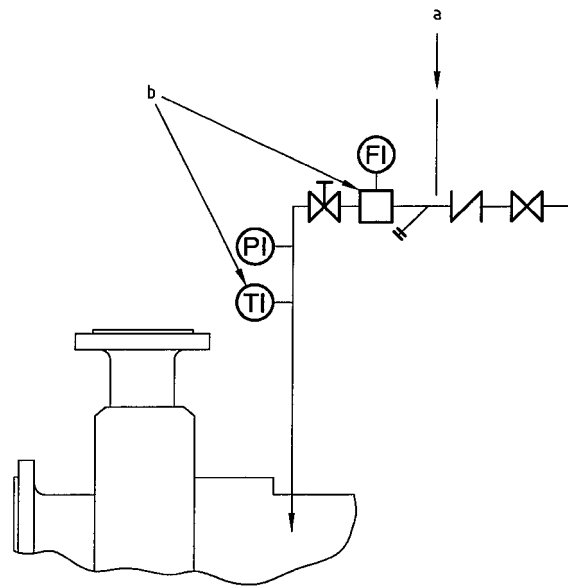
b) Seal chamber details

Key

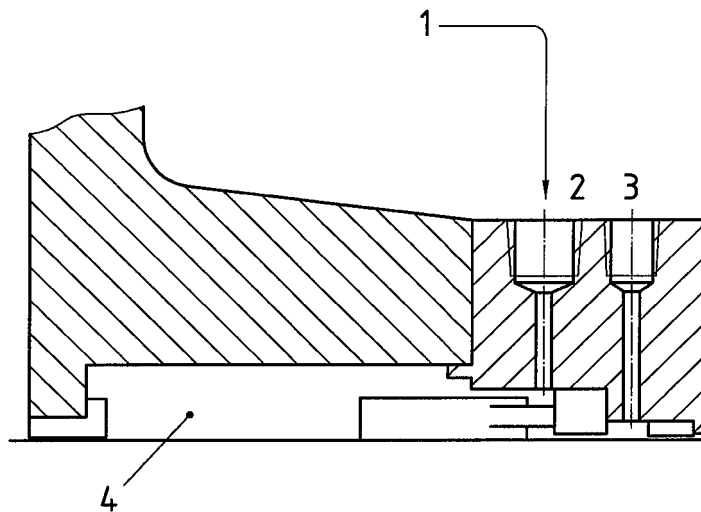
- 1 from pump discharge
- 2 to pump suction
- 3 flush (F)
- 4 quench/drain (Q/D)
- 5 seal chamber

Recirculation from pump discharge through a cyclone separator delivering the clean fluid to the seal chamber. The solids are delivered to the pump suction line.

Figure G.10 — Standard seal flush plan 31



a) Piping and instrumentation schematic



b) Seal chamber details

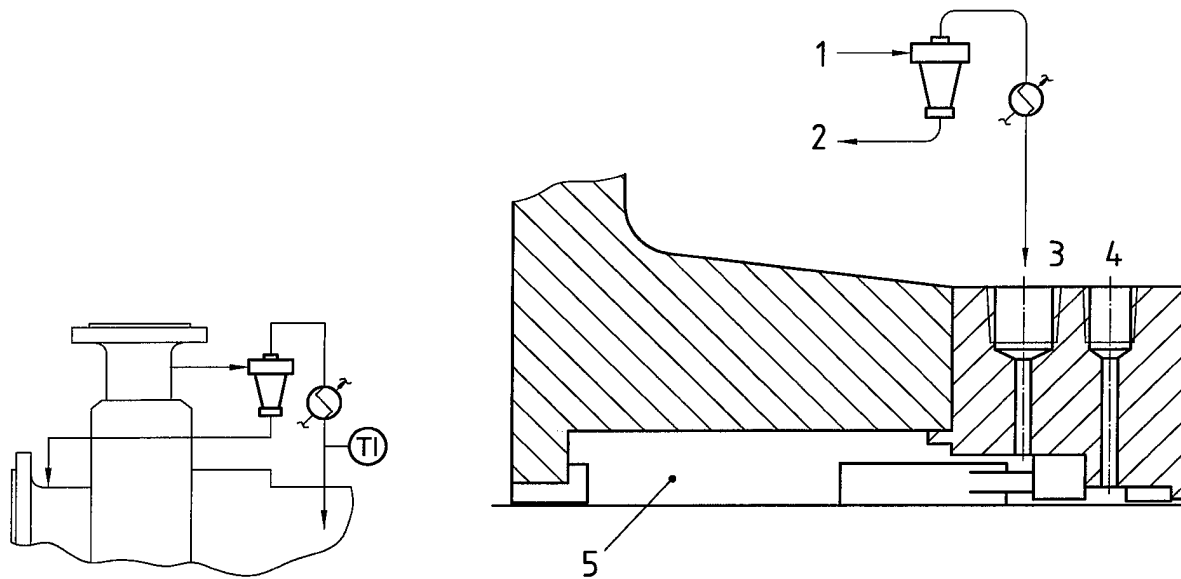
Key

- 1 from external source
- 2 flush (F)
- 3 quench/drain (Q/D)
- 4 seal chamber
- FI flow indicator
- PI pressure indicator
- TI temperature indicator

Flush is injected into the seal chamber from an external source. Care must be exercised in choosing a proper source of seal flush to eliminate potential for vaporization of the injected fluid and to avoid contamination of the fluid being pumped with the injected flush.

- ^a Items to the left of this line shall be supplied by the vendor; items to the right are the responsibility of the purchaser.
- ^b Optional.

Figure G.11 — Standard seal flush plan 32



a) Piping and instrumentation schematic

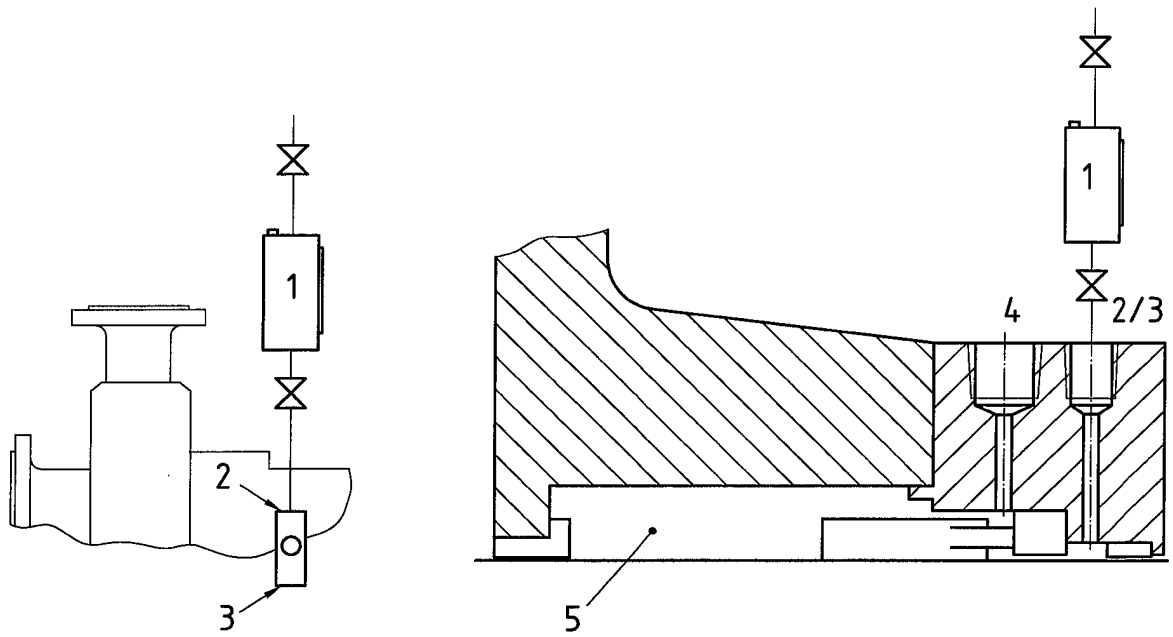
b) Seal chamber details

Key

- 1 from pump discharge
- 2 to pump suction
- 3 flush (F)
- 4 quench/drain (Q/D)
- 5 seal chamber
- TI temperature indicator

Recirculation from pump discharge through a cyclone separator delivering the clean fluid to a seal cooler and then to the seal chamber. The solids are delivered to the pump suction line.

Figure G.12 — Standard seal flush plan 41



a) Piping and instrumentation schematic

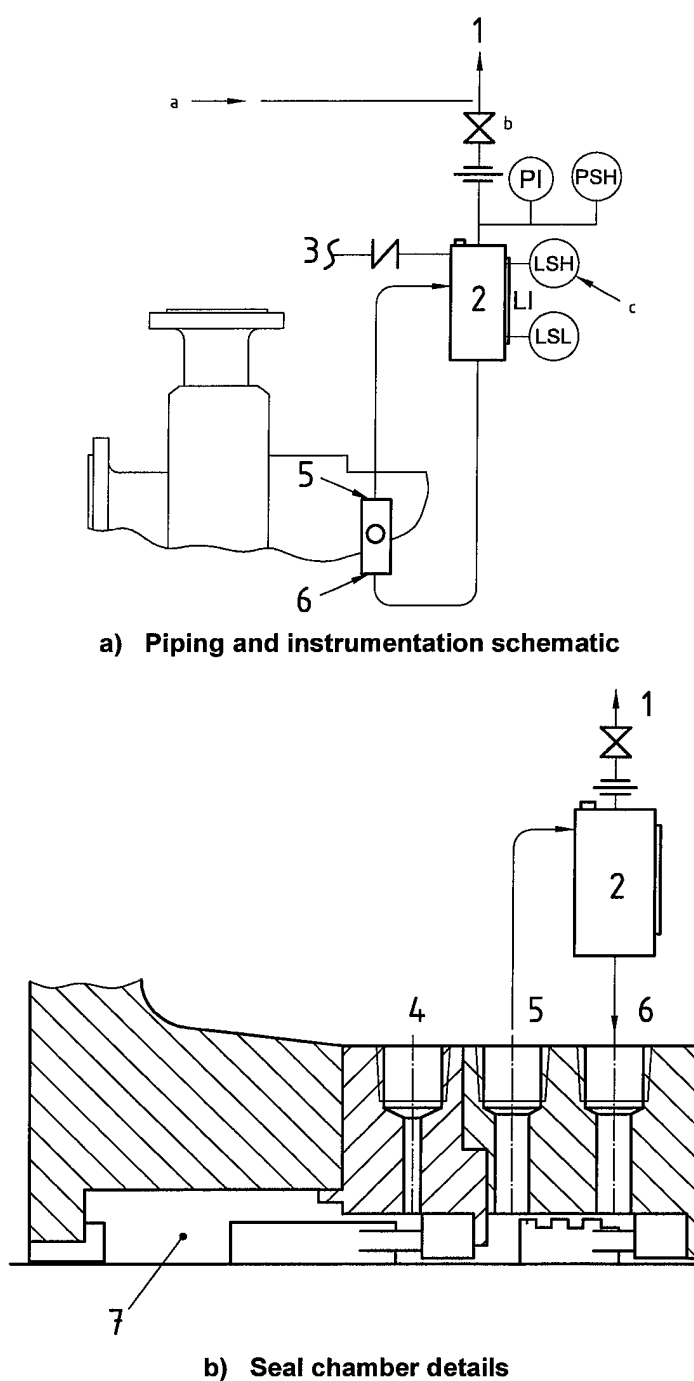
b) Seal chamber details

Key

- 1 reservoir
- 2 quench (Q)
- 3 drain (D), plugged
- 4 flush (F)
- 5 seal chamber

External reservoir providing a dead-ended blanket for fluid to the quench connection of the gland.

Figure G.13 — Standard seal flush plan 51



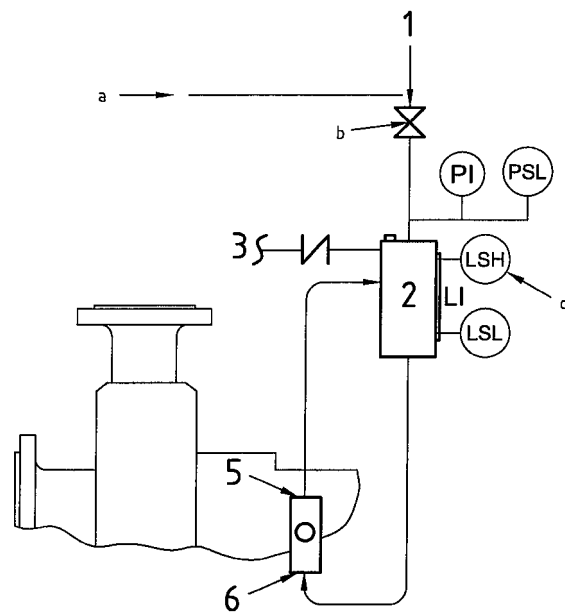
Key

1 to collection system	5 liquid buffer outlet (LBO)	LSH level switch high	PI pressure indicator
2 reservoir	6 liquid buffer inlet (LBI)	LSL level switch low	PSH pressure switch high
3 make-up buffer fluid	7 seal chamber	LI level indicator	
4 flush (F)			

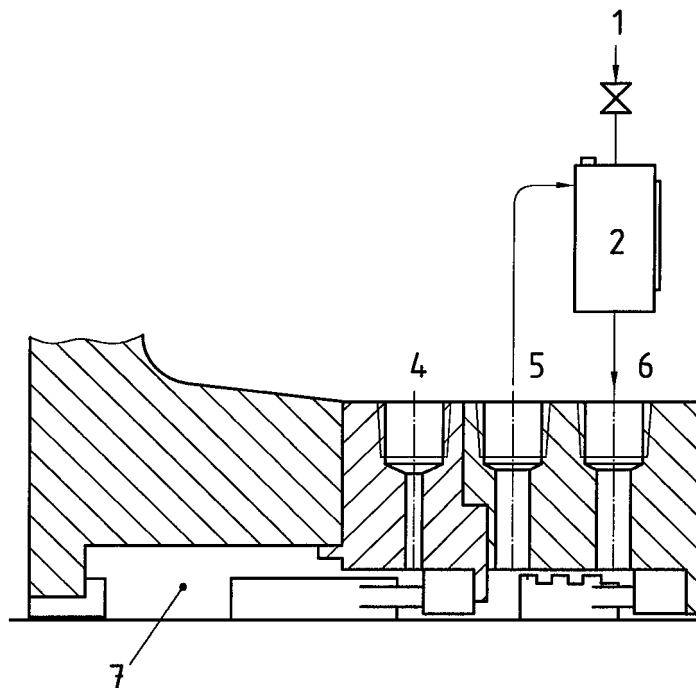
External reservoir providing buffer liquid for the outer seal of an Arrangement 2 seal. During normal operation, circulation is maintained by an internal pumping ring. The reservoir is usually continuously vented to a vapour recovery system and is maintained at a pressure less than the pressure in the seal chamber.

- ^a Items above this line are the responsibility of the purchaser; items below this line shall be supplied by the vendor.
- ^b Normally open.
- ^c If specified.

Figure G.14 — Standard seal flush plan 52



a) Piping and instrumentation schematic



b) Seal chamber details

Key

1 from external pressure source	5 liquid barrier outlet (LBO)	LSH level switch high	PI pressure indicator
2 reservoir	6 liquid barrier inlet (LBI)	LSL level switch low	PSL pressure switch low
3 make-up barrier fluid	7 seal chamber	LI level indicator	
4 flush (F)			

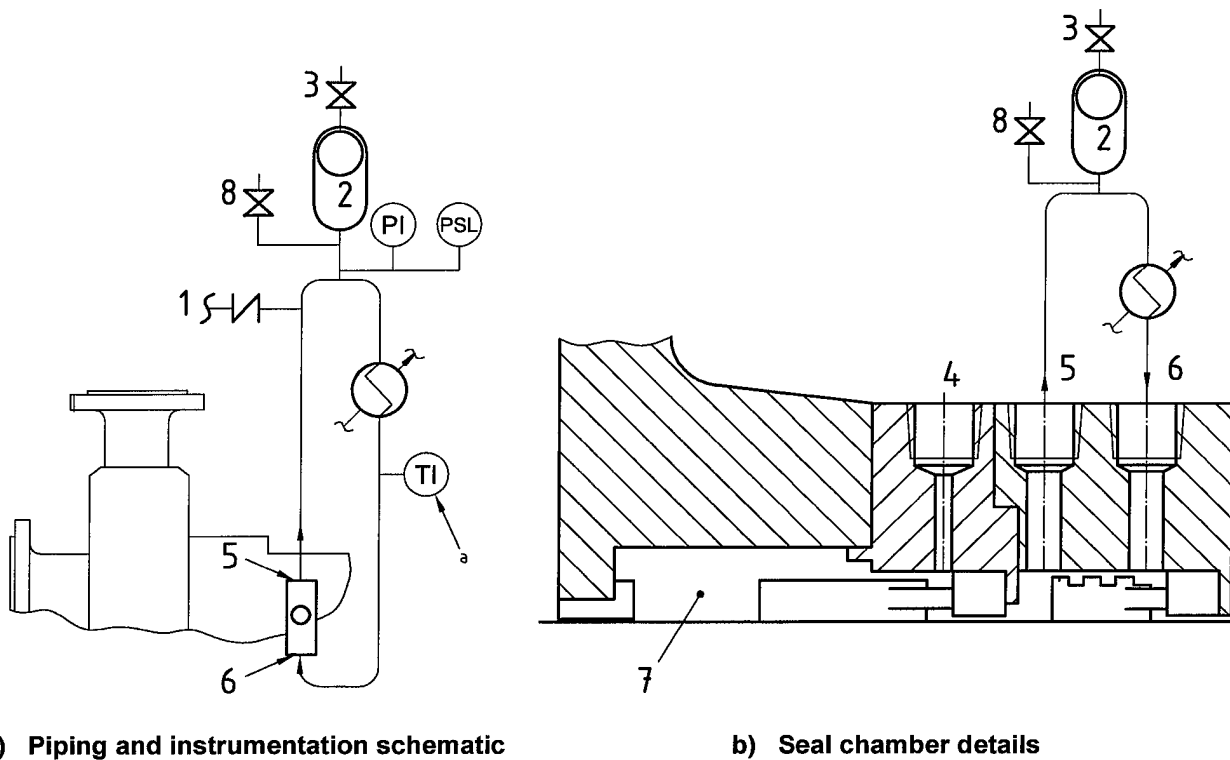
Pressurized external barrier fluid reservoir supplying clean fluid to the seal chamber. Circulation is by an internal pumping ring. Reservoir pressure is greater than the process pressure being sealed. This plan is used with an Arrangement 3 seal.

^a Items above this line are the responsibility of the purchaser; items below this line shall be supplied by the vendor.

^b Normally open.

^c If specified.

Figure G.15 — Standard seal flush plan 53A



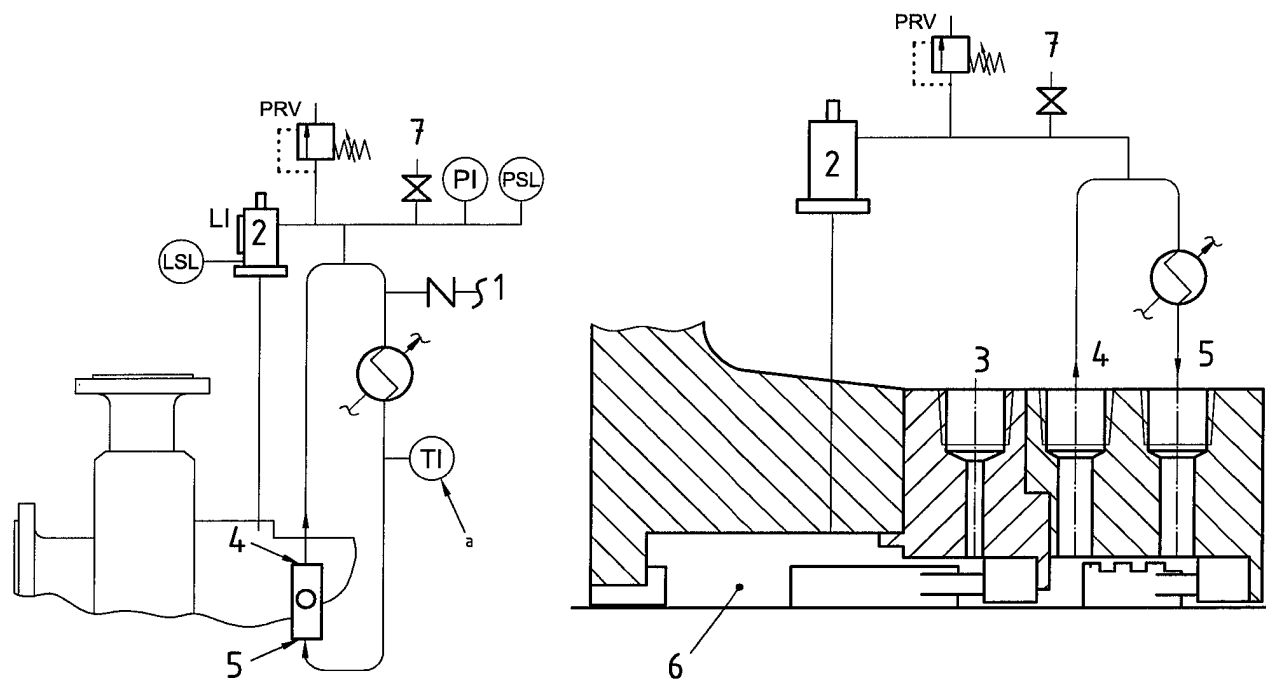
Key

- 1 make-up barrier fluid
- 2 bladder accumulator
- 3 bladder charge connection
- 4 flush (F)
- 5 liquid barrier outlet (LBO)
- 6 liquid barrier inlet (LBI)
- 7 seal chamber
- 8 vent
- PI pressure indicator
- PSL pressure switch low
- TI temperature indicator

External piping provides fluid for the outer seal of a pressurized dual seal arrangement. Pre-pressurized bladder accumulator provides pressure to the circulation system. Flow is maintained by an internal pumping ring. Heat is removed from the circulation system by an air-cooled or water-cooled heat exchanger. This plan is used with an Arrangement 3 seal.

^a If specified.

Figure G.16 — Standard seal flush plan 53B



a) Piping and instrumentation schematic

b) Seal chamber details

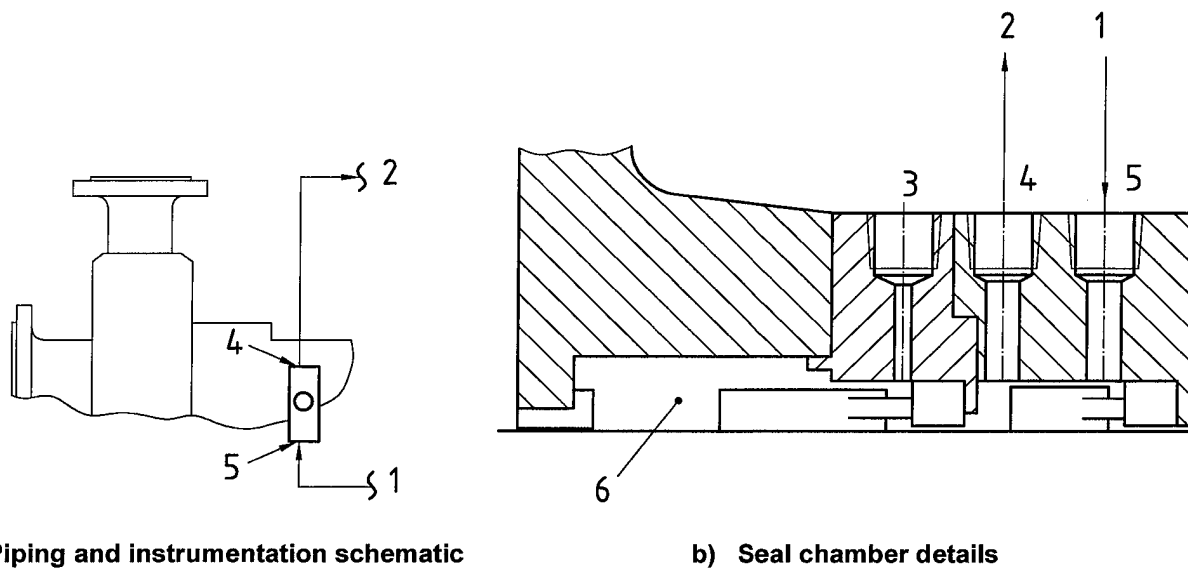
Key

- 1 make-up barrier fluid
- 2 piston accumulator
- 3 flush (F)
- 4 liquid barrier outlet (LBO)
- 5 liquid barrier inlet (LBI)
- 6 seal chamber
- 7 vent
- LI level indicator
- LSL level switch low
- PI pressure indicator
- PRV pressure relief valve
- PSL pressure switch low
- TI temperature indicator

External piping provides fluid for the outer seal of a pressurized dual seal arrangement. Reference line from the seal chamber to a piston accumulator provides pressure to the circulation system. Flow is maintained by an internal pumping ring. Heat is removed from the circulation system by an air-cooled or water-cooled heat exchanger.

^a If specified.

Figure G.17 — Standard seal flush plan 53C

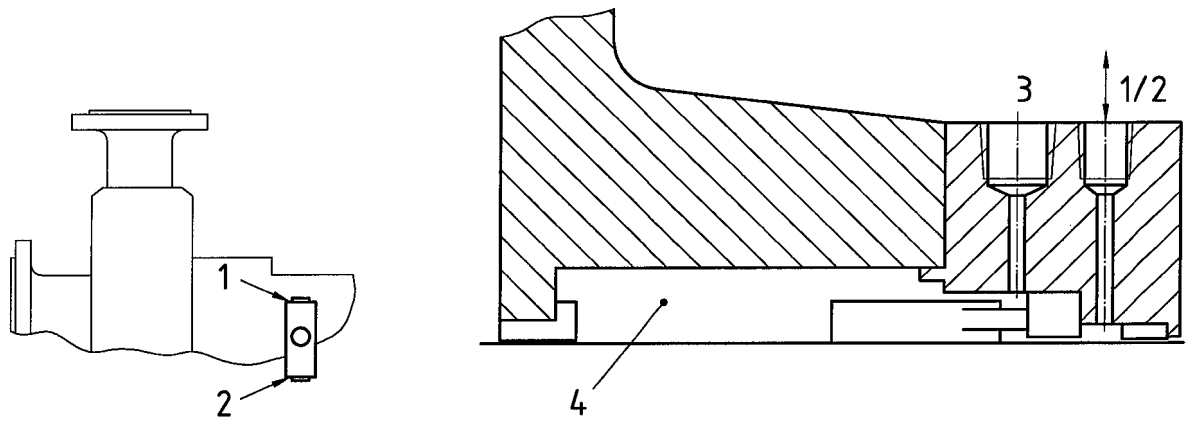


Key

- 1 from external source
- 2 to external source
- 3 flush (F)
- 4 liquid barrier outlet (LBO)
- 5 liquid barrier inlet (LBI)
- 6 seal chamber

Pressurized external barrier fluid reservoir or system supplying clean fluid to the seal chamber. Circulation is by an external pump or pressure system. Reservoir pressure is greater than the process pressure being sealed. This plan is used with an Arrangement 3 seal.

Figure G.18 — Standard seal flush plan 54



a) Piping and instrumentation schematic

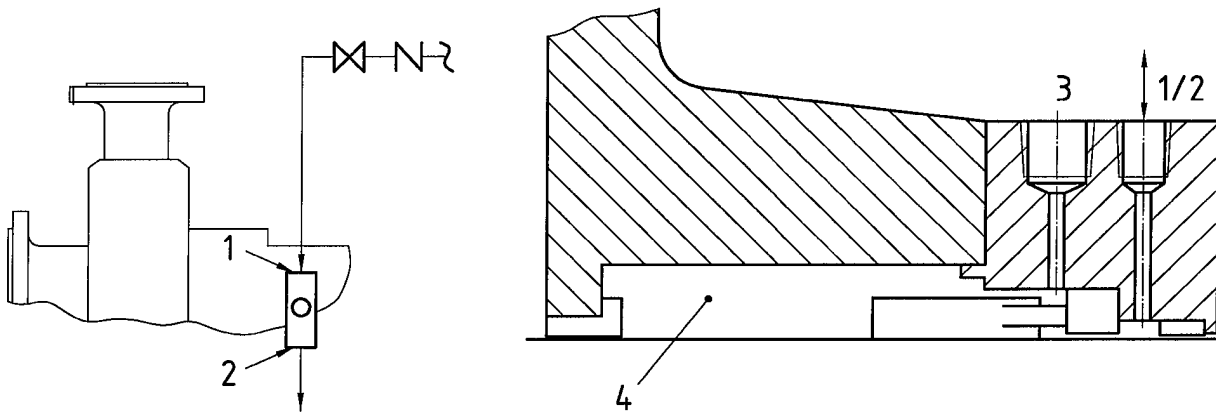
b) Seal chamber details

Key

- 1 quench (Q), plugged
- 2 drain (D), plugged
- 3 flush (F)
- 4 seal chamber

Tapped and plugged connections for the purchaser's use. Typically this plan is used when the purchaser is to provide fluid (such as steam, gas, or water) to an external sealing device.

Figure G.19 — Standard seal flush plan 61



a) Piping and instrumentation schematic

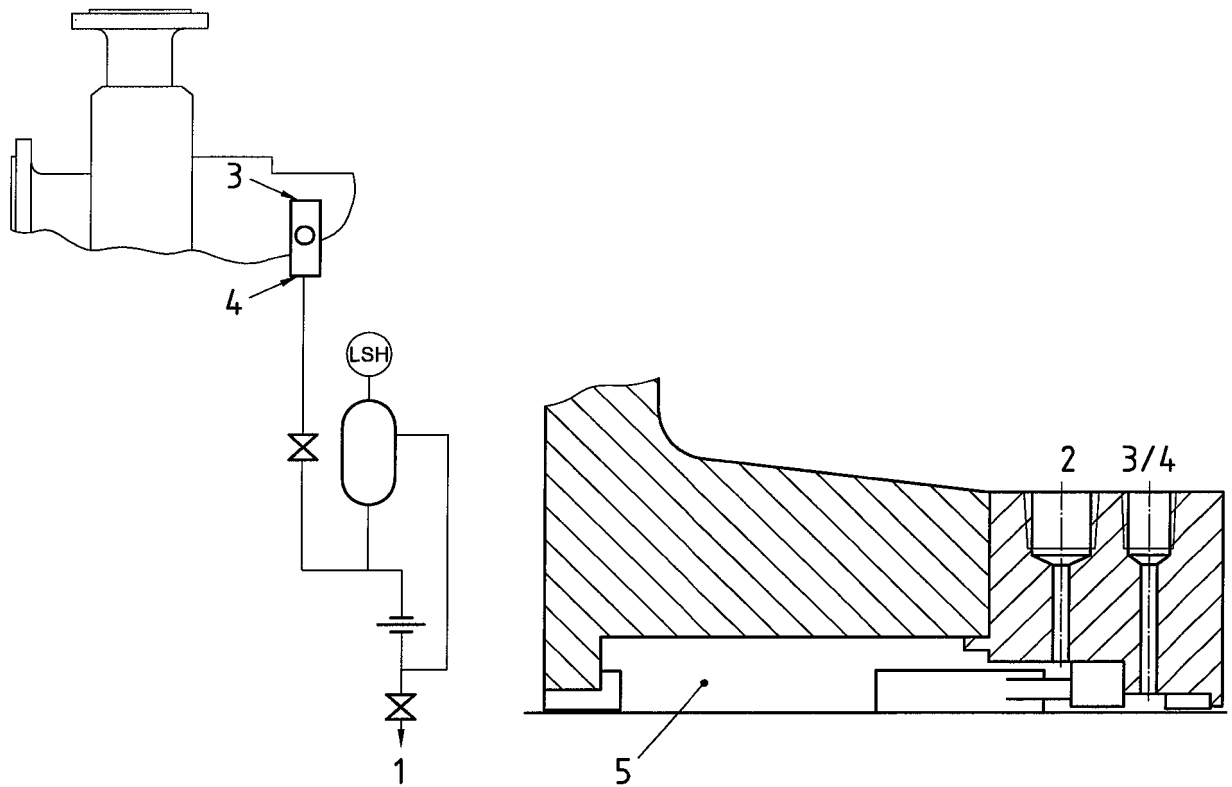
b) Seal chamber details

Key

- 1 quench (Q)
- 2 drain (D)
- 3 flush (F)
- 4 seal chamber

Exterior source providing a quench. The quench may be required to prevent solids from accumulating on the atmospheric side of the seal. Typically used with a close-clearance throttle bushing.

Figure G.20 — Standard seal flush plan 62



a) Piping and instrumentation schematic

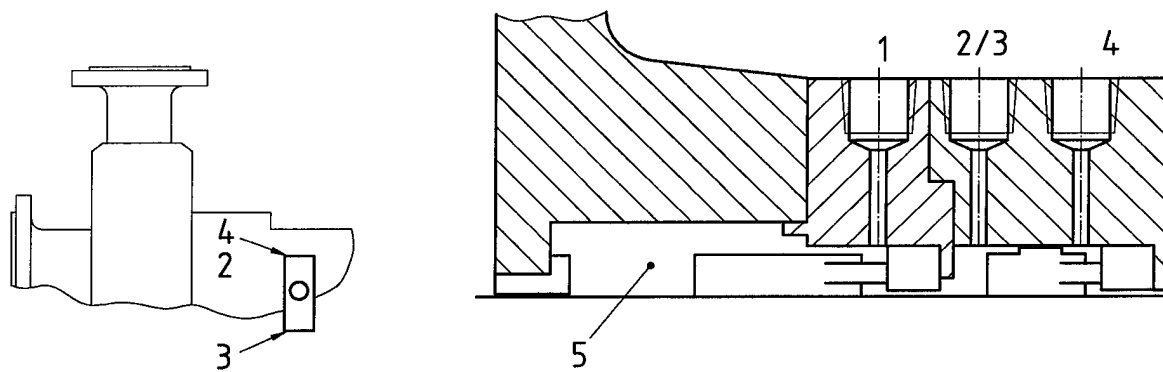
b) Seal chamber details

Key

- 1 to liquid collection system
- 2 flush (F)
- 3 quench (Q), plugged
- 4 drain (D)
- 5 seal chamber
- LSH level switch high

External drain piping is arranged to alarm on high seal leakage, measured by a float type level switch. The orifice downstream of the level switch is typically 5 mm (0,25 in) and is located in a vertical piping leg.

Figure G.21 — Standard seal flush plan 65



a) Piping and instrumentation schematic

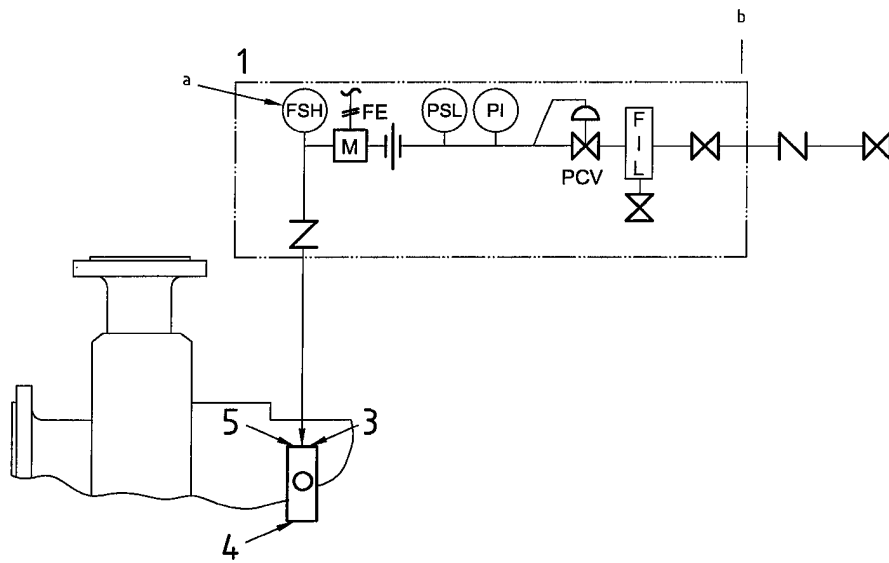
b) Seal chamber details

Key

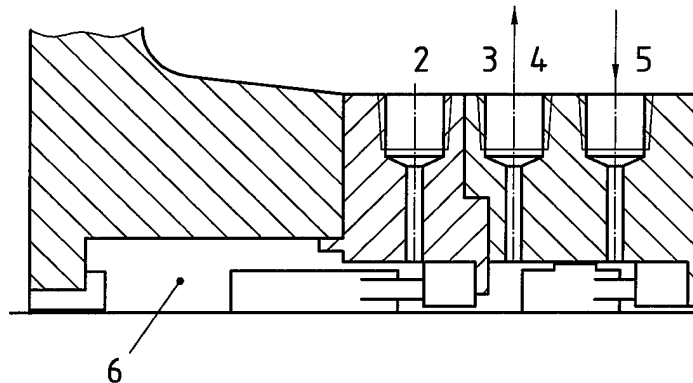
- 1 flush
- 2 containment seal vent (CSV), plugged
- 3 containment seal drain (CSD), plugged
- 4 gas buffer inlet (GBI), plugged
- 5 seal chamber

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

Figure G.22 — Standard seal flush plan 71



a) Piping and instrumentation schematic



b) Seal chamber details

Key

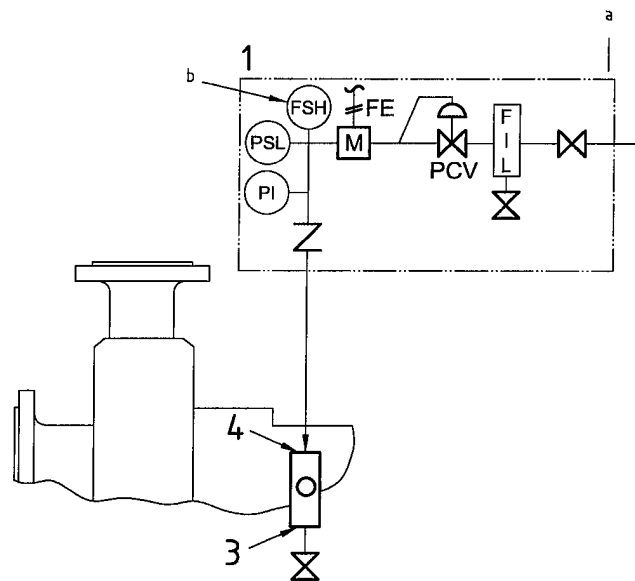
- 1 buffer gas panel
- 2 flush (F)
- 3 containment seal vent (CSV)
- 4 containment seal drain (CSD)
- 5 gas buffer inlet (GBI)
- 6 seal chamber
- FE flow meter (magnetic type shown)
- FIL coalescing filter, used to ensure solids and/or liquids which might be present in buffer gas do not contaminate seals
- PCV pressure control valve, used to limit buffer gas pressure to prevent reverse pressurization of inner seal and/or limit pressure applied to containment seal
- PI pressure indicator
- PSL pressure switch low
- FSH flow switch high

Externally supplied gas buffer for Arrangement 2 seals. Buffer gas may be used alone to dilute seal leakage or in conjunction with Plan 75 or 76 to help sweep leakage into a closed collection system. Pressure of buffer gas is lower than the process-side pressure of inner seal.

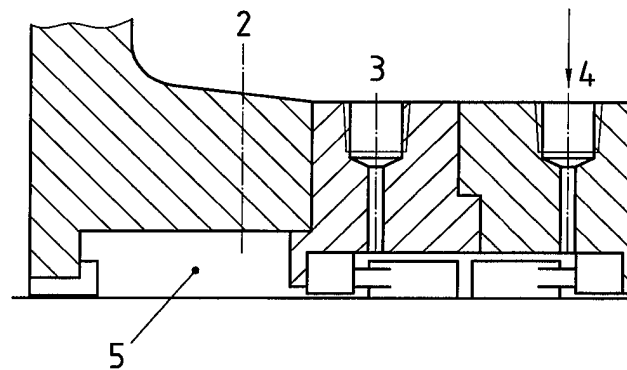
^a If specified.

^b Items to the left of this line shall be supplied by the vendor; items to the right are the responsibility of the purchaser.

Figure G.23 — Standard seal flush plan 72



a) Piping and instrumentation schematic



b) Seal chamber details

Key

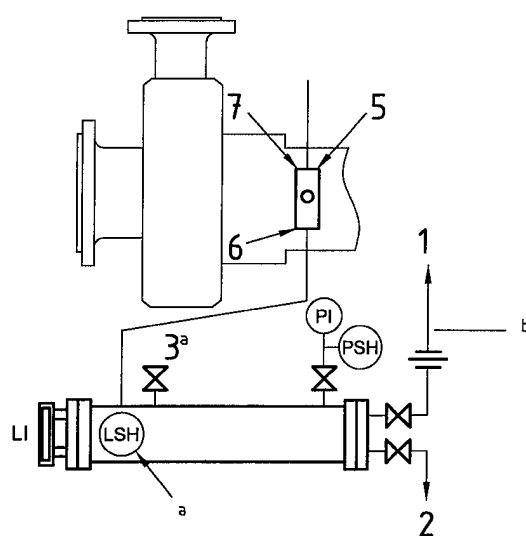
- 1 gas barrier panel
- 2 vent (if required)
- 3 gas barrier outlet (normally closed), used only to depressurize seal chamber
- 4 gas barrier inlet
- 5 seal chamber
- FE flow meter
- FIL coalescing filter, used to ensure solids and/or liquids which might be present in barrier gas do not contaminate seals
- FSH flow switch high
- PI pressure indicator
- PCV pressure control valve, set pressure above process side of inner seal
- PSL pressure switch low

Externally supplied barrier gas used to positively prevent process fluid from leaking to atmosphere. Pressure of barrier gas is higher than process side of inner seal. Venting of the seal chamber may be required prior to start-up and operation to avoid the collection of gas in the pump.

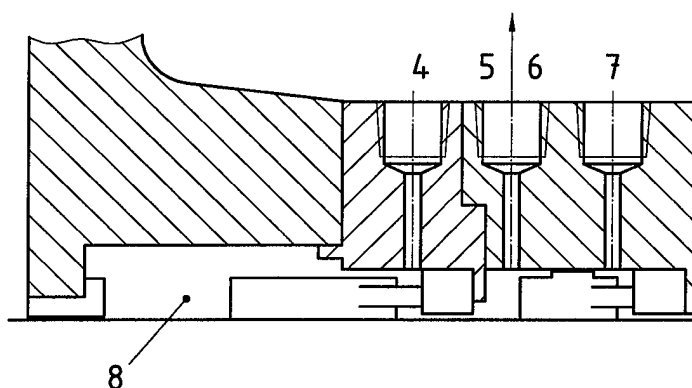
^a Items to the left of this line shall be supplied by the vendor; items to the right are the responsibility of the purchaser.

^b If specified.

Figure G.24 — Standard seal flush plan 74



a) Piping and instrumentation schematic



b) Seal chamber details

Key

- 1 to vapour collection system
- 2 to liquid collection system
- 3 test connection
- 4 flush (F)
- 5 containment seal vent (CSV), plugged
- 6 containment seal drain (CSD)
- 7 gas buffer inlet (GBI)
- 8 seal chamber
- LI level indicator
- LSH level switch high
- PSH pressure switch high
- PI pressure indicator

Containment seal chamber drain for condensing leakage on Arrangement 2 seals. This plan is used when pumped fluid condenses at ambient temperatures. System is supplied by vendor.

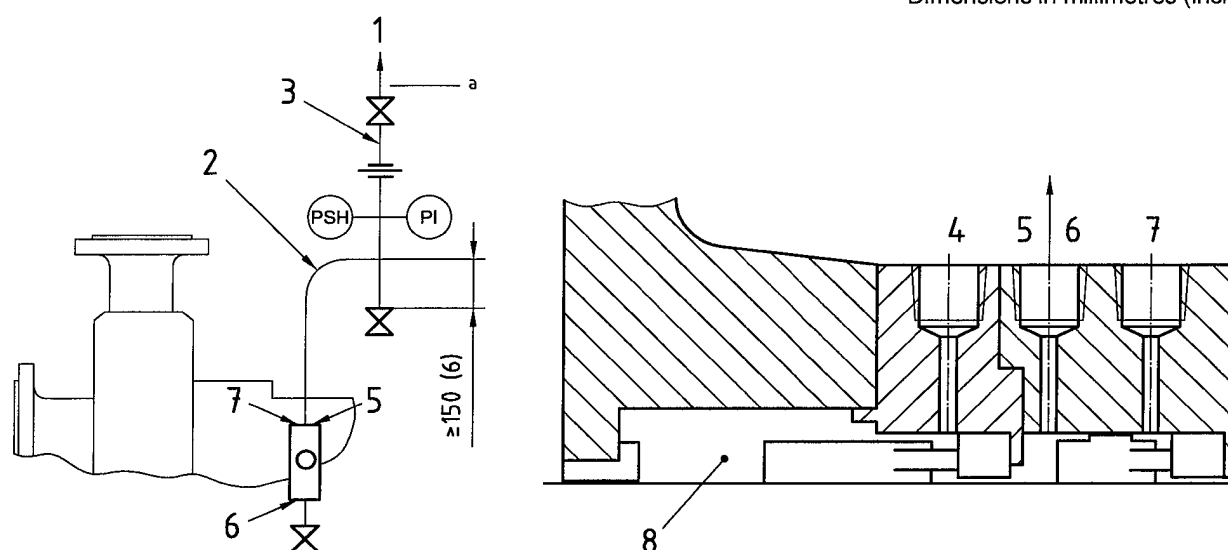
Valves to be installed per figure and must be accessible for operator use relative to ground clearance and other obstructions.

^a If specified.

^b Items above this line are the responsibility of the purchaser; items below this line shall be supplied by the vendor.

Figure G.25 — Standard seal flush plan 75

Dimensions in millimetres (inches)



a) Piping and instrumentation schematic

b) Seal chamber details

Key

- 1 to vapour recovery system
- 2 tube, see below
- 3 pipe, see below
- 4 flush (F)
- 5 containment seal vent (CSV)
- 6 containment seal drain (CSD)
- 7 gas buffer inlet (GBI)
- 8 seal chamber
- PI pressure indicator
- PSH pressure switch high

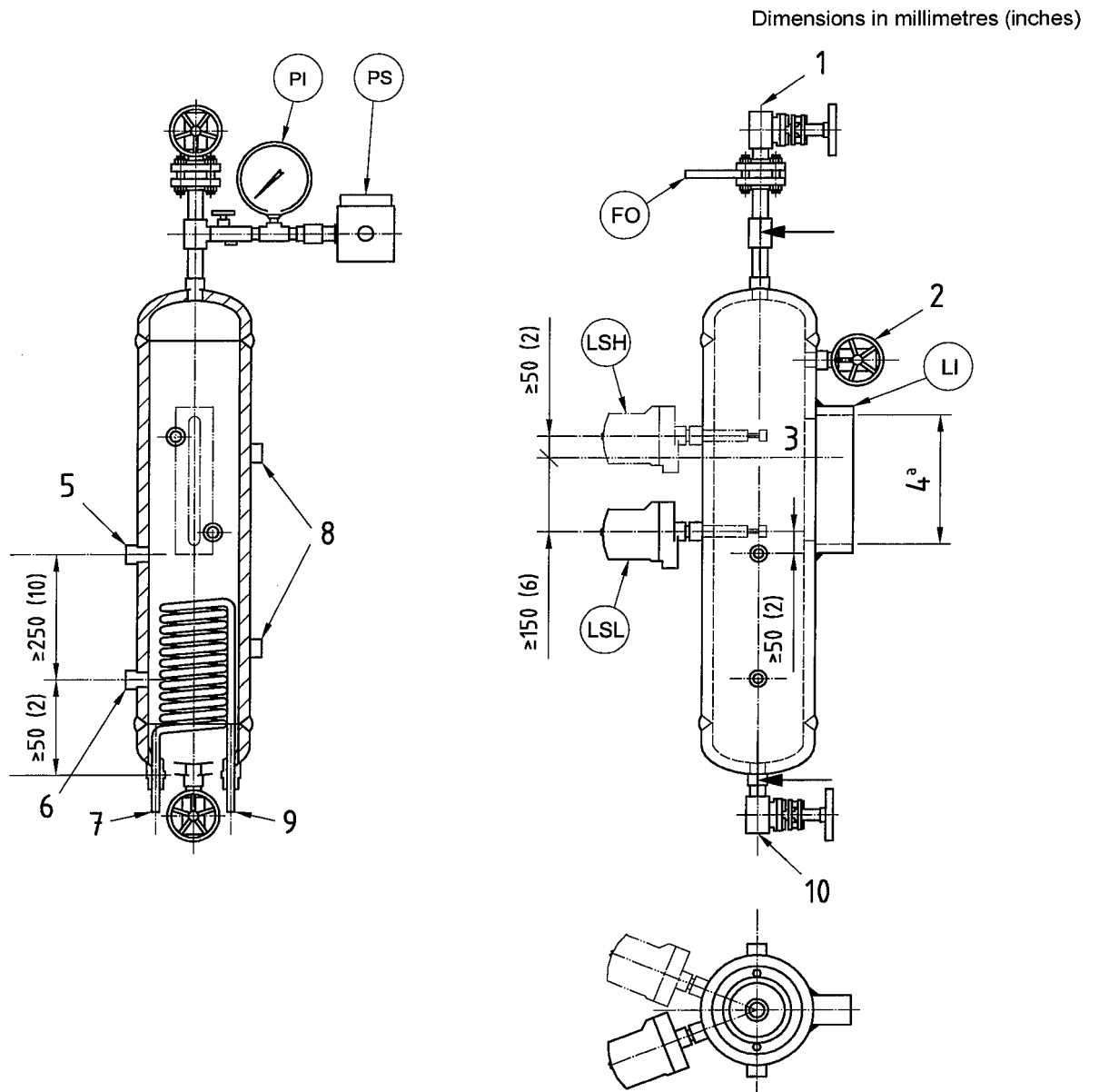
Containment seal chamber drain for non-condensing leakage on Arrangement 2 seals. This plan is used when pumped fluid does not condense at ambient temperatures. System is supplied by the vendor.

Tubing shall be 13 mm (1/2 in) minimum diameter and shall rise continuously from the CSV connection to the piping /instrumentation harness.

The harness shall be pipe of minimum size DN 15 (NPS 1/2). Harness shall be supported from overhead structure or side stand such that no strain is put on tubing connected to seal gland.

^a Items above this line are the responsibility of the purchaser; items below this line shall be supplied by the vendor.

Figure G.26 — Standard seal flush plan 76



Key

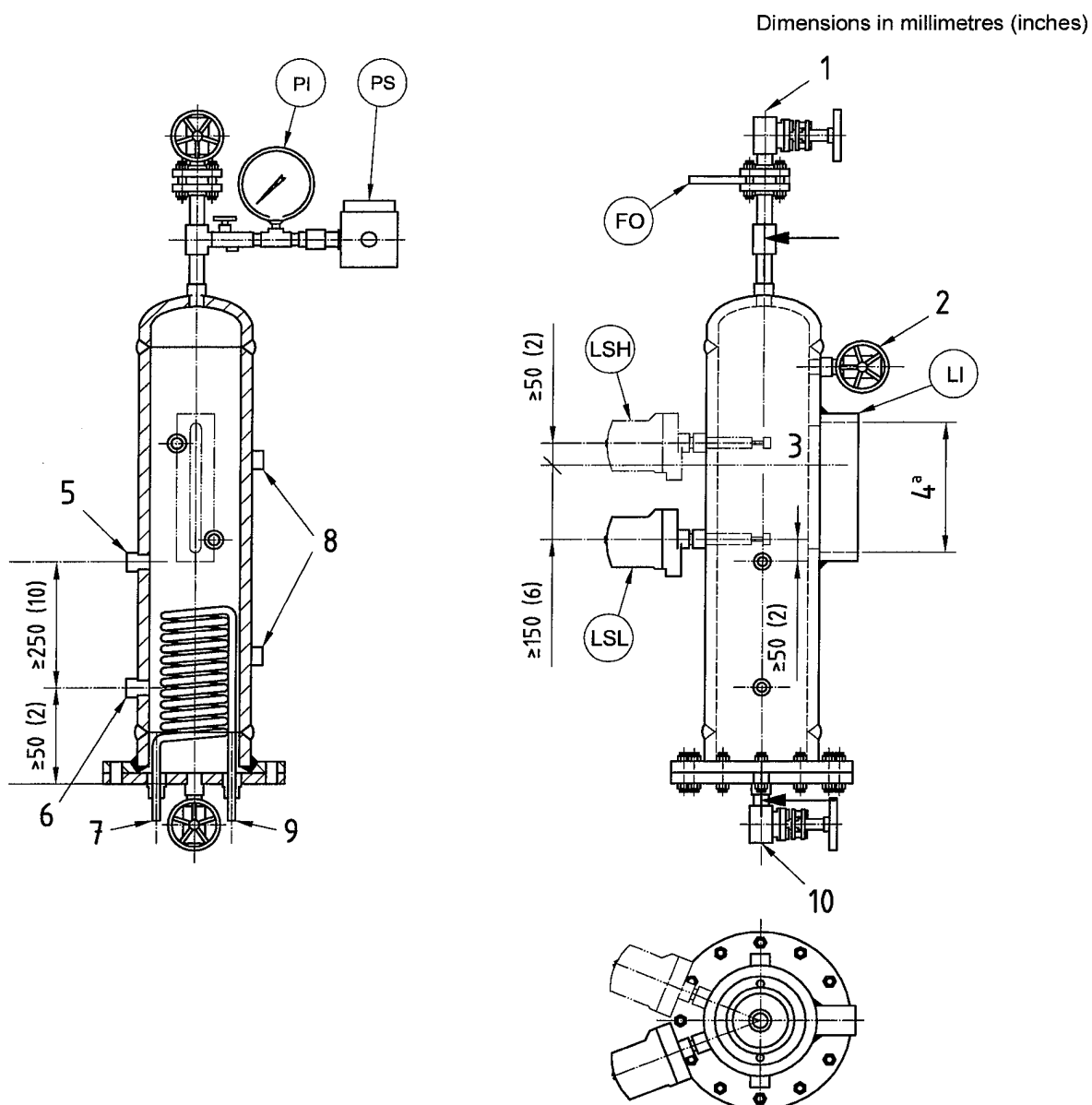
- 1 3/4 NPT vent
- 2 3/4 NPT pressure fill
- 3 normal liquid level
- 4 visible length ^a
- 5 3/4 NPT return
- 6 3/4 NPT supply
- 7 13 mm (0,5 in) OD tubing, cooling liquid inlet
- 8 mounting lugs
- 9 13 mm (0,5 in) OD tubing, cooling liquid outlet
- 10 3/4 NPT drain

- FO flow orifice
- LSH level switch high (if specified)
- LSL level switch low
- LI level indicator
- PI pressure indicator
- PS pressure switch

Refer to data sheet for component definition.

^a Visible length shall extend from below LSL to the greater of 75 mm (3,0 in) above NLL or 25 mm (1,0 in) above LSH.

Figure G.27 — Standard external barrier/buffer fluid reservoir



Key

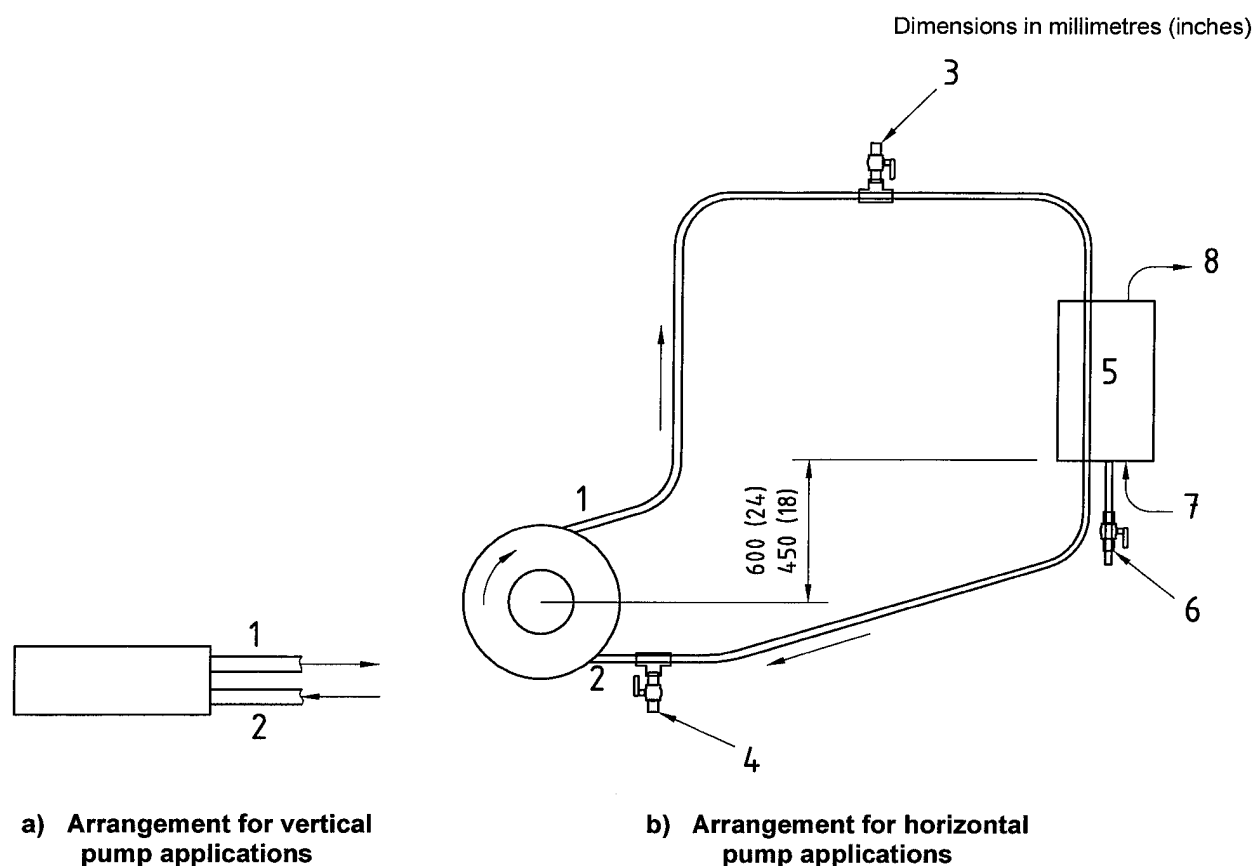
- 1 3/4 NPT vent
- 2 3/4 NPT pressure fill
- 3 normal liquid level
- 4 visible length
- 5 3/4 NPT return
- 6 3/4 NPT supply
- 7 13 mm (0,5 in) OD tubing, cooling liquid inlet
- 8 mounting lugs
- 9 13 mm (0,5 in) OD tubing, cooling liquid outlet
- 10 3/4 NPT drain

- FO flow orifice
- LSH level switch high (if specified)
- LSL level switch low
- LI level indicator
- PI pressure indicator
- PS pressure switch

Refer to data sheet for component definition.

^a Visible length shall extend from below LSL to the greater of 75 mm (3,0 in) above NLL or 25 mm (1,0 in) above LSH.

Figure G.28 — Alternative external barrier/buffer fluid reservoir

**Key**

- 1 to seal cooler
- 2 from seal cooler
- 3 high point vent in connecting tubing
- 4 low point drain in connecting tubing
- 5 seal flush cooler
- 6 cooling water service drain
- 7 cooling water inlet (CWI)
- 8 cooling water outlet (CWO)

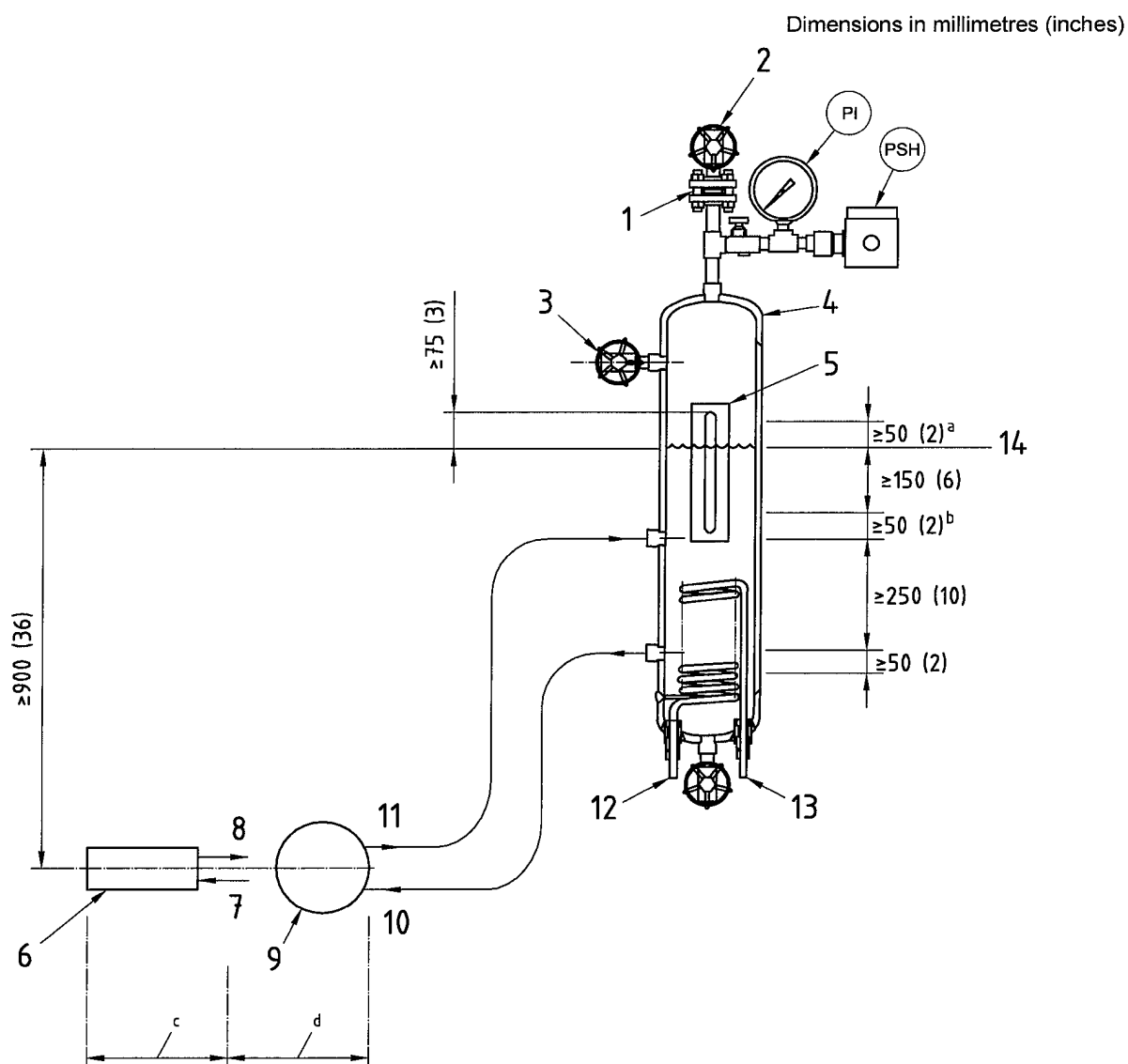
The seal flush cooler shall have the cooling liquid on the shell side and process fluid on the tube side. The cooler arrangement shall provide drainage for both the cooling liquid and process fluids.

The seal flush cooler shall be located as close to the pump as possible while leaving sufficient room for operation and maintenance. It should not be located directly above the pump. Hot lines should be insulated as necessary for safety.

For tubing, use smooth, long radius bends. For piping, minimize the number of 90° elbows, although 45° elbows may be used.

All lines shall slope up from the gland to the high point vent; the slope shall be at least 40 mm/m (0,5 in/ft).

Figure G.29 — Typical installation of a plan 23 circulation system

**Key**

1 flanged orifice	6 gland	11 return from seal	PI pressure indicator
2 vent	7 inlet to seal	12 cooling liquid inlet	PSH pressure switch high
3 fill	8 outlet from seal	13 cooling liquid outlet	
4 reservoir	9 gland	14 normal liquid level	
5 sight flow	10 supply to seal		

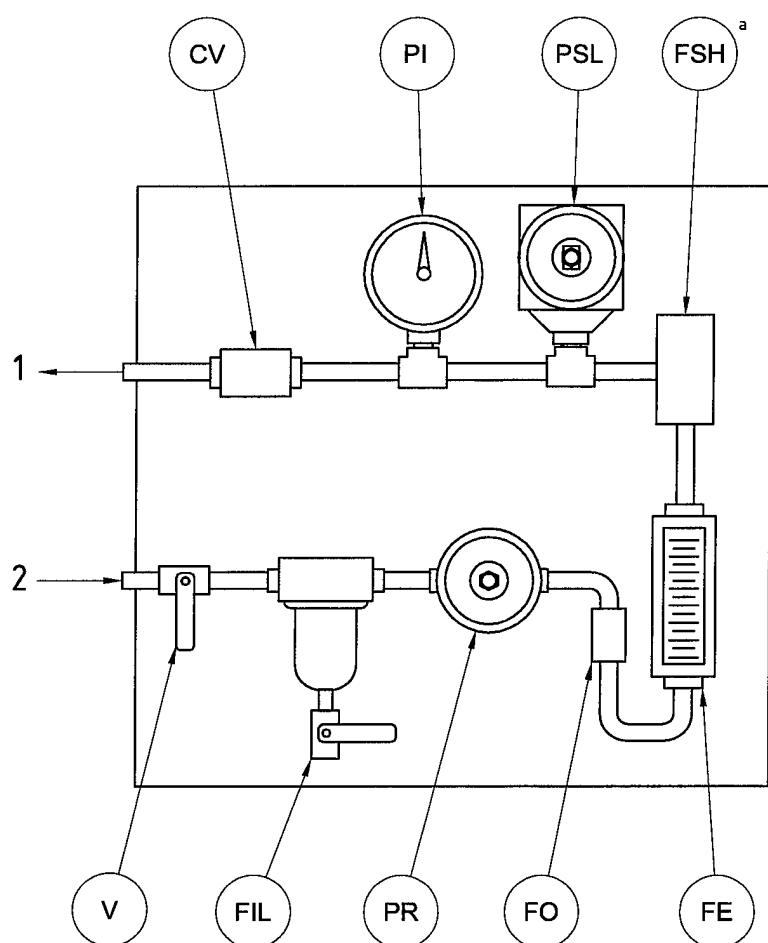
For tubing, use smooth, long radius bends. For piping, minimize the number of 90° elbows, although 45° elbows may be used.

All lines shall slope up from the gland to the high point vent; the slope shall be at least 40 mm/m (0,5 in/ft).

The seal flush cooler shall be located as close to the pump as possible while leaving sufficient room for operation and maintenance. It should not be located directly above the pump. Hot lines should be insulated as necessary for safety.

- a High level alarm installed in this range.
- b Low level alarm installed in this range.
- c For vertical applications.
- d For horizontal applications.

Figure G.30 — Typical installation of a barrier/buffer fluid reservoir



Key

- 1 to seal
- 2 from gas supply
- CV check valve
- FE flow meter
- FIL coalescing filter
- FO flow orifice 1,5 mm (0,062 in), if required
- FSH flow switch high
- PI pressure indicator
- PR pressure regulator
- PSL pressure switch low
- V shut-off valve

This figure shows a general arrangement of components on the gas supply panel. The physical layout of components may be different provided all required components and the described flow sequence are present.

^a If specified.

Figure G.31 — Standard external barrier gas supply panel

Annex H (informative)

Inspector checklist for all seals

Item	Subclause reference	Date inspected	Inspected by	Status
Gland connections marked	6.1.2.17			
No plastic plugs	6.1.2.18 10.4.3			
Weld procedures approved	6.1.6.10.1			
Repair procedures approved	6.1.6.10.2			
Wrought material inspections	6.1.6.10.4			
Welded connections	6.1.6.10.5			
Impact test results	6.1.6.11.3			
Adequate clearance and safe access	8.1.4			
Piping, fabrication, examination and inspection meet standards and weld procedures approved.	8.1.6			
Tags attached to coolers	8.2.3.2			
Orifice data	8.5.2.2			
Buffer/barrier-fluid reservoir tag	8.5.4.4.4			
Thermal sizing criteria	8.5.4.5 a)			
Relief valve list	9.8.1			
Compliance with inspector's checklist	10.1.7			
NDE inspection results	10.2.3			
Cleanliness inspection	10.2.3 j) 10.4.3 c)			
Hardness test results	10.2.3 k)			
Qualification test results	10.3.1.5 11.2.2 11.2.4			
Test certificate	10.3.1.5			
Certified hydrostatic test results	10.3.2.1			
Seal supplied air test tag	10.3.3.2			
Seal leakage acceptance criteria	10.3.1.4.1			
Site storage procedures	10.4.2			
Preparation for shipment	10.4.3			
Auxiliary piping connections tagged or marked	10.4.4			
Installation instructions	10.4.5			
Contract data	11.3.1			

Annex I
(normative)

Form for mechanical seal qualification test

Mechanical seal qualification test form

CW1, 2CW-CW, 3CW-FB, 3CW-FF and 3CW-BB

Date: _____
Revision: _____

Manufacturer: _____ Seal Model / Type: _____

Seal type: _____ A _____ B _____ C _____ ES _____

Matl. of construction: _____ Rotating face _____ Stationary face _____
Secondary seals _____ Metal hardware _____

Seal size: _____ Seal code: _____ Seal plan: _____ Shaft speed: _____

Rotating face matl.: _____ Stationary face matl.: _____

Application group (Table 7) _____ Non-hydrocarbon (water, caustic, acid) _____ Non-flashing hydrocarbon _____ Flashing hydrocarbon _____

Shaft runout (Fig. 18) _____ Sleeve runout (Fig. 18) _____ Seal chamber concentricity (Fig. 13) _____ Seal chamber face runout (Fig. 15) _____

Fluid: _____ Base-point temp °C/°F _____ / _____ Base-point pressure MPa (bar)/psig _____ / _____

Relative density (SG) _____ Vapour pressure _____ Solids _____ Particle size _____

* Dual seals

DYNAMIC TEST 100 h minimum	Date	Time		Pressure MPa (bar) (psig)	Process temp. °C (°F)	Flush temp. °C (°F)	IN °C (°F)	OUT °C (°F)	Flush flowrate m ³ /h (U.S. gal/min)	Seal chamber temp. °C (°F)	Barrier fluid press. MPa (bar) (psig)	Barrier fluid temp. °C (°F)	IN °C (°F)	OUT °C (°F)	Sleeve-to-box concentricity	Power consumption kW (hp)	Hydrocarbon leakage g/day	Non-hydrocarbon leakage (cm ³ /min)	Circulating device m ³ /h (U.S. gal/min)
		Start	Stop																
STATIC TEST 4 h minimum																			
CYCLIC TEST 5 cycles minimum																			

Figure I.1 — Mechanical seal qualification test form

Mechanical seal qualification test form

2CW-CS, 2NC-CS, 3NC-FF, 3NC-BB, 3NC-FB

Manufacturer	Seal type/model				
Arrangement	2CW-CS	2NC-CS	3NC-FF	3NC-BB	3NC-FB
Material of construction	Rotating face		Stationary face		
Fluid service	Non-hydrocarbon (water, caustic, acid)		Non-flashing hydrocarbon		
Shaft runout	Sleeve runout		Face-to-sleeve concentricity		
Test fluid	Base-point temperature		Base-point pressure		
Relative density (SG)	Vapour pressure		Solids		
Test procedure	10.3.1.2.10 (for 2CW-CS, 2NC-CS Arrangements)				
	10.3.1.2.12 (for 3NC-FF, 3NC-BB, 3NC-FB Arrangements)				

[illegible]

Outer Seal Face Wear	Stationary face _____	Rotating face _____	mm (in) _____
Inner Seal Face Wear	Stationary face _____	Rotating face _____	mm (in) (10.3.1.2.12 only) _____

Figure I.2 — Mechanical seal qualification test form (2CW-CS, 2NC-CS, 3NC-CS, 3NC-FF, 3NC-BB and 3NC-FB)

Annex J (normative)

Mechanical seals data requirements form

CATEGORY 3 SEALS		Required for		Site:	Unit:
		Job/Project No.:		Item No.	
MECHANICAL SEALS DATA REQUIREMENTS FORM		Requisition/Spec. Number		/	
		Enquiry number:		By	
		Purchase Order Number:		Date:	
		Revision No.: 0		Date:	
Nomenclature: ... S = Number of weeks prior to shipment ... F = Number of weeks after firm order ... D = Number of weeks after receipt of approved drawings					
Data required		Proposal	Contract		
		No. of copies	No. of copies	Date due	Date received
1	Cross-sectional drawing (typical) – Reference 11.2.2	0			
2	Auxiliary system schematic – Reference 11.3.3	0	0		
3	Appropriately completed data sheets – Reference Annex C	0	0		
4	Alternatives proposed	0			
5	Exceptions to this International Standard	0			
6	Detailed bill of materials for seal and auxiliary system	0	0		
7	Estimated seal leakage of 2NC-CS (if applicable)	0			
8	Seal Qualification Test results – Reference 11.2.4, Figures I.1 and I.2	0			
9	Seal design performance parameters – Reference 11.2.3	0			
10	Seal axial thrust on the shaft (see data sheet, Annex C)	0	0		
11	Cross sectional drawing (specific) – Reference 11.3.2		0		
12	Detailed drawing of auxiliary system – Reference 11.3.4		0		
13	Seal energy and heat soak calculations (see Annex F)		0		
14	Internal circulating device performance – Reference 8.6.2.2		0		
15	Installation, operation and maintenance instructions (specific) – Reference 11.3.6* and 11.3.7*		0		
16	Hydrostatic test certification – Reference 10.3.2		0		
17	Material safety data sheets – Reference 11.3.8		0		
18	Additional proposal data – specify	0			
19	Additional contract data – specify		0		
* NOTE: A copy to be supplied with the seal and auxiliary system.					
Address for forwarding data: _____ _____					
Vendor signature: (Signature confirms receipt of approved drawings) _____ Date _____					

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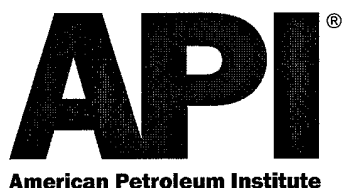
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