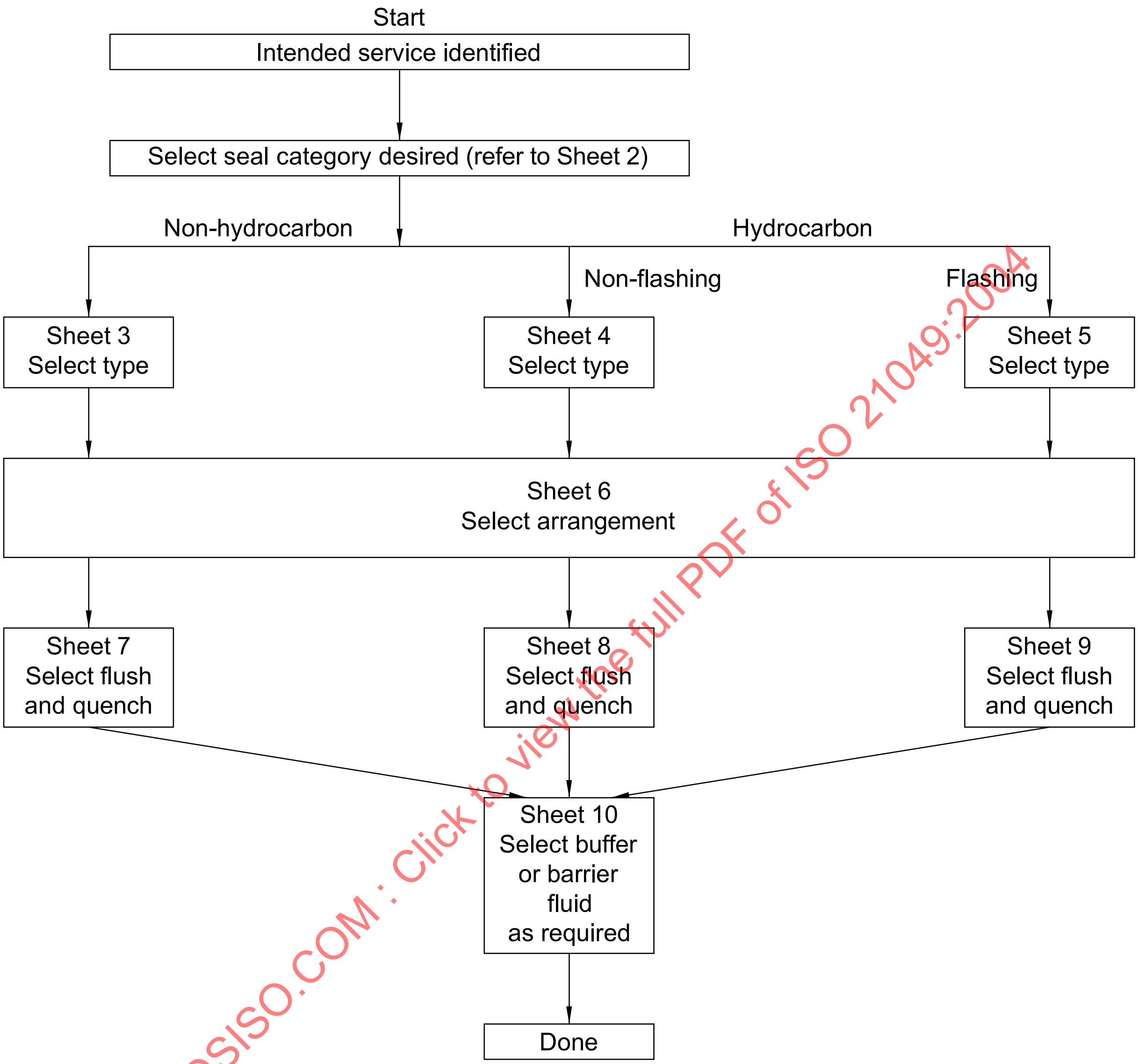
RECOMMENDED SEAL SELECTION PROCEDURE (US CUSTOMARY UNITS)
SHEET 1 OF 10



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/buffer 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

		Operating conditions, recommended seal types and special features							
	Fluids	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
		Water	Water	Water	Sour water	Sour water	Caustic, amines crystallize	Caustic, amines crystallize	Acids [a] H_2SO_4, H_3PO_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 contami-nants [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_2SO_4 at 77 °F only. Up to 20 % H_3PO_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

		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	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 contami-nants [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_2S			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 contami-nants [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_2S			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.

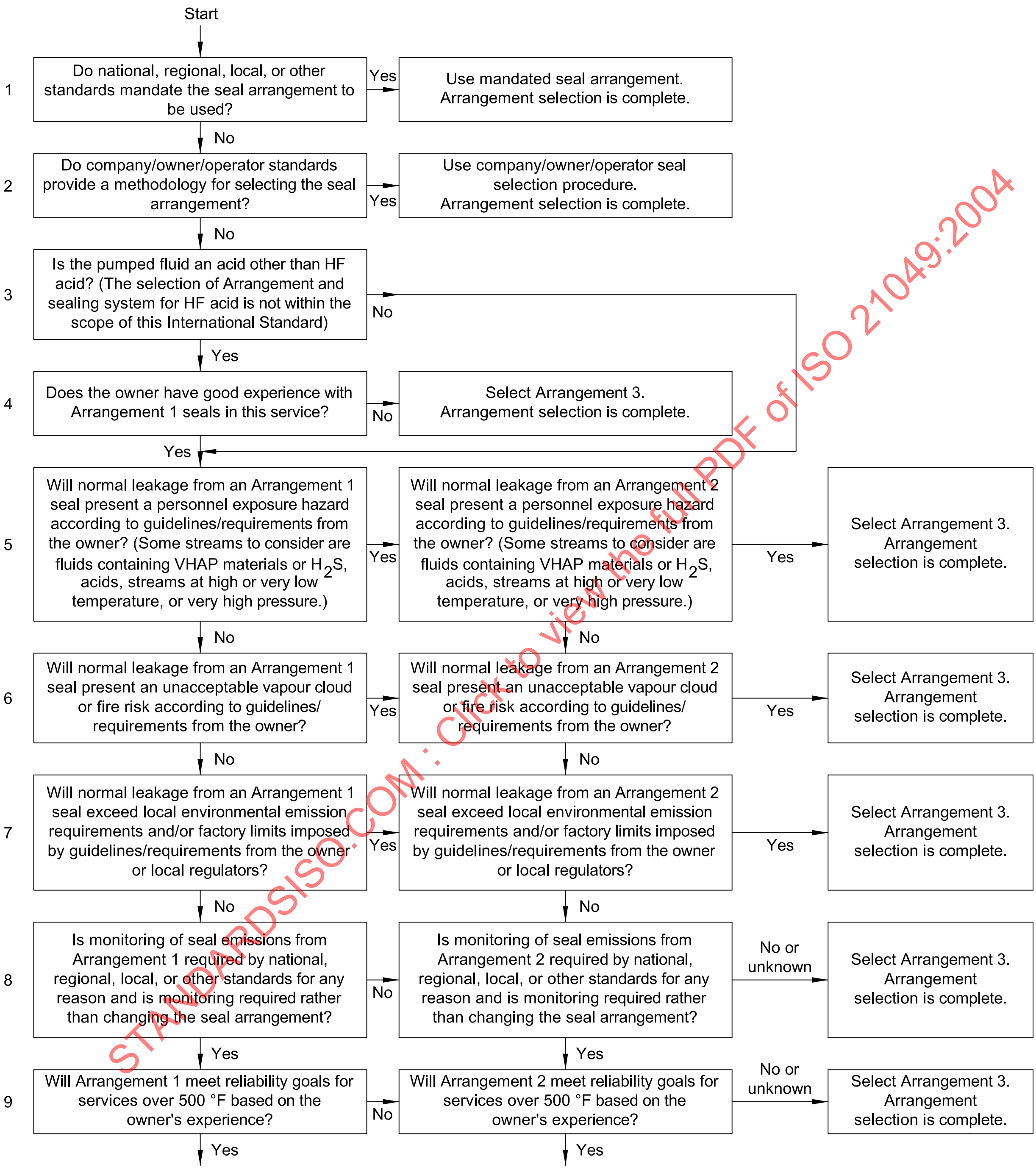
b Engineered bellows.

c Special features listed apply only in mixtures having pH between 4 and 11.

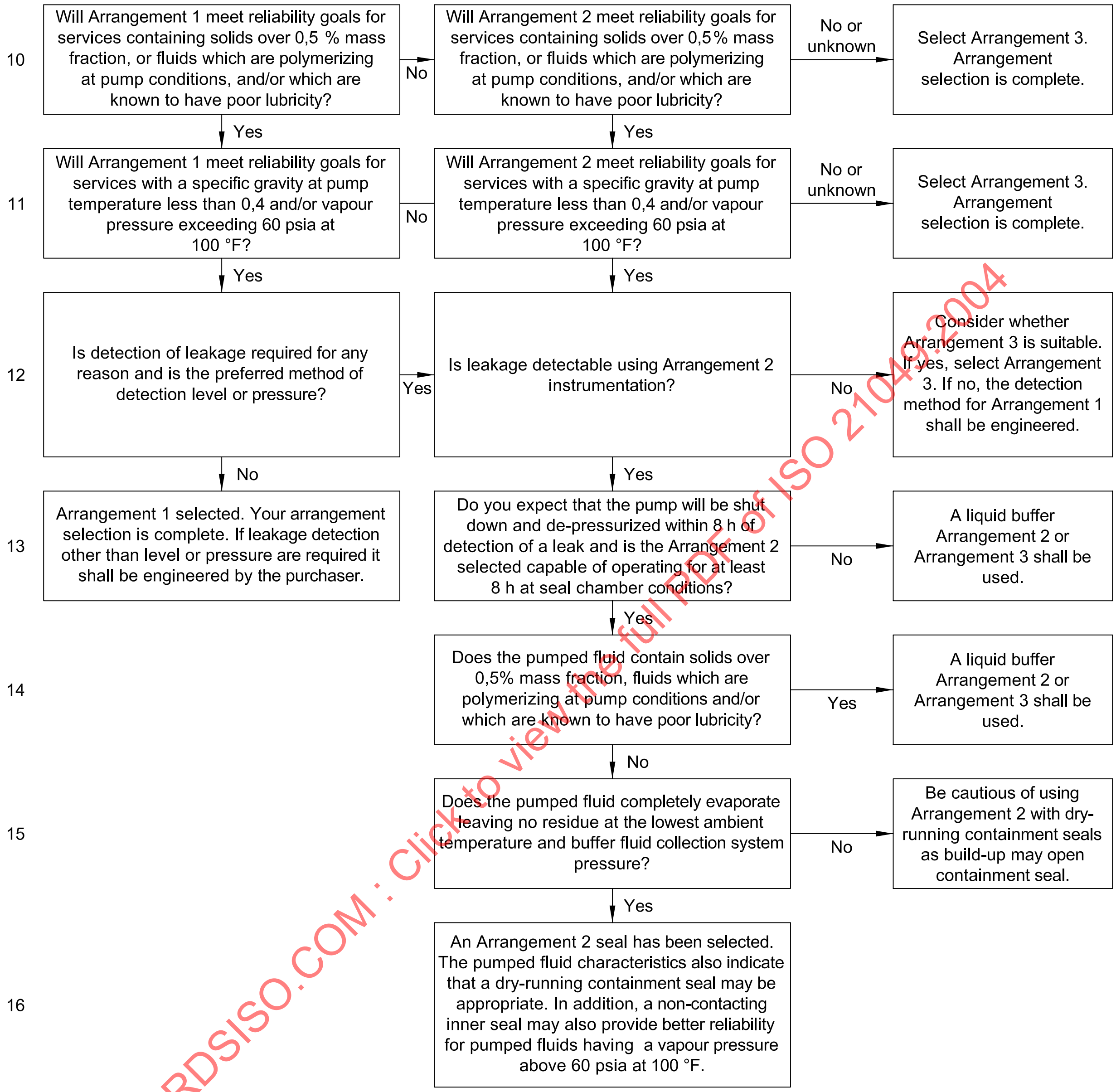
d Requires special feature (circulating device) above 140 °F, and special feature (perfluoroelastomer) if pumping temperature is above 350 °F.

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

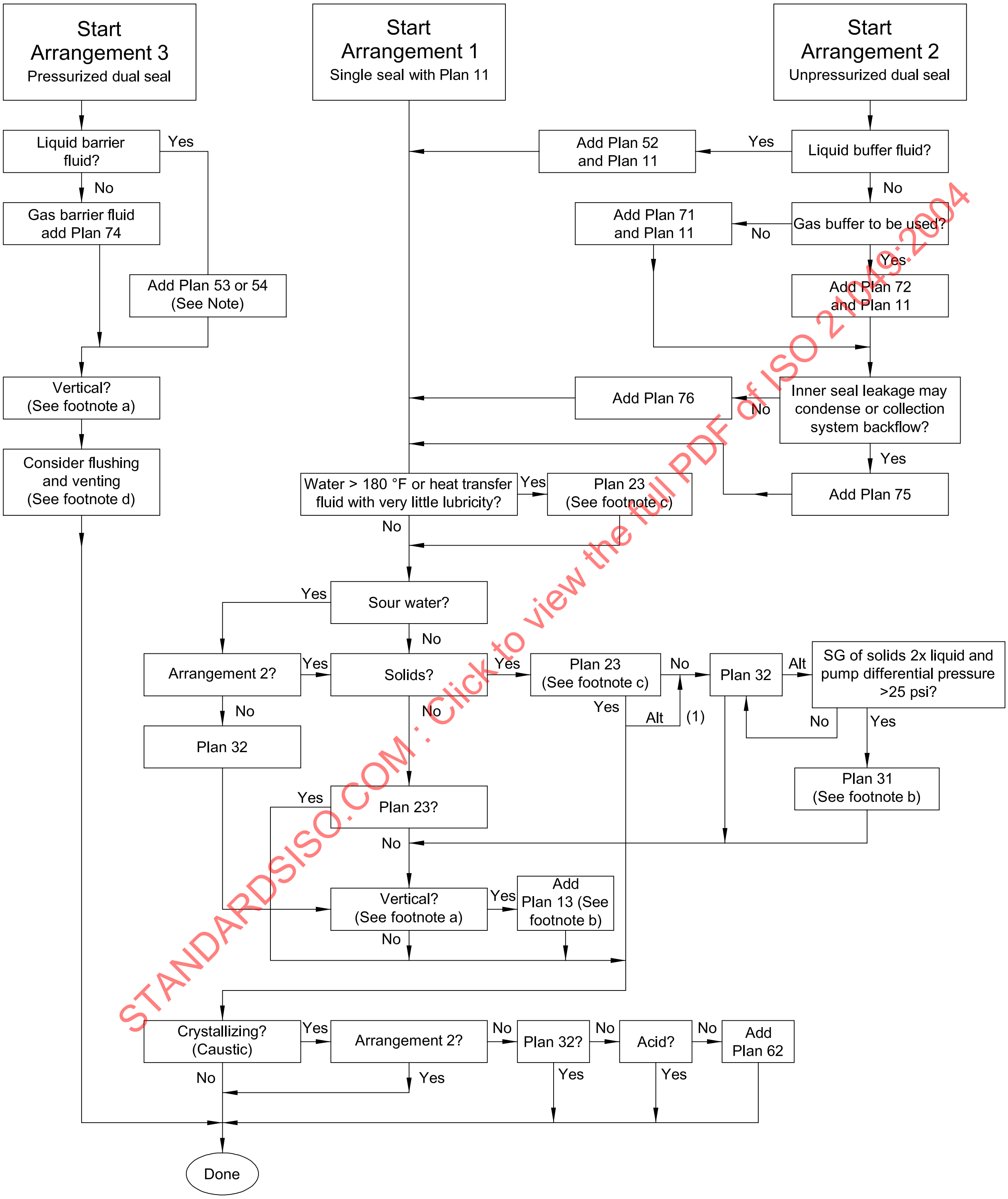
Assume Arrangement 1 to begin



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.

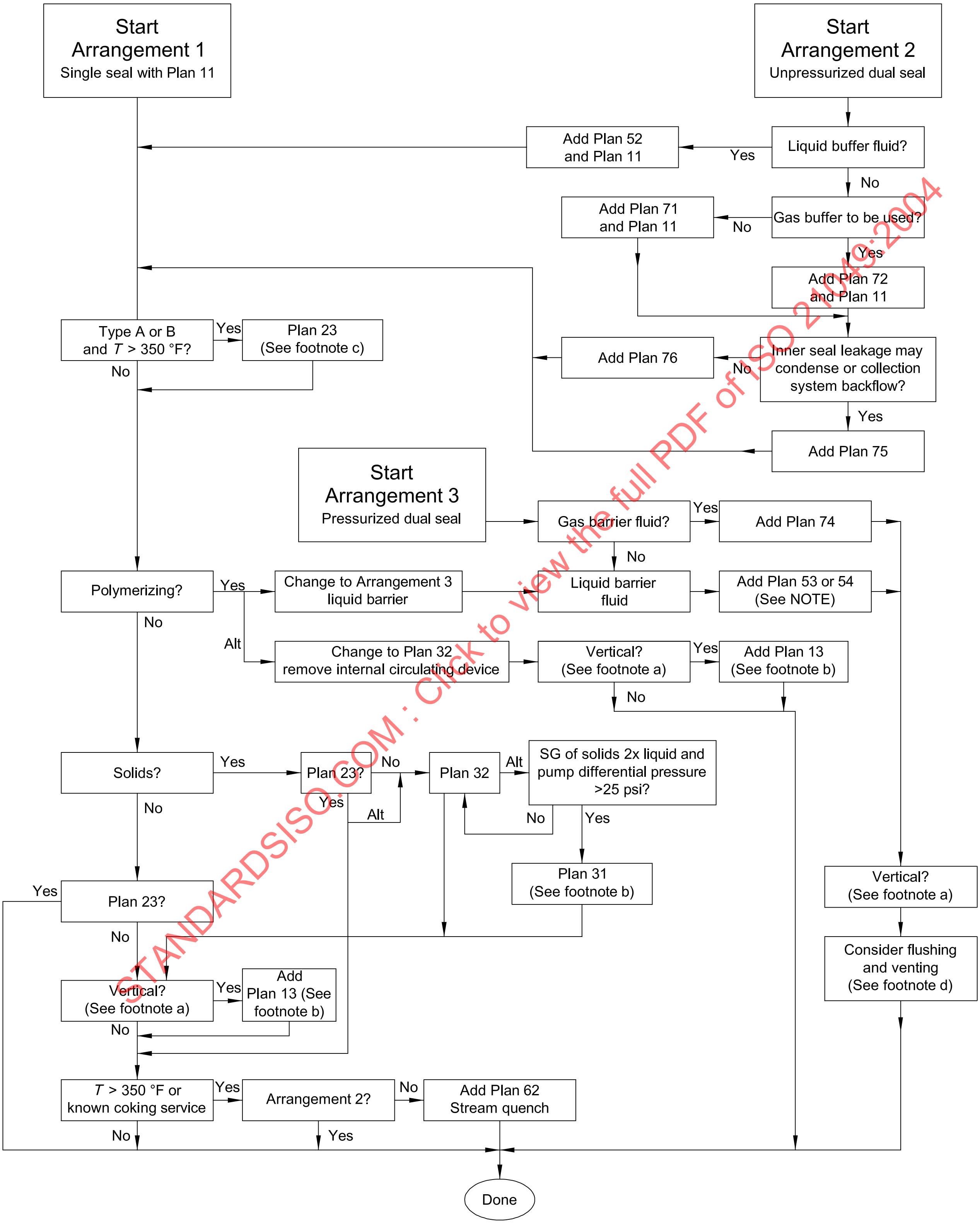
[a] The user should evaluate whether to add Plan 13 or not, considering such factors as the inclusion of a bleed bushing, contamination of the seal chamber with pumped fluid, the need for venting of the seal chamber, and the need to reduce seal chamber pressure, due to static or dynamic pressure rating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

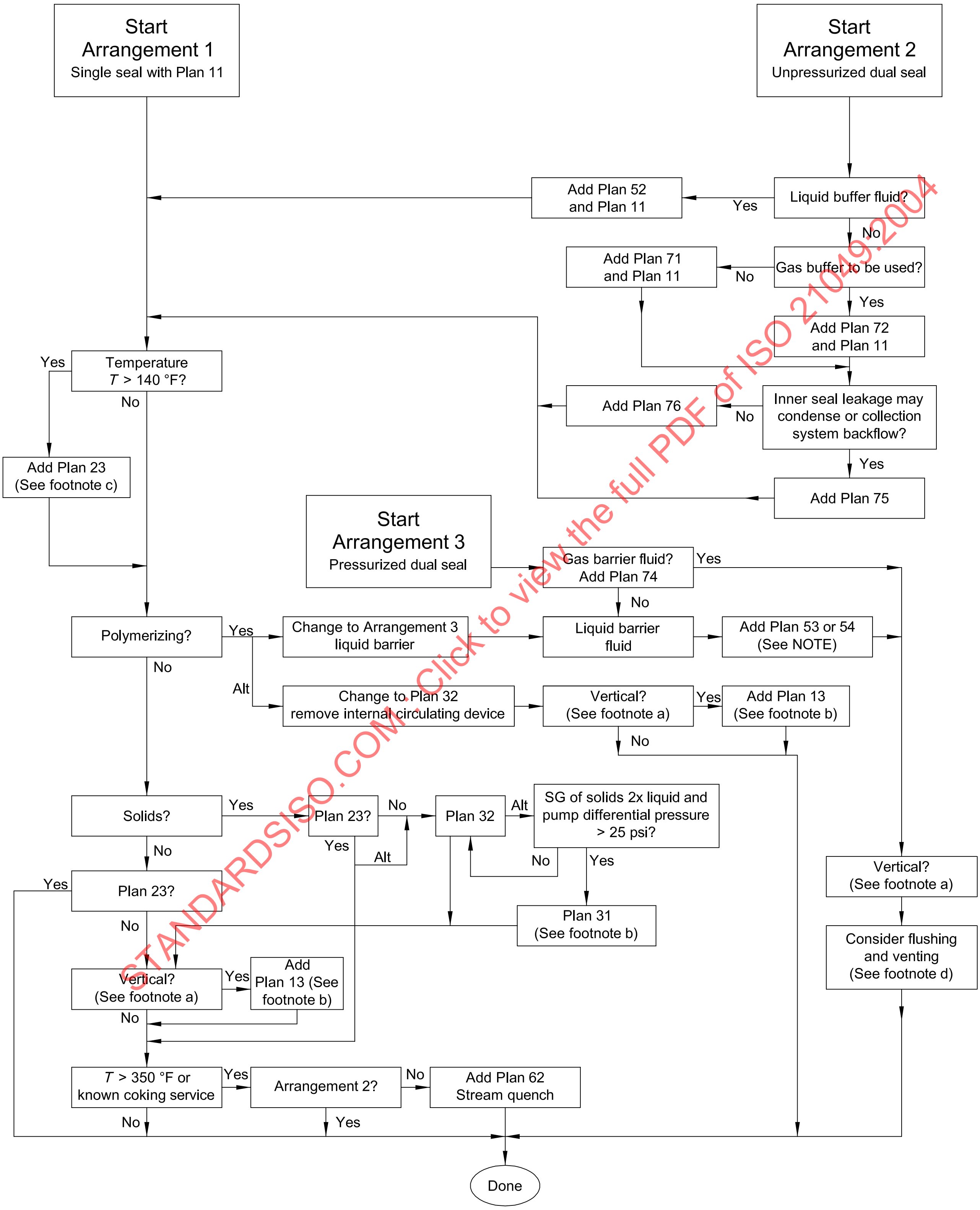
[a] The user should evaluate whether to add Plan 13 or not, considering such factors as the inclusion of a bleed bushing, contamination of the seal chamber with pumped fluid, the need for venting of the seal chamber and the need to reduce seal chamber pressure, due to static or dynamic pressure rating 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 re-consider 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 (US CUSTOMARY 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 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 H_2S, as H_2S 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) 21 bar (300 psi) requires special engineering for the high pressure.

This selection is made to maximize the standardization process, as the Type A seal is recommended for all pressure ranges. Sour water may become flashing as the temperature and H_2S content 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 H_2S) amine streams, to highlight the need for control beyond a single seal without external flush. The highlight is needed because specifications often overlook the need for added control measures on this type of stream.

A.3.7 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	USA			Europe			Japan	
		ISO	ASTM	Grade	UNS	Standard	Symbol	Mat. No.	JIS	
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	1.4107 1.4317	G 5121 G 5121	Cl SCS 1 Cl SCS 6
	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	1.4006 1.4313	G 3214 G 3214	Gr. SUS 410-A Cl SUS F6 NM
	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	1.4006 1.4005 1.4122	G 4303	Gr. SUS 410 or 403
	Bolts and studs	3506-1, C4-70	A 193	Gr B6	S 41000	EN 10269	X22CrMoV12-1	1.4923	G 4303	Gr. SUS 410 or 403
	Nuts	3506-2, C4-70	A 194	Gr 6		EN 10269	X22CrMoV12-1	1.4923	G 4303	Gr. SUS 410 or 403
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	1.4309 1.4409	G 5121 G 5121	Cl SCS 13A Cl SCS 14A
	Forging	9327-5, X2CrNi18-10	A 182	Gr F 304L	S 30403	EN 10222-5	X2CrNi19-11	1.4306	G 3214	Gr. SUS F 304 L
		9327-5, X2CrNiMo17-12	A 182	Gr F 316L	S 31603	EN 10222-5	X2CrNiMo17-12-2	1.4404	G 3214	Gr. SUS F 316 L
	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	1.4401 1.4404 1.4571	G 4303 G 4303 G 4303	Gr. SUS 316 Gr. SUS 316 L Gr. SUS 316 Ti
	Bolts and studs	3506-1, A4-70	A 193	Gr B8M Cl2	S 31600	EN 10250-4	X6CrNiMoTi17-12-2	1.4571	G 4303	Gr. SUS 316
	Nuts	3506-2, A4-70	A 194	Gr 8M	S 31600	EN 10250-4	X6CrNiMoTi17-12-2	1.4571	G 4303	Gr. SUS 316

Table B.1 — Materials standards *(continued)*

Material class	Applications	International	USA			Europe			Japan	
		ISO	ASTM	Grade	UNS	Standard	Symbol	Mat. No.	JIS	
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	G 4303	Gr. SUS 329J3L
			A 276		S 32550	EN 10088-3	X2CrNiMoCuN25-6-3	1.4507		
			A 276		S 32760	EN 10088-3	X2CrNiMoCuWN25-7-4	1.4501		
Alloy 20	Casting		A 744	CN 7M	N 08007				G 5121	Gr. SCS 23
	Bar		B 473		N 08020		NiCr20CuMo	2.4660		
Low-carbon nickel molybdenum chromium alloy (Alloy C276)	Forging		B 564		N 10276		NiMo16Cr15W	2.4819		
	Bar and rod	9723, NW0276	B 574		N 10276		NiMo16Cr15W	2.4819		
	Plate, sheet and strip	6208, NW0276	B 575		N 10276		NiMo16Cr15W	2.4819		
	Weldable casting	12725, NC6455	A 494	Gr. CW2M						
Nickel copper alloy (“Alloy 400”)	Forging	9725, NW4400	B 564		N 04400		NiCu30Fe	2.4360		
	Bar and rod	9723, NW4400	B 164	Class A	N 04400		NiCu30Fe	2.4360		
	Plate, sheet and strip	6208, NW4400	B 127		N 04400		NiCu30Fe	2.4360		
	Weldable casting		A 494	Gr. M30C			G-NiCu30Nb	2.4365		
Precipitation-hardening nickel alloy (“Alloy 718”)	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	USA			Europe			Japan	
		ISO	ASTM	Grade	UNS	Standard	Symbol	Mat. No.	JIS	
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					
	Austenitic ductile cast iron	2892, SNiCr20 2	A 439	Type D2	F 43000					
Elastomer	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						
Flexible graphite	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	REQUIRED FOR: ______ SITE: ______ UNIT: ______
MECHANICAL SEAL DATA SHEET	JOB/PROJECT NO. ______ ITEM NO. ______
FOR CENTRIFUGAL & ROTARY PUMPS	REQUISITION / SPEC. NUMBER ______ / ______
S.I. UNITS	INQUIRY NUMBER ______ BY ______
PAGE 1 OF 2	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

4 **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)

	ARR'G'T		DEFAULT CONFIGURATION	ALTERNATIVE DESIGN	FLUSH PLANS (SEE ANNEX G)
8					
9	**1** (3.2)		▣ 1CW-FX	▣ 1CW-FL ▣ DIST. FLUSH	▣ 01 ▣ 11 ▣ 14 ▣ 23 ▣ 32 ▣ 50 ▣ 61
10				▣ ALTERNATIVE BUSH	▣ 02 ▣ 13 ▣ 21 ▣ 31 ▣ 41 ▣ 51 ▣ 62
11	**2** (3.3)	BUFFER LIQUID	▣ 2CW-CW	▣ FX ▣ DIST. FLUSH	▣ 01 ▣ 13 ▣ 23 ▣ 41 ▣ 62 ▣ 75
12				▣ TANGENTIAL LBO CONN'N	▣ 02 ▣ 14 ▣ 31 ▣ 52 ▣ 71 ▣ 76
13		BUFFER GAS	▣ 2CW-CS	▣ 2NC-CS ▣ FX ▣ DIST. FLUSH	▣ 11 ▣ 21 ▣ 32 ▣ 61 ▣ 72
14	**3** (3.4)	BARRIER LIQUID	▣ 3CW-FB	▣ 3CW-BB ▣ FX	▣ 01 ▣ 13 ▣ 53A ▣ 54 ▣ 74
15				▣ 3CW-FF ▣ TANG. LBO	▣ 02 ▣ 14 ▣ 53B ▣ 61
16		BARRIER GAS	▣ 3NC-BB	▣ 3NC-FF ▣ 3NC-FB	▣ 11 ▣ 32 ▣ 53C ▣ 62

17 **SLEEVE-SHAFT DRIVE** ▣ SET-SCREW ONTO SHAFT ▣ ALTERNATIVE (6.1.3.13) - SPECIFY

18 **MATERIALS (REFERENCE 6.1.6 & ANNEX B)**

	SECONDARY SEALS	SEAL FACES	METAL BELLOWS	SPRINGS	METAL PARTS
19					
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:

24 **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

31 **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

35 **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

41 **FLUID DATA - (FOR QUENCH, BUFFER AND BARRIER FLUID DATA, SEE PAGE 2)**

42 **PUMPED STREAM** | ○ HAZARDOUS ○ FLAMMABLE ○ ______
43 ○ TYPE OR NAME ______ CONC'N ______ % | ○ FLUID SOLID @ AMBIENT
44 ○ DISSOLVED CONTAMINANT ○ H_2S ______ ml/m^3 ○ WET | ○ SOLIDIFIES @ ______ °C POUR POINT ______ °C
45 ○ Cl_2 ______ ml/m^3 ○ OTHER ______ @ ______ ml/m^3 | ○ PUMPED STREAM SOLIDIFIES UNDER SHEAR
46 ○ SOLID CONTAMINANT ______ | ○ PUMPED STREAM CONTAINS AGENTS THAT POLYMERIZE
47 ○ CONCENTRATION (MASS FRACTION) ______ | SPECIFY AGENTS ______ @ TEMP ______ °C
48 ○ PUMPING TEMPERATURE | ○ PUMPED STREAM CAN PLATE OUT OR DECOMPOSE:
49 MIN ______ °C NORMAL ______ °C MAX ______ °C | SPECIFY CONDITIONS ______
50 ○ RELATIVE DENSITY (TO WATER @ 25°C) AT REF. TEMP. | ○ PUMPED STREAM IS REGULATED FOR FUGITIVE OR
51 @ NORMAL TEMP ______ @ MAX TEMP ______ | OTHER EMISSIONS. REGULATION LEVEL ______ ml/m^3
52 ○ ABSOLUTE VAPOR PRESSURE AT REFERENCE TEMP. | ○ SPECIAL PUMP CLEANING PROCEDURES
53 NORMAL TEMP ______ kPa MAX TEMP ______ kPa | SPECIFY; ______
54 ○ ATMOSPHERIC BOILING POINT. ______ °C | ○ ALTERNATIVE PROCESS FLUIDS & CONCENTRATION
55 ○ VISCOSITY @ NORMAL PUMPING TEMP. ______ Pa.s | (INCL. COMMISIONING)

56 **FLUSH FLUID** (PLAN 32) If flush fluid is pumpage, then flush fluid data is not required.
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 MECHANICAL SEAL DATA SHEET FOR CENTRIFUGAL & ROTARY PUMPS S.I. 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 ____ PURCHASE ORDER NUMBER ____ DATE ____ REVISION NO. 0 DATE

Line		
1	INDICATES DATA COMPLETED BY PURCHASER	BY SEAL VENDOR — BY SEAL VENDOR OR PURCHASER
2	DEFAULT SELECTION	
3	**FLUID DATA - (QUENCH, BUFFER AND BARRIER FLUID DATA, LIQUID AND GAS)**	
4	**QUENCH MEDIUM** (PLAN 51, 62)	SUPPLY TEMPERATURE MAX/MIN ____ / ____ °C
5	TYPE OR NAME	FLOW RATE REQ'D MAX/MIN ____ / ____ l/min
6	**BUFFER/BARRIER MEDIUM**	
7	TYPE OR NAME ____	RELATIVE DENSITY (TO WATER @ 25°C) AT REF. TEMP.
8	PURCHASER SELEC'N — SEAL VENDOR SELEC'N	@ NORMAL TEMP ____ @ MAX TEMP ____
9	SEAL VENDOR REVIEW — PURCHASER REVIEW	ABSOLUTE VAPOR PRESSURE AT REFERENCE TEMP.
10	FLOW RATE REQ'D MAX/MIN. ____ / ____ l/min	NORMAL TEMP ____ kPa MAX TEMP ____ kPa
11	COOLING/HEATING REQUIRED (+ OR -) ____ kW	ATMOSPHERIC BOILING POINT (LIQUID) ____ °C
12	SUPPLY PRESSURE MAX/MIN. ____ / ____ kPa (bar) [ga]	VISCOSITY @ NORMAL TEMP (LIQUID) ____ Pa.s
13	FLUID OPERATING TEMPERATURE	SPECIFIC HEAT CAPACITY @ CONSTANT PRESSURE
14	MIN ____ °C; NORMAL ____ °C; MAX ____ °C	FOR LIQUID @ NORMAL TEMPERATURE ____ J/kg.K
15	**SITE AND UTILITIES**	
16	CONTROL VOLTAGE ____ V PHASE ____ HERTZ ____	COOLING H_2O SUPPLY TEMP. ____ °C Cl_2 ____ ml/m³
17	ELECTRICAL AREA CL ____ GR ____ DIV ____	COOLING H_2O PRESS. NORM./DES. ____ / ____ kPa (bar) [ga]
18	DESIGN AMBIENT MIN./MAX. ____ / ____ °C	ATEX (EC DIRECTIVE 94/9/EC) GR ____ CAT. ____ T CLASS ____
19	**ACCESSORIES (CLAUSES 8 AND 9)**	
20	**GENERAL**	**PLAN 52 AND 53 SYSTEMS CONTINUED**
21	JOINT USER/VENDOR LAYOUT OF EQUIPMENT (8.1.4)	EQUIPMENT SUPPORT SUPPLIER ____
22	PIPE TAPER THREADS (8.1.9) — ISO 7 — ASME B1.20.1	FILLING SYSTEM SUPPLIER ____
23	SPECIAL REQUIREMENTS FOR HAZARDOUS SERVICE	ASME CODE STAMP REQUIRED
24	____	EN 13445 OR OTHER CODE APPLICABLE ____
25	SPECIAL CLEANING AND DECONTAMINATION REQ'TS	RESERVOIR CAPACITY (8.5.4.3) ____ l
26	UTILITY MANIFOLD CONNECTIONS REQUIRED (8.4.4)	NLL TO GLAND PLATE HEIGHT (8.5.4.2) ____ m
27	TYPE AND SPEC. OF HEAT TRACING (8.6.5.8)	RESERVOIR MAWP (3.41) ____ kPa (bar) [ga] @ ____ °C
28	____	SET PRESSURE RANGE, MAX/MIN ____ / ____ kPa (bar) [ga]
29	THERMAL RELIEF VALVES REQUIRED (9.8.3)	SYSTEM HOLD-UP PERIOD (PLANS 53B & 53C) ____ DAYS
30	**COOLING SYSTEM (PLAN 21, 22, 23, 41, 53B, 53C)**	TEMPERATURE INDICATOR (PLAN 53B & 53C)
31	HEAT EXCHANGER SUPPLIER ____	PRESSURE SWITCH (8.5.4.2.h) TO ACTIVATE ON;
32	WATER COOLED — AIR COOLED — ISO 15649	RISING PRESSURE (ARR 2) SET @ ____ kPa (bar) [ga]
33	EQUIPMENT REFERENCE/CODE ____	FALLING PRESSURE (ARR 3) SET @ ____ kPa (bar) [ga]
34	COOLING WATER LINES SUPPLIER ____	HIGH LEVEL ALARM REQUIRED (8.5.4.2.i)
35	TUBING — GALVANISED PIPING (8.4.2)	TEST BASED H/Q CURVE FOR INTERNAL CIRC. DEVICE
36	COOLING WATER FLOW RATE ____ l/min	EXTERNAL CIRCULATING PUMP (8.6.3.1)
37	SIGHT FLOW INDICATORS (8.4.3) — OPEN — CLOSED	**PLAN 72 AND 74 SYSTEM**
38	**PLAN 11, 13, 14, 21, 23, 31, 32 AND 41 SYSTEMS**	EQUIPMENT SUPPLIER
39	CONNECTING LINES SUPPLIER ____	HIGH FLOW ALARM SWITCH (8.6.6.5) ____
40	TUBING — PIPING (8.5.2.2) ____	**PLAN 75 AND 76 SYSTEM**
41	RESTRICTION ORIFICE NIPPLE IN FLUSH LINE (8.5.2.4)	EQUIPMENT SUPPLIER ____
42	CYCLONE SEPARATOR SUPPLIER ____	HIGH LEVEL ALARM SWITCH FOR PLAN 75 (8.6.5.3)
43	PLAN 32 EQUIPMENT SUPPLIER ____	TEST CONNECTION (8.6.5.4)
44	PLAN 32 FLOW IND'R — PLAN 32 TEMPERATURE IND'R	**INSTRUMENTATION**
45	**PLAN 52 AND 53 SYSTEMS**	USER SPECIFICATION REFERENCE FOR
46	STANDARD (FIG G.27) — ALTERNATIVE (FIG G.28)	INSTRUMENTATION/CONTROLS ____
47	DIMENSIONAL VARIATIONS TO STANDARD (FIG G.27)	PRESSURE GAUGES (9.4);
48	____	OIL FILLED PRESSURE GAUGES (9.4.3)
49	DIMENSIONAL VARIATIONS TO ALTERNATIVE (FIG G.28)	PRESSURE SWITCHES (9.5.2); — TRANSMITTER (9.5.2.3)
50	____	LEVEL SWITCHES (9.5.3); — TRANSMITTER (9.5.3.2)
51	ALTERNATIVE FABRICATION STANDARD ____	HYDROSTATIC — CAPACITANCE — ULTRASONIC
52	PRIMARY EQUIPMENT SUPPLIER ____	LEVEL INDICATORS (9.6)
53	SUPPLIER REFERENCE/CODE ____	WELD PAD — EXTERNAL, REMOVABLE (9.6.2)
54	CONNECTING LINES SUPPLIER ____	FLOW INSTRUMENTS (9.7); — TRANSMITTER (9.7.3)
55	TUBING — SCH 80 PIPING (8.5.4.4.9)	
56	**INSPECTION AND TESTING**	
57	PURCHASER PARTICIPATION IN INSPECTION & TEST	100% INSPECTION OF ALL WELDS (6.1.6.10.5) USING;
58	SPECIFY; ____	MAGNETIC PARTICLE — LIQUID PENETRANT
59	INSPECTOR'S CHECK LIST (10.1.7 & ANNEX H)	RADIOGRAPHIC — ULTRASONIC
60	PURCHASER APPROVAL REQUIRED FOR WELDED	OPTIONAL QUALIFICATION TESTING REQ'D (10.3.1.1.2)
61	CONNECTION DESIGNS, (6.1.6.10.5)	MOD. FACES FOR PUMP TEST (10.3.5.1), SEE PG 1, LINE 30
62	HARDNESS TEST (10.2.3 k) REQUIRED FOR;	ALTERNATIVE SEAL PUMP TEST (10.3.5.2), SEE PG 1, LINE 25
63		

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 ◻ ALTERNATIVE BUSH	◻ 01 ◻ 11 ◻ 14 ◻ 23 ◻ 32 ◻ 50 ◻ 61 ◻ 02 ◻ 13 ◻ 21 ◻ 31 ◻ 41 ◻ 51 ◻ 62
2 (3.3)	BUFFER LIQUID	◻ 2CW-CW	◻ FX ◻ DIST. FLUSH ◻ TANGENTIAL LBO CONN'N	◻ 01 ◻ 13 ◻ 23 ◻ 41 ◻ 62 ◻ 75 ◻ 02 ◻ 14 ◻ 31 ◻ 52 ◻ 71 ◻ 76
	BUFFER GAS	◻ 2CW-CS	◻ 2NC-CS ◻ FX ◻ DIST. FLUSH	◻ 11 ◻ 21 ◻ 32 ◻ 61 ◻ 72
3 (3.4)	BARRIER LIQUID	◻ 3CW-FB	◻ 3CW-BB ◻ FX ◻ 3CW-FF ◻ TANG. LBO	◻ 01 ◻ 13 ◻ 53A ◻ 54 ◻ 74 ◻ 02 ◻ 14 ◻ 53B ◻ 61
	BARRIER GAS	◻ 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 OR N06455	◻ UNS S31600/ S31635
◻ SPIRAL-W GASKET	◻ SIC VS SIC	◻ UNS N07718 (TYPE C)		◻ UNS N10276
◻ NBR	◻ SS-SIC ◻ RB-SIC	◻ UNS N08020	◻ UNS S31600 OR S31635	◻ UNS N08020
◻ OTHER:	◻ VS	◻ OTHER:		◻ 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_2S ______ PPM ○ WET	○ SOLIDIFIES @ ______ °F POUR POINT ______ °F
○ Cl_2 ______ PPM ○ OTHER ______ @ ______ PPM	○ PUMPED STREAM SOLIDIFIES UNDER SHEAR
○ SOLID CONTAMINANT ______	○ PUMPED STREAM CONTAINS AGENTS THAT POLYMERIZE
○ CONCENTRATION (% BY WT, OR PPM) ______	SPECIFY AGENTS ______ @ TEMP ______ °F
○ PUMPING TEMPERATURE	○ PUMPED STREAM CAN PLATE OUT OR DECOMPOSE:
MIN ______ °F NORMAL ______ °F MAX ______ °F	SPECIFY CONDITIONS ______
○ SPECIFIC GRAVITY AT TEMPERATURE INDICATED	○ PUMPED STREAM IS REGULATED FOR FUGITIVE OR
@ NORMAL TEMP ______ @ MAX TEMP ______	OTHER EMISSIONS. REGULATION LEVEL ______ PPMV
○ VAPOR PRESSURE AT TEMPERATURE INDICATED	○ SPECIAL PUMP CLEANING PROCEDURES
NORMAL TEMP ______ PSIA MAX TEMP ______ PSIA	SPECIFY; ______
○ ATMOSPHERIC BOILING POINT. ______ °F	○ 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 ☐ BY SEAL VENDOR ⊡ BY SEAL VENDOR OR PURCHASER
⊡ ● DEFAULT SELECTION

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_2O SUPPLY TEMP. ______ °F ○ Cl_2 ______ PPM
○ COOLING H_2O 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)

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 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 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)

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 (3.41) ______ 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)
○ TEST BASED H/Q CURVE FOR INTERNAL CIRC. DEVICE
○ EXTERNAL CIRCULATING PUMP (8.6.3.1)

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

○ 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

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)

TYPE (CODE-CW): ◻ TYPE A (3.72) ◻ TYPE B (3.73) ◻ ALTERNATIVE STATIONARY (TYPE A & B)
◻ 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-FL	◻ ALTERNATIVE BUSH	◻ 01 ◻ 11 ◻ 14 ◻ 23 ◻ 32 ◻ 51 ◻ 62 ◻ 02 ◻ 13 ◻ 21 ◻ 31 ◻ 41 ◻ 61 ◻ 65
2 (3.3)	BUFFER LIQUID	◻ 2CW-CW	◻ FX ◻ DIST. FLUSH	◻ 01 ◻ 13 ◻ 23 ◻ 41 ◻ 62 ◻ 75 ◻ 02 ◻ 14 ◻ 31 ◻ 52 ◻ 71 ◻ 76
	BUFFER GAS	◻ 2CW-CS	◻ 2NC-CS ◻ FX ◻ DIST. FLUSH	◻ 11 ◻ 21 ◻ 32 ◻ 61 ◻ 72
3 (3.4)	BARRIER LIQUID	◻ 3CW-FB	◻ 3CW-BB ◻ 3CW-FF ◻ FX	◻ 01 ◻ 11 ◻ 14 ◻ 53A ◻ 53C ◻ 61 ◻ 74
	BARRIER GAS	◻ 3NC-BB	◻ 3NC-FF ◻ 3NC-FB	◻ 02 ◻ 13 ◻ 32 ◻ 53B ◻ 54 ◻ 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 OR N06455	◻ UNS S31600/ S31635
◻ SPIRAL-W GASKET	◻ SIC VS SIC	◻ UNS N07718 (TYPE C)		◻ UNS N10276
◻ NBR	◻ SS-SIC ◻ RB-SIC	◻ UNS N08020	◻ UNS S31600 OR S31635	◻ UNS N08020
◻ OTHER:	◻ VS	◻ OTHER:		◻ OTHER:

MECHANICAL SEAL DATA

○ SEAL VENDOR ______
○ DATA REQUIREMENTS FORM (ANNEX J)
☐ SIZE/TYPE ______
☐ SEAL DRAWING NUMBER ______
◻ SEAL CODE (ANNEX D) C3
☐ VENDOR'S SEAL CODE ______
☐ MODIFIED FACES FOR PUMP PERFORMANCE TEST
☐ ALTERNATIVE SEAL FOR PUMP PERFORMANCE TEST

☐ DYNAMIC SEALING PRESSURE RATING (3.19) ______ kPa (bar) [ga]
☐ STATIC SEALING PRESSURE RATING (3.69) ______ kPa (bar) [ga]
☐ MAXIMUM ALLOWABLE TEMPERATURE (3.40) ______ °C
○ MINIMUM DESIGN METAL TEMPERATURE (6.1.6.11.1) ______ °C
☐ GENERATED HEAT @ NORM. CONDITIONS ______ kW
☐ HEAT SOAK @ NORMAL CONDITIONS ______ kW
☐ TOTAL SEAL AXIAL THRUST ON SHAFT ______ N

SEAL CHAMBER DATA (REFERENCE 6.1.2.4)

◻ ISO 13709 (ISO 3069-H) ◻ OTHER, SPECIFY ______ ○ BOLT-ON CHAMBER (6.1.2.5)
◻ SEAL CHAMBER FLUSH PORT REQ'D ◻ SEAL CHAMBER VENT REQ'D ◻ CHAMBER HEATING REQ'D
◻ FLOATING THROAT BUSH ◻ FIXED THROAT BUSH

PUMP DATA

PUMP DESIGN ○ MANUFACTURER ______ ○ MODEL ______ ○ FRAME/SIZE ______ ○ CASE MATERIAL ______
PUMP OPERATING PRESSURE ○ SUCTION PRESS. (RATED) ______ kPa (bar) [ga] ○ DISCHARGE PRESSURE ______ kPa (bar) [ga]
SEAL CHAMBER ○ NORMAL ______ kPa (bar) [ga] ○ MIN / MAX (3.42) ______ / ______ kPa (bar) [ga] ○ MSSP (3.44) ______ kPa (bar) [ga]
SHAFT ○ HORIZONTAL ○ VERTICAL ○ DIA. ______ mm ○ SHAFT SPEED ______ r/min
SHAFT DIRECTION (FROM DRIVER): ○ CW ○ CCW

FLUID DATA - (FOR QUENCH, BUFFER AND BARRIER FLUID DATA, SEE PAGE 2)

PUMPED STREAM
○ TYPE OR NAME ______ CONC'N ______ %
○ DISSOLVED CONTAMINANT ○ H_2S ______ ml/m³ ○ WET
○ Cl_2 ______ ml/m³ ○ OTHER ______ @ ______ ml/m³
○ SOLID CONTAMINANT ______
○ CONCENTRATION (MASS FRACTION) ______
○ PUMPING TEMPERATURE
MIN ______ °C NORMAL ______ °C MAX ______ °C
○ RELATIVE DENSITY (TO WATER @ 25°C) AT REF. TEMP.
@ NORMAL TEMP ______ @ MAX TEMP ______
○ ABSOLUTE VAPOR PRESSURE AT REFERENCE TEMP.
NORMAL TEMP ______ kPa MAX TEMP ______ kPa
○ ATMOSPHERIC BOILING POINT. ______ °C
○ VISCOSITY @ NORMAL PUMPING TEMP. ______ Pa.s

○ HAZARDOUS ○ FLAMMABLE ○ ______
○ FLUID SOLID @ AMBIENT
○ SOLIDIFIES @ ______ °C POUR POINT ______ °C
○ PUMPED STREAM SOLIDIFIES UNDER SHEAR
○ PUMPED STREAM CONTAINS AGENTS THAT POLYMERIZE
SPECIFY AGENTS ______ @ TEMP ______ °C
○ PUMPED STREAM CAN PLATE OUT OR DECOMPOSE:
SPECIFY CONDITIONS ______
○ PUMPED STREAM IS REGULATED FOR FUGITIVE OR OTHER EMISSIONS. REGULATION LEVEL ______ ml/m³
○ SPECIAL PUMP CLEANING PROCEDURES
SPECIFY; ______
○ ALTERNATIVE PROCESS FLUIDS & CONCENTRATION (INCL. COMMISSIONING)

FLUSH FLUID (PLAN 32) If flush fluid is pumpage, then flush fluid data is not required.
○ TYPE OR NAME ______ CONC'N ______ %
○ SEAL VENDOR REVIEW REQUIRED
○ FLUID TEMPERATURE
MIN ______ °C NORMAL ______ °C MAX ______ °C
○ RELATIVE DENSITY (TO WATER @ 25°C) AT REF. TEMP.
@ NORMAL TEMP @ MAX TEMP

○ ABSOLUTE VAPOR PRESSURE AT REFERENCE TEMP.
NORMAL TEMP ______ kPa MAX TEMP ______ kPa
○ ATMOSPHERIC BOILING POINT. ______ °C
○ VISCOSITY @ NORMAL PUMPING TEMP. ______ Pa.s
☐ FLOW RATE REQ'D MAX/MIN ______ / ______ l/min
☐ PRESSURE REQ'D MAX/MIN / kPa (bar) [ga]

Category 3 Seals	
MECHANICAL SEAL DATA SHEET	REQUIRED FOR: ______ SITE: ______ UNIT: ______
FOR CENTRIFUGAL & ROTARY PUMPS	JOB/PROJECT NO. ______ ITEM NO. ______
S.I. UNITS	REQUISITION /SPEC. NUMBER ______ / ______
PAGE 2 OF 2	INQUIRY NUMBER ______ BY ______
(FLUID DATA, UTILITIES, ACCESSORIES, & INSP./TEST.)	PURCH ORDER NUMBER ______ DATE ______
	REVISION NO. 0 DATE

Line		
1	○ INDICATES DATA COMPLETED BY PURCHASER	☐ BY SEAL VENDOR ⧈ BY SEAL VENDOR OR PURCHASER
2	⧈ ● DEFAULT SELECTION	
3	**FLUID DATA - (QUENCH, BUFFER, AND BARRIER FLUID DATA, LIQUID AND GAS)**	
4	**QUENCH MEDIUM** (PLAN 51, 62)	⧈ SUPPLY TEMPERATURE MAX/MIN ______ / ______ °C
5	⧈ TYPE OR NAME	☐ FLOW RATE REQ'D MAX/MIN ______ / ______ l/min
6	**BUFFER AND BARRIER LIQUID/GAS**	
7	⧈ TYPE OR NAME ______	⧈ RELATIVE DENSITY (TO WATER @ 25°C) AT REF. TEMP.
8	○ PURCHASER SELEC'N ☐ SEAL VENDOR SELEC'N	@ NORMAL TEMP ______ @ MAX TEMP ______
9	○ SEAL VENDOR REVIEW ☐ PURCHASER REVIEW	⧈ ABSOLUTE VAPOR PRESSURE AT REFERENCE TEMP.
10	☐ FLOW RATE REQ'D MAX/MIN. ______ / ______ l/min	NORMAL TEMP ______ kPa MAX TEMP ______ kPa
11	☐ COOLING/HEATING REQUIRED (+ OR -) ______ kW	⧈ ATMOSPHERIC BOILING POINT (LIQUID) ______ °C
12	⧈ SUPPLY PRESSURE MAX/MIN. ______ / ______ kPa (bar) [ga]	⧈ VISCOSITY @ NORMAL TEMP (LIQUID) ______ Pa.s
13	⧈ FLUID OPERATING TEMPERATURE	⧈ SPECIFIC HEAT CAPACITY @ CONSTANT PRESSURE
14	MIN °C; NORMAL °C; MAX °C	FOR LIQUID @ NORMAL TEMPERATURE ______ J/Kg.K
15	**SITE AND UTILITIES**	
16	○ CONTROL VOLTAGE ______ V PHASE ______ HERTZ ______	○ COOLING H_2O SUPPLY TEMP. ______ °C ○ Cl_2 ______ ml/m^3
17	○ ELECTRICAL AREA CL ______ GR ______ DIV ______	○ COOLING H_2O PRESS. NORM./DES. ______ / ______ kPa (bar) [ga]
18	○ DESIGN AMBIENT MIN./MAX. ______ / ______ °C	○ ATEX (EC DIRECTIVE 94/9/EC) GR CAT. T CLASS
19	**ACCESSORIES (CLAUSES 8 AND 9)**	
20	**GENERAL**	**PLAN 52 AND 53 SYSTEMS CONTINUED**
21	○ JOINT USER/VENDOR LAYOUT OF EQUIPMENT (8.1.4)	○ ALTERNATIVE CODE/INSPECTION - SPECIFY ______
22	○ PIPE TAPER THREADS (8.1.9) ○ ISO 7 ○ ASME B1.20.1	○ EQUIPMENT SUPPORT SUPPLIER ______
23	○ SPECIAL REQUIREMENTS FOR HAZARDOUS SERVICE	⧈ RESERVOIR CAPACITY (8.5.4.3) ______ l
24	______	⧈ NLL TO GLAND PLATE HEIGHT (8.5.4.2) ______ m
25	○ SPECIAL CLEANING AND DECONTAMINATION REQ'TS	☐ RESERVOIR MAWP (3.41) ______ kPa (bar) [ga] @ ______ °C
26	○ UTILITY MANIFOLD CONNECTIONS REQUIRED (8.4.4)	⧈ SET PRESSURE RANGE, MAX/MIN ______ / ______ kPa (bar) [ga]
27	○ TYPE AND SPEC. OF HEAT TRACING (8.6.5.8)	⧈ SYSTEM HOLD-UP PERIOD (PLANS 53B &53C) ______ DAYS
28	______	○ TEMPERATURE INDICATOR (PLAN 53B & 53C)
29	○ THERMAL RELIEF VALVES REQUIRED (9.8.3)	PRESSURE SWITCH (8.5.4.2.h) TO ACTIVATE ON;
30	**COOLING SYSTEM (PLAN 21, 22, 23, 41, 53B & 53C)**	⧈ RISING PRESSURE (ARR 2) SET @ ______ kPa (bar) [ga]
31	○ HEAT EXCHANGER SUPPLIER ______	⧈ FALLING PRESSURE (ARR 3) SET @ ______ kPa (bar) [ga]
32	⧈ WATER COOLED ⧈ AIR COOLED ○ ISO 15649	⧈ HIGH LEVEL ALARM REQUIRED (8.5.4.2.i)
33	⧈ EQUIPMENT REFERENCE/CODE ______	○ CONNECTING LINES SUPPLIER ______
34	○ COOLING WATER LINES SUPPLIER ______	● TUBING ○ SCH 80 PIPING (8.5.4.4.9)
35	● TUBING ○ GALVANISED PIPING (8.4.2)	○ FILLING SYSTEM SUPPLIER ______
36	⧈ COOLING WATER FLOW RATE ______ l/min	○ EXTERNAL CIRCULATING PUMP (8.6.3.1) ______
37	○ SIGHT FLOW INDICATORS (8.4.3) ○ OPEN ○ CLOSED	**PLAN 72 AND 74 SYSTEM**
38	**PLAN 11, 13, 14, 23, 31, 32 AND 41 SYSTEMS**	○ EQUIPMENT SUPPLIER ______
39	○ CONNECTING LINES SUPPLIER ______	○ HIGH FLOW ALARM SWITCH (8.6.6.5) ______
40	○ TUBING ○ PIPING (8.5.2.2) ______	**PLAN 75 AND 76 SYSTEM**
41	○ RESTRICTION ORIFICE NIPPLE IN FLUSH LINE (8.5.2.4)	○ EQUIPMENT SUPPLIER ______
42	○ CYCLONE SEPARATOR SUPPLIER ______	○ HIGH LEVEL ALARM SWITCH FOR PLAN 75 (8.6.5.3)
43	○ PLAN 32 EQUIPMENT SUPPLIER ______	○ TEST CONNECTION (8.6.5.4)
44	○ PLAN 32 FLOW IND'R ○ PLAN 32 TEMPERATURE IND'R	**INSTRUMENTATION**
45	**PLAN 52 AND 53 SYSTEMS**	○ USER SPECIFICATION REFERENCE FOR
46	⧈ STANDARD (FIG G.27) ⧈ ALTERNATIVE (FIG G.28)	INSTRUMENTATION/CONTROLS ______
47	☐ DIMENSIONAL VARIATIONS TO STANDARD (FIG G.27)	PRESSURE GAUGES (9.4);
48	______	○ OIL FILLED PRESSURE GAUGES (9.4.3)
49	☐ DIMENSIONAL VARIATIONS TO ALTERNATIVE (FIG G.28)	PRESSURE SWITCHES (9.5.2); ○ TRANSMITTER (9.5.2.3)
50	______	LEVEL SWITCHES (9.5.3); ○ TRANSMITTER (9.5.3.2)
51	⧈ ALTERNATIVE FABRICATION STANDARD ______	○ HYDROSTATIC ○ CAPACITANCE ○ ULTRASONIC
52	○ PRIMARY EQUIPMENT SUPPLIER ______	LEVEL INDICATORS (9.6)
53	⧈ SUPPLIER REFERENCE/CODE ______	● WELD PAD ○ EXTERNAL, REMOVABLE (9.6.2)
54	○ ASME CODE STAMP REQUIRED	FLOW INSTRUMENTS (9.7); ○ TRANSMITTER (9.7.3)
55	**INSPECTION AND TESTING**	
56	○ PURCHASER PARTICIPATION IN INSPECTION & TEST	○ 100% INSPECTION OF ALL WELDS (6.1.6.10.5) USING;
57	SPECIFY; ______	○ MAGNETIC PARTICLE ○ LIQUID PENETRANT
58	○ INSPECTOR'S CHECK LIST (10.1.7 & ANNEX H)	○ RADIOGRAPHIC ○ ULTRASONIC
59	○ PURCHASER APPROVAL REQUIRED FOR WELDED	○ OPTIONAL QUALIFICATION TESTING REQ'D (10.3.1.1.2)
60	CONNECTION DESIGNS, (6.1.6.10.5)	⧈ MOD. FACES FOR PUMP TEST (10.3.5.1), SEE PG 1, LINE 29
61	○ HARDNESS TEST (10.2.3 k) REQUIRED FOR:	⧈ ALTERNATIVE SEAL PUMP TEST (10.3.5.2), SEE PG 1, LINE 30
62		

	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	HARDWARE SUPPLIED ○ CUSTOMARY UNITS ○ SI UNITS
2	○ INDICATES DATA COMPLETED BY PURCHASER	☐ BY SEAL VENDOR ◙ BY SEAL VENDOR OR PURCHASER
3	◙ ○ DEFAULT SELECTION	

4	**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'G'T**		**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)	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	3 (3.4)	BARRIER	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	

16	**MATERIALS (REFERENCE 6.1.6 & ANNEX B)**				
17	**SECONDARY SEALS**	**SEAL FACES**	**METAL BELLOWS**	**SPRINGS**	**METAL PARTS**
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:

22	**MECHANICAL SEAL DATA**	
23	○ SEAL VENDOR ______	☐ DYNAMIC SEALING PRESSURE RATING (3.19) ______ PSIG
24	○ DATA REQUIREMENTS FORM (ANNEX J)	☐ STATIC SEALING PRESSURE RATING (3.69) ______ PSIG
25	☐ SIZE/TYPE ______	☐ MAXIMUM ALLOWABLE TEMPERATURE (3.40) ______ °F
26	☐ SEAL DRAWING NUMBER ______	○ MINIMUM DESIGN METAL TEMPERATURE (6.1.6.11.1) ______ °F
27	◙ SEAL CODE (ANNEX D) C3	☐ GENERATED HEAT @ NORM. CONDITIONS ______ BTU/HR
28	☐ VENDOR'S SEAL CODE ______	☐ HEAT SOAK @ NORM. CONDITIONS ______ BTU/HR
29	☐ MODIFIED FACES FOR PUMP PERFORMANCE TEST	☐ TOTAL SEAL AXIAL THRUST ON SHAFT ______ LBF
30	☐ ALTERNATIVE SEAL FOR PUMP PERFORMANCE TEST	

31	**SEAL CHAMBER DATA (REFERENCE 6.1.2.4)**		
32	◙ ISO 13709 (ISO 3069-H)	◙ OTHER, SPECIFY ______	○ BOLT-ON CHAMBER (6.1.2.5)
33	◙ SEAL CHAMBER FLUSH PORT REQ'D	◙ SEAL CHAMBER VENT REQ'D	◙ CHAMBER HEATING REQ'D
34	◙ FLOATING THROAT BUSH	◙ FIXED THROAT BUSH	

35	**PUMP DATA**
36	**PUMP DESIGN** ○ MANUFACTURER ______ ○ MODEL ______ ○ FRAME/SIZE ______ ○ CASE MATERIAL ______
37	**PUMP OPERATING PRESSURE** ○ SUCTION PRESSURE (RATED) ______ PSIG ○ DISCHARGE PRESSURE ______ PSIG
38	**SEAL CHAMBER** ○ NORMAL ______ PSIG ○ MIN / MAX (MDSP, 3.42) ______ / ______ PSIG ○ MSSP (3.44) ______ PSIG
39	**SHAFT** ○ HORIZONTAL ○ VERTICAL ○ DIA. ______ IN ○ SHAFT SPEED ______ RPM
40	SHAFT DIRECTION (FROM DRIVER): ○ CW ○ CCW

41	**FLUID DATA - (FOR QUENCH, BUFFER AND BARRIER FLUID DATA, SEE PAGE 2)**	
42	**PUMPED STREAM**	○ HAZARDOUS ○ FLAMMABLE ○ ______
43	○ TYPE OR NAME ______ CONC'N ______ %	○ FLUID SOLID @ AMBIENT
44	○ DISSOLVED CONTAMINANT ○ H_2S ______ PPM ○ WET	○ SOLIDIFIES @ ______ °F POUR POINT ______ °F
45	○ Cl_2 ______ PPM ○ OTHER ______ @ ______ PPM	○ PUMPED STREAM SOLIDIFIES UNDER SHEAR
46	○ SOLID CONTAMINANT ______	○ PUMPED STREAM CONTAINS AGENTS THAT POLYMERIZE
47	○ CONCENTRATION (% BY WT, OR PPM) ______	SPECIFY AGENTS ______ @ TEMP ______ °F
48	○ PUMPING TEMPERATURE	○ PUMPED STREAM CAN PLATE OUT OR DECOMPOSE:
49	MIN ______ °F NORMAL ______ °F MAX ______ °F	SPECIFY CONDITIONS ______
50	○ SPECIFIC GRAVITY AT TEMPERATURE INDICATED	○ PUMPED STREAM IS REGULATED FOR FUGITIVE OR
51	@ NORMAL TEMP ______ @ MAX TEMP ______	OTHER EMISSIONS. REGULATION LEVEL ______ PPMV
52	○ VAPOR PRESSURE AT TEMPERATURE INDICATED	○ SPECIAL PUMP CLEANING PROCEDURES
53	NORMAL TEMP ______ PSIA MAX TEMP ______ PSIA	SPECIFY; ______
54	○ ATMOSPHERIC BOILING POINT. ______ °F	○ ALTERNATIVE PROCESS FLUIDS & CONCENTRATION
55	○ VISCOSITY @ NORMAL PUMPING TEMP. ______ Cp	(INCL. COMMISSIONING)
56	**FLUSH FLUID** (PLAN 32) If flush fluid is pumpage, then flush fluid data is not required.	
57	○ TYPE OR NAME ______ CONC'N ______ %	○ VAPOR PRESSURE AT TEMPERATURE INDICATED
58	○ SEAL VENDOR REVIEW REQUIRED	NORMAL TEMP ______ PSIA MAX TEMP ______ PSIA
59	○ FLUID TEMPERATURE	○ ATMOSPHERIC BOILING POINT. ______ °F
60	MIN ______ °F NORMAL ______ °F MAX ______ °F	○ VISCOSITY @ NORMAL PUMPING TEMP. ______ Cp
61	○ SPECIFIC GRAVITY AT TEMPERATURE INDICATED	☐ FLOW RATE REQ'D MAX/MIN ______ / ______ GPM
62	@ 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

Line		
1	○ INDICATES DATA COMPLETED BY PURCHASER	☐ BY SEAL VENDOR ▣ BY SEAL VENDOR OR PURCHASER
2	▣ ● DEFAULT SELECTION	
3	**FLUID DATA - (QUENCH, BUFFER AND BARRIER FLUID DATA, LIQUID AND GAS)**	
4	**QUENCH MEDIUM** (PLAN 51, 62)	▣ SUPPLY TEMPERATURE MAX/MIN ____ / ____ °F
5	▣ TYPE OR NAME	☐ FLOW RATE REQ'D MAX/MIN ____ / ____ GPM/SCFH
6	**BUFFER AND BARRIER LIQUID/GAS**	
7	▣ TYPE OR NAME ____	▣ SPECIFIC GRAVITY AT TEMP. INDICATED (LIQUID)
8	○ PURCHASER SELEC'N ☐ SEAL VENDOR SELEC'N	@ NORMAL TEMP ____ @ MAX TEMP ____
9	○ SEAL VENDOR REVIEW ☐ PURCHASER REVIEW	▣ VAPOR PRESSURE AT TEMPERATURE INDICATED (LIQUID)
10	☐ FLOW RATE REQ'D MAX/MIN. ____ / ____ GPM/SCFH	NORMAL TEMP ____ PSIA MAX TEMP ____ PSIA
11	☐ COOLING/HEATING REQUIRED (+ OR -) ____ Btu/h	▣ ATMOSPHERIC BOILING POINT (LIQUID) ____ °F
12	▣ SUPPLY PRESSURE MAX/MIN. ____ / ____ PSIG	▣ VISCOSITY @ NORMAL TEMP (LIQUID) ____ cP
13	▣ FLUID OPERATING TEMPERATURE	▣ SPECIFIC HEAT @ NORMAL TEMP ____ Btu/h.ft.°F
14	MIN °F; NORMAL °F; MAX °F	
15	**SITE AND UTILITIES**	
16	○ CONTROL VOLTAGE ____ V PHASE ____ HERTZ ____	○ COOLING H_2O SUPPLY TEMP. ____ °F ○ Cl_2 ____ PPM
17	○ ELECTRICAL AREA CL ____ GR ____ DIV ____	○ COOLING H_2O PRESS. NORM./DES. ____ / ____ PSIG
18	○ DESIGN AMBIENT MIN./MAX. / °F	○ ATEX (EC DIRECTIVE 94/9/EC) GR CAT. T CLASS
19	**ACCESSORIES (CLAUSES 8 AND 9)**	
20	**GENERAL**	**PLAN 52 AND 53 SYSTEMS CONTINUED**
21	○ JOINT USER/VENDOR LAYOUT OF EQUIPMENT (8.1.4)	○ ALTERNATIVE CODE/INSPECTION - SPECIFY ____
22	○ PIPE TAPER THREADS (8.1.9) ○ ISO 7 ○ ASME B1.20.1	○ EQUIPMENT SUPPORT SUPPLIER ____
23	○ SPECIAL REQUIREMENTS FOR HAZARDOUS SERVICE	▣ RESERVOIR CAPACITY (8.5.4.3) ____ GAL
24	____	▣ NLL TO GLAND PLATE HEIGHT (8.5.4.2) ____ FT
25	○ SPECIAL CLEANING AND DECONTAMINATION REQ'TS	☐ RESERVOIR MAWP (3.41) ____ PSIG @ ____ °F
26	○ UTILITY MANIFOLD CONNECTIONS REQUIRED (8.4.4)	▣ SET PRESSURE RANGE, MAX/MIN ____ / ____ PSIG
27	○ TYPE AND SPEC. OF HEAT TRACING (8.6.5.8)	▣ SYSTEM HOLD-UP PERIOD (PLANS 53B &53C) ____ DAYS
28	____	○ TEMPERATURE INDICATOR (PLAN 53B & 53C)
29	○ THERMAL RELIEF VALVES REQUIRED (9.8.3)	PRESSURE SWITCH (8.5.4.2.h) TO ACTIVATE ON;
30	**COOLING SYSTEM (PLAN 21, 22, 23, 41, 53B & 53C)**	▣ RISING PRESSURE (ARR 2) SET @ ____ PSIG
31	○ HEAT EXCHANGER SUPPLIER ____	▣ FALLING PRESSURE (ARR 3) SET @ ____ PSIG
32	▣ WATER COOLED ▣ AIR COOLED ○ ISO 15649	▣ HIGH LEVEL ALARM REQUIRED (8.5.4.2.i)
33	▣ EQUIPMENT REFERENCE/CODE ____	○ CONNECTING LINES SUPPLIER ____
34	○ COOLING WATER LINES SUPPLIER ____	● TUBING ○ SCH 80 PIPING (8.5.4.4.9)
35	● TUBING ○ GALVANISED PIPING (8.4.2)	○ FILLING SYSTEM SUPPLIER ____
36	▣ COOLING WATER FLOW RATE ____ GPM	○ EXTERNAL CIRCULATING PUMP (8.6.3.1) ____
37	○ SIGHT FLOW INDICATORS (8.4.3) ○ OPEN ○ CLOSED	**PLAN 72 AND 74 SYSTEM**
38	**PLAN 11, 13, 14, 23, 31, 32 AND 41 SYSTEMS**	○ EQUIPMENT SUPPLIER ____
39	○ CONNECTING LINES SUPPLIER ____	○ HIGH FLOW ALARM SWITCH (8.6.6.5) ____
40	○ TUBING ○ PIPING (8.5.2.2)	**PLAN 75 AND 76 SYSTEM**
41	○ RESTRICTION ORIFICE NIPPLE IN FLUSH LINE (8.5.2.4)	○ EQUIPMENT SUPPLIER ____
42	○ CYCLONE SEPARATOR SUPPLIER ____	○ HIGH LEVEL ALARM SWITCH FOR PLAN 75 (8.6.5.3)
43	○ PLAN 32 EQUIPMENT SUPPLIER ____	○ TEST CONNECTION (8.6.5.4)
44	○ PLAN 32 FLOW IND'R ○ PLAN 32 TEMPERATURE IND'R	**INSTRUMENTATION**
45	**PLAN 52 AND 53 SYSTEMS**	○ USER SPECIFICATION REFERENCE FOR
46	▣ STANDARD (FIG G.27) ▣ ALTERNATIVE (FIG G.28)	INSTRUMENTATION/CONTROLS ____
47	☐ DIMENSIONAL VARIATIONS TO STANDARD (FIG G.27)	PRESSURE GAUGES (9.4);
48	____	○ OIL FILLED PRESSURE GAUGES (9.4.3)
49	☐ DIMENSIONAL VARIATIONS TO ALTERNATIVE (FIG G.28)	PRESSURE SWITSHES (9.5.2); ○ TRANSMITTER (9.5.2.3)
50	____	LEVEL SWITCHES (9.5.3); ○ TRANSMITTER (9.5.3.2)
51	▣ ALTERNATIVE FABRICATION STANDARD ____	○ HYDROSTATIC ○ CAPACITANCE ○ ULTRASONIC
52	○ PRIMARY EQUIPMENT SUPPLIER ____	LEVEL INDICATORS (9.6)
53	▣ SUPPLIER REFERENCE/CODE ____	● WELD PAD ○ EXTERNAL, REMOVABLE (9.6.2)
54	○ ASME CODE STAMP REQUIRED	FLOW INSTRUMENTS (9.7); ○ TRANSMITTER (9.7.3)
55	**INSPECTION AND TESTING**	
56	○ PURCHASER PARTICIPATION IN INSPECTION & TEST	○ 100% INSPECTION OF ALL WELDS (6.1.6.10.5) USING:
57	SPECIFY; ____	○ MAGNETIC PARTICLE ○ LIQUID PENETRANT
58	○ INSPECTOR'S CHECK LIST (10.1.7 & ANNEX H)	○ RADIOGRAPHIC ○ ULTRASONIC
59	○ PURCHASER APPROVAL REQUIRED FOR WELDED	○ OPTIONAL QUALIFICATION TESTING REQ'D (10.3.1.1.2)
60	CONNECTION DESIGNS, (6.1.6.10.5)	▣ MOD. FACES FOR PUMP TEST (10.3.5.1), SEE PG 1, LINE 29
61	○ HARDNESS TEST (10.2.3 k) REQUIRED FOR:	▣ ALTERNATIVE SEAL PUMP TEST (10.3.5.2), SEE PG 1, LINE 30
62		

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:

$$F_{\text{opening}} = A \times \Delta p \times K \qquad \text{(F.1)}$$

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

$$A = \frac{\pi(D_o^2 - D_i^2)}{4} \qquad \text{(F.2)}$$

F.1.3.2 Seal balance ratio, B

$$B = \left(\frac{D_o^2 - D_b^2}{D_o^2 - D_i^2}\right) \qquad \text{(F.3)}$$

F.1.3.3 Spring pressure, p_{sp}

$$p_{sp} = \frac{F_{sp}}{A} \qquad \text{(F.4)}$$

F.1.3.4 Total face pressure, p_{tot}

$$p_{tot} = \Delta p(B - K) + p_{sp} \qquad \text{(F.5)}$$

F.1.3.5 Mean face diameter, D_m

$$D_m = \frac{(D_o + D_i)}{2} \qquad \text{(F.6)}$$

F.1.3.6 Running torque, T_r

$$T_r = p_{tot} \times A \times f \left(\frac{D_m}{2\,000}\right) \qquad \text{(F.7)}$$

F.1.3.7 Starting torque, T_s, estimated at 3 to 5 times running torque

$$T_s = T_r \times 4 \qquad \text{(F.8)}$$

F.1.3.8 Power, P

$$P = \frac{(T_r \times N)}{9\;550} \qquad \text{(F.9)}$$

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 mm

D_i = 48,9 mm

D_b = 52,4 mm

F_{sp} = 190 N

Δp = 2 MPa (20 bar)

n = 3 000 r/min

f = 0,07

K = 0,5

Equation (F.2) gives:

$$A = \left(\frac{\pi}{4}\right) \times \left(61{,}6^2 - 49{,}9^2\right) = 1\,102\ \text{mm}^2$$

Equation (F.3) gives:

$$B = \frac{\left(61{,}6^2 - 52{,}4^2\right)}{\left(61{,}6^2 - 48{,}9^2\right)} = 0{,}746$$

Equation (F.4) gives:

$$p_{\text{sp}} = \left(\frac{190}{1\ 102}\right) = 0{,}172\ \text{N/mm}^2$$

Equation (F.5) gives:

$$p_{\text{tot}} = 2\left(0{,}746 - 0{,}5\right) + 0{,}172 = 0{,}664\ \text{N/mm}^2$$

Equation (F.6) gives:

$$D_{\text{m}} = \frac{\left(61{,}6 + 48{,}9\right)}{2} = 55{,}25\ \text{mm}$$

Equation (F.7) gives:

$$T_{\text{r}} = 0{,}664 \times 1\ 102 \times 0{,}07 \left(\frac{55{,}25}{2\ 000}\right) = 1{,}42\ \text{N}\cdot\text{m}$$

Equation (F.8) gives:

$$T_{\text{s}} = 1{,}42 \times 4 = 5{,}68\ \text{N}\cdot\text{m}$$

Equation (F.9) gives:

$$P = \frac{\left(1{,}42 \times 3\ 000\right)}{9\ 550} = 0{,}446\ \text{kW}$$

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:

$$\Delta T = \frac{(60\,000 \times Q)}{(d \times q_{\text{inj}} \times c_p)} \tag{F.10}$$

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:

$$Q_{\text{heatsoak}} = U \times A \times D_{\text{b}} \times \Delta T \tag{F.11}$$

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 mm (seal balance diameter)

pump temperature = 175 °C

desired seal chamber temperature = 65 °C

ΔT = 175 – 65 = 110 K

Q_{heatsoak} = 0,000 25 × 55 × 110 = 1,5 kW

If the heat soak is known, the temperature rise (ΔT, in kelvin) can be calculated by the following equation:

$$\Delta T = 60\,000 \times \frac{\left(Q + Q_{\text{heatsoak}}\right)}{\left(d \times q_{\text{inj}} \times c_p\right)} \qquad \text{(F.12)}$$

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:

$$q_{\text{inj}} = \frac{\left(60\,000 \times Q\right)}{\left(d \times \Delta T \times c_p\right)} \qquad \text{(F.13)}$$

For Piping Plan 21, 22, 32, or 41, the equation would be:

$$q_{\text{inj}} = 60\,000 \times \frac{\left(Q + Q_{\text{heatsoak}}\right)}{\left(d \times \Delta T \times c_p\right)} \qquad \text{(F.14)}$$

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 kW

q_{inj} = 11 l/min

d = 0,75

c_p = 2 300 J/kg·K

F.2.3.2 Calculation

Equation (F.10) gives:

$$\Delta T = \frac{\left(60\,000 \times 0{,}9\right)}{\left(0{,}75 \times 11 \times 2\,300\right)}$$

$$= 2{,}8\ \text{K}$$

F.2.4 Example of calculation of q_{inj}

F.2.4.1 Given

Q = 0,9 kW

ΔT_{max} = 5 K

d = 0,90

c_p = 2 593 J/kg·K

F.2.4.2 Calculation

Equation (F.13) gives:

$$q_{inj} = \frac{(60\,000 \times 0{,}9)}{(0{,}9 \times 5 \times 2\,593)}$$

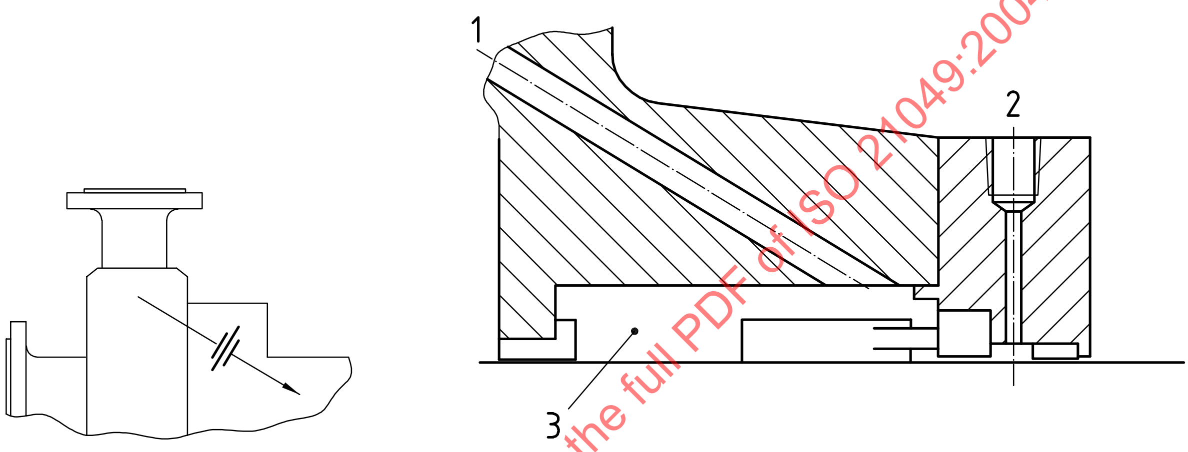
$$= 4{,}6 \text{ l/min}$$

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

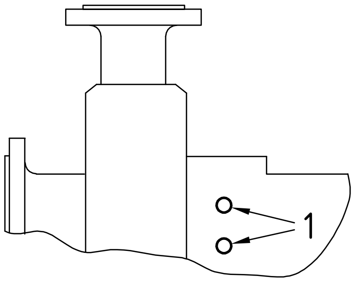
1 inlet

2 quench/drain (Q/D)

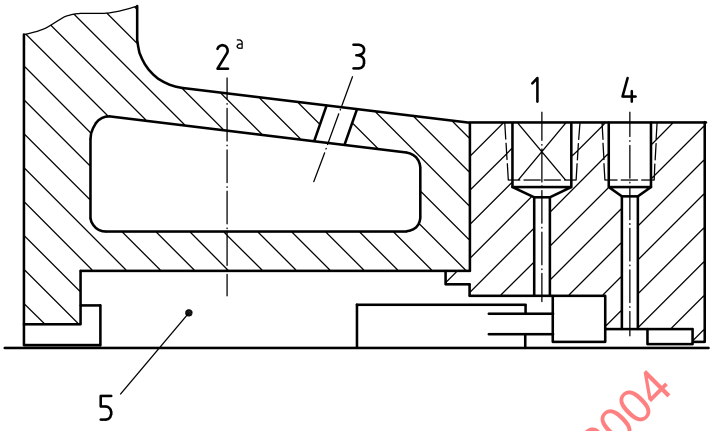
3 seal chamber

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)

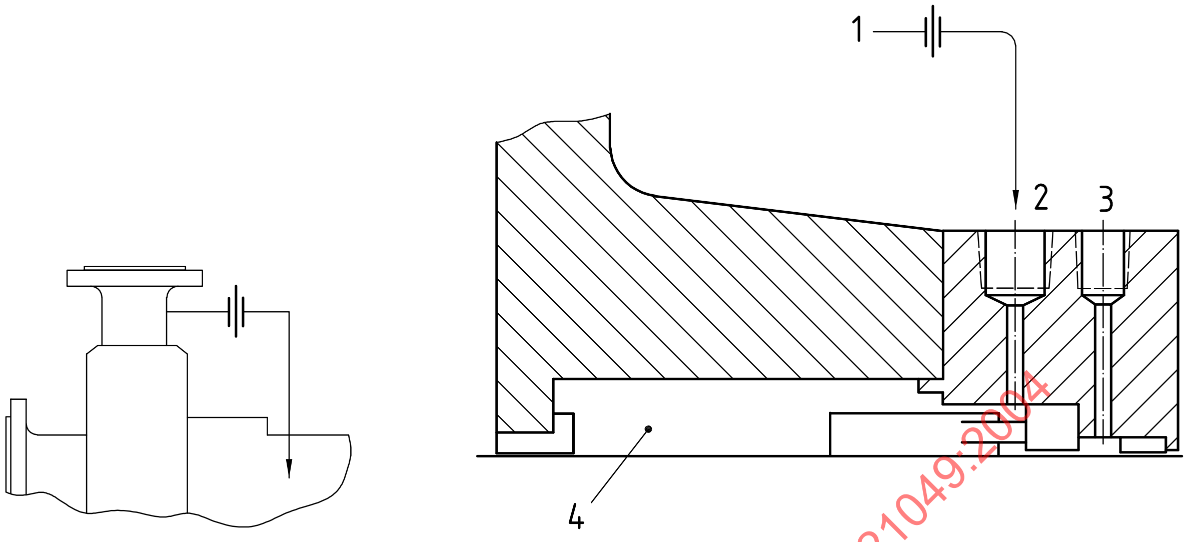
4 quench/drain (Q/D)

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

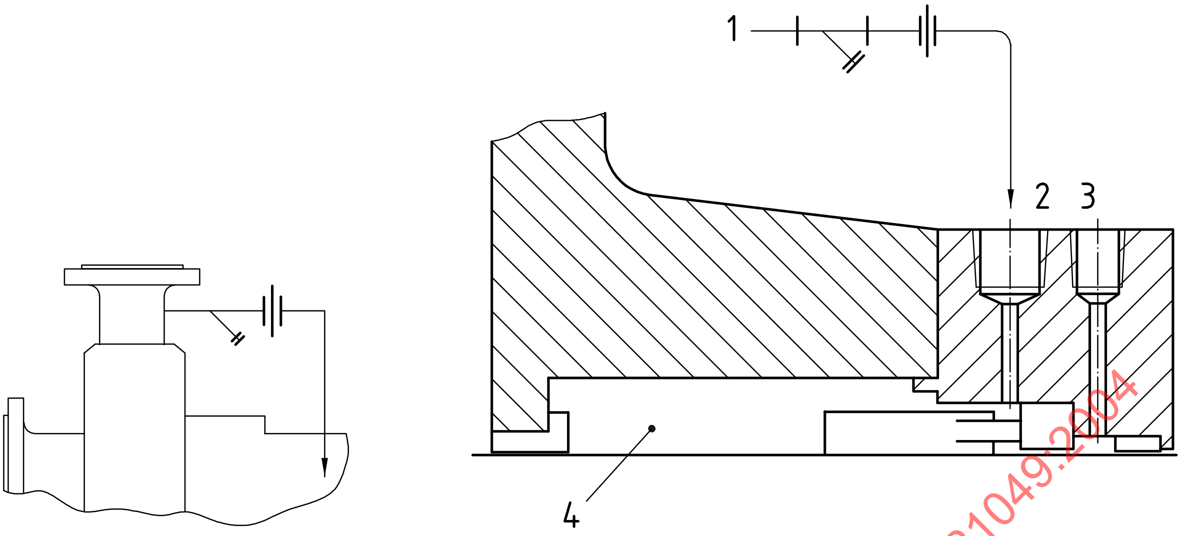
2 flush (F)

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**

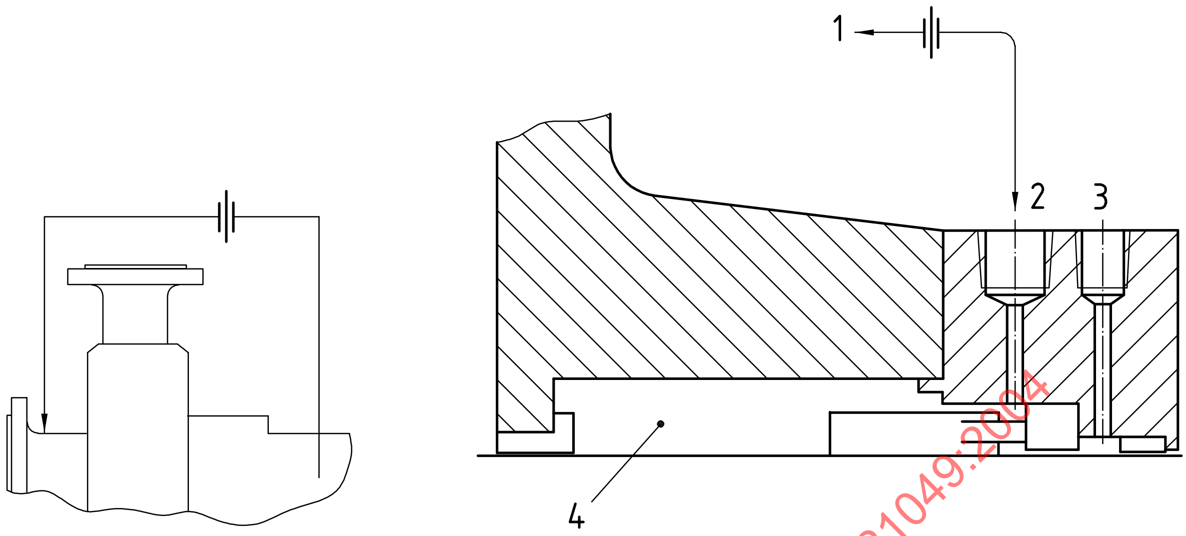
Key

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



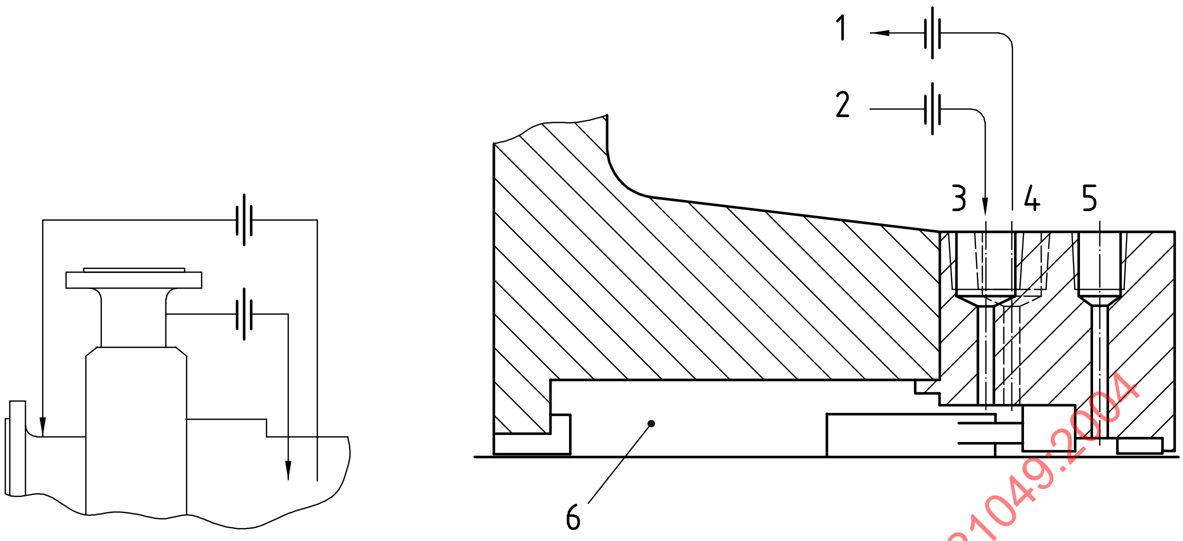
a) **Piping and instrumentation schematic** b) **Seal chamber details**

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



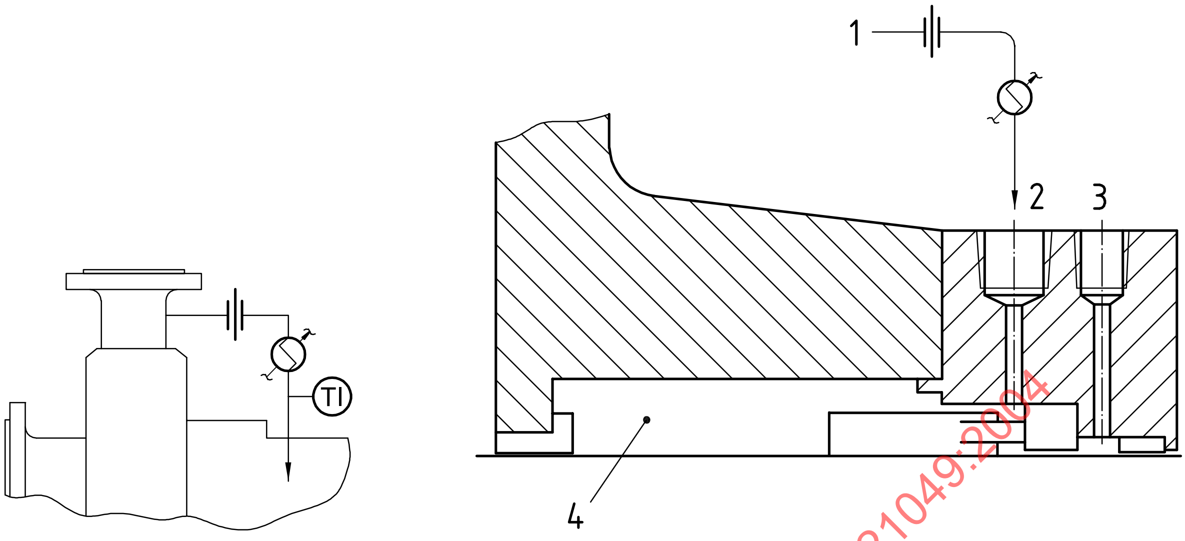
a) Piping and instrumentation schematic **b) Seal chamber details**

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)

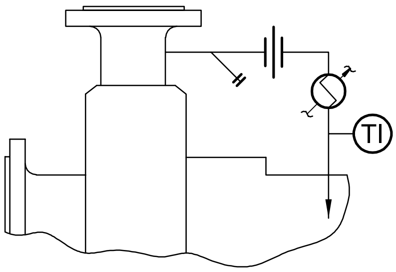
3 quench/drain (Q/D)

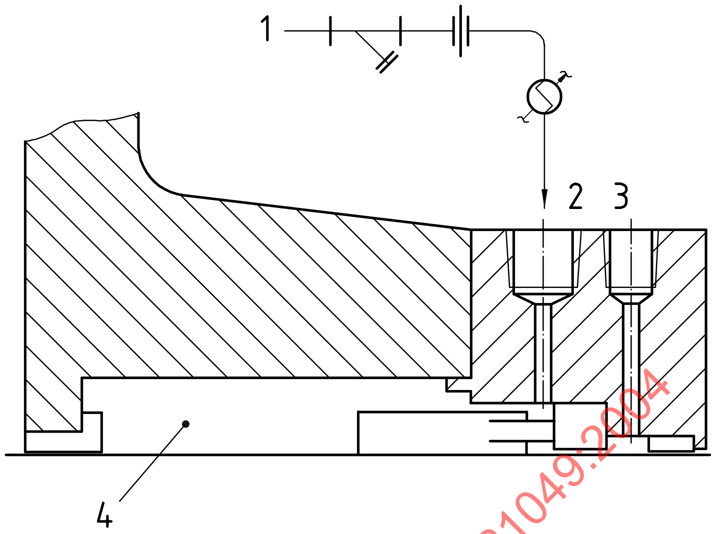
4 seal chamber

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**

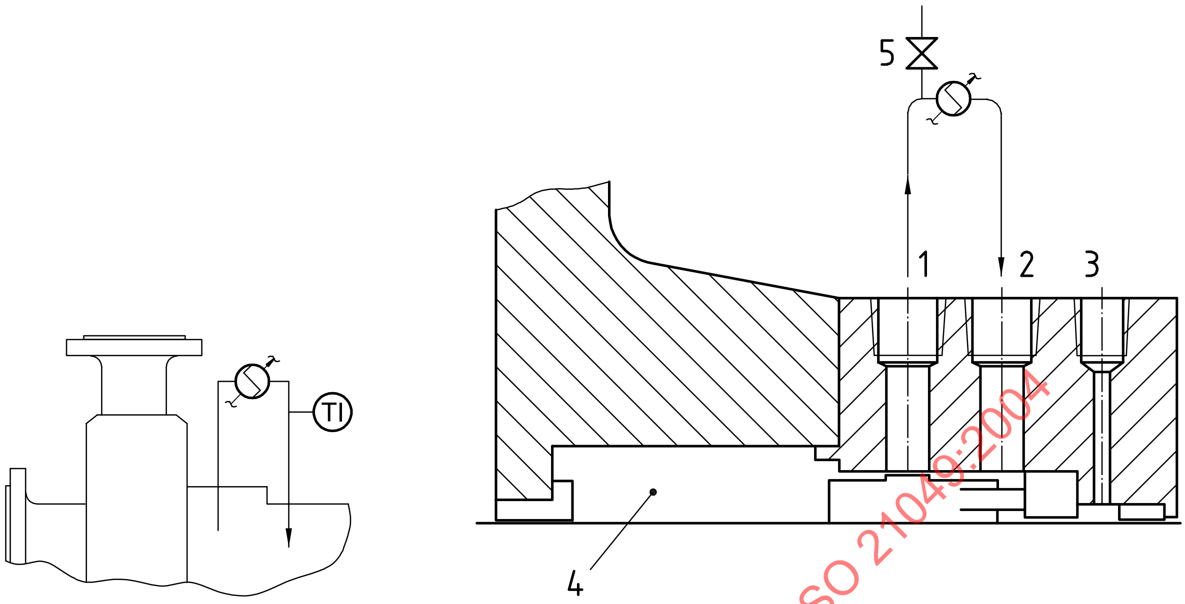
Key

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



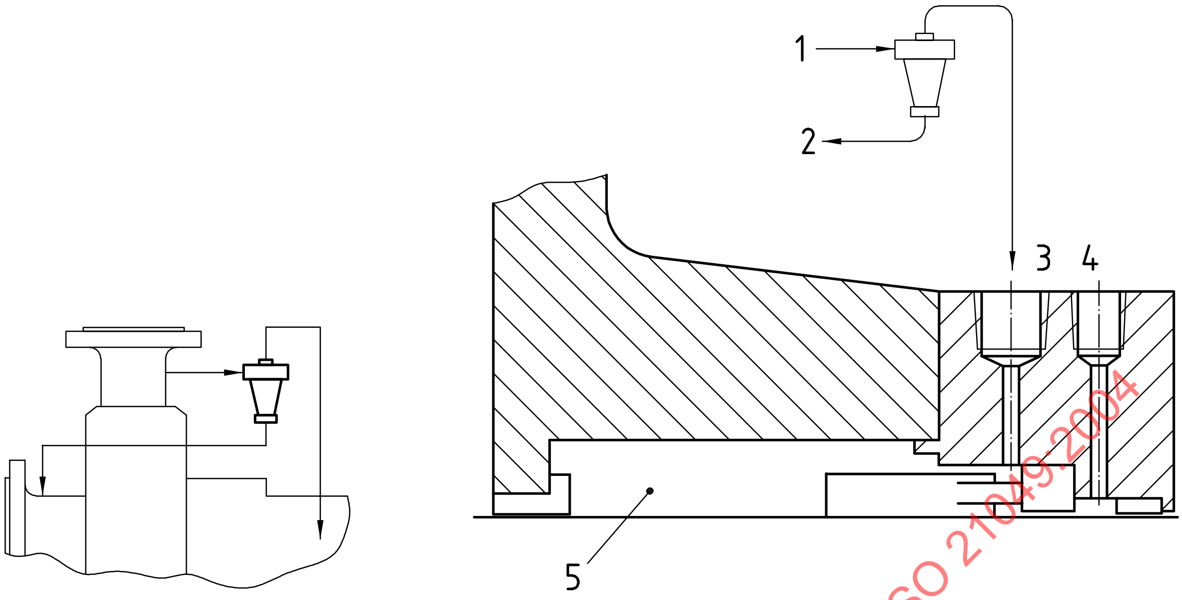
a) **Piping and instrumentation schematic** b) **Seal chamber details**

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



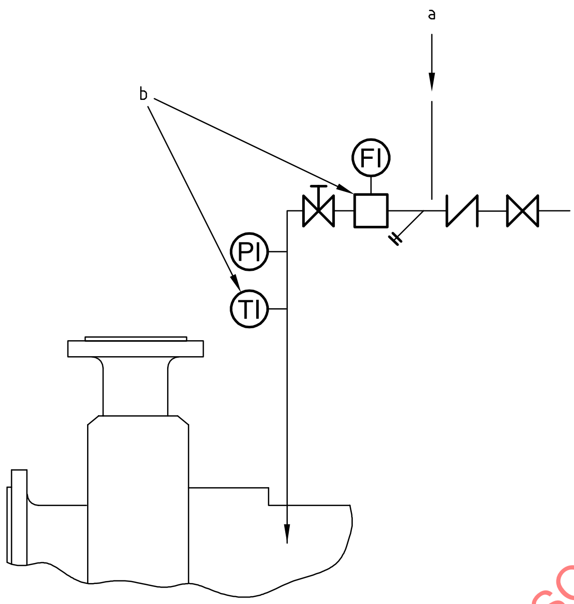
a) **Piping and instrumentation schematic** b) **Seal chamber details**

Key

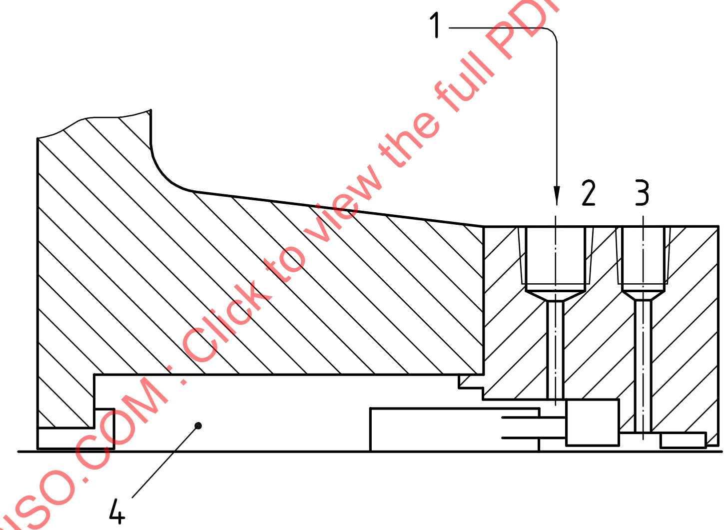
1 from pump discharge
2 to pump suction
3 flush (F)
4 quench/drain (Q/D)
5 seal chamber

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**

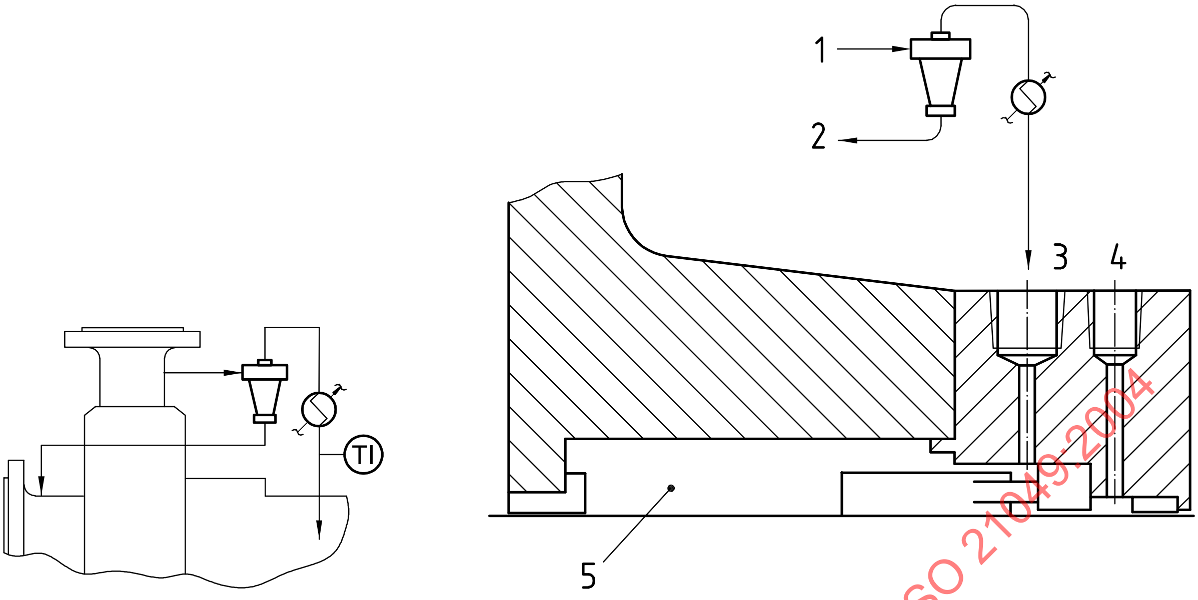
Key

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



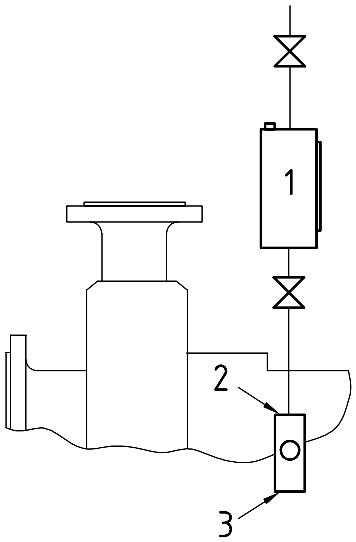
a) **Piping and instrumentation schematic** b) **Seal chamber details**

Key

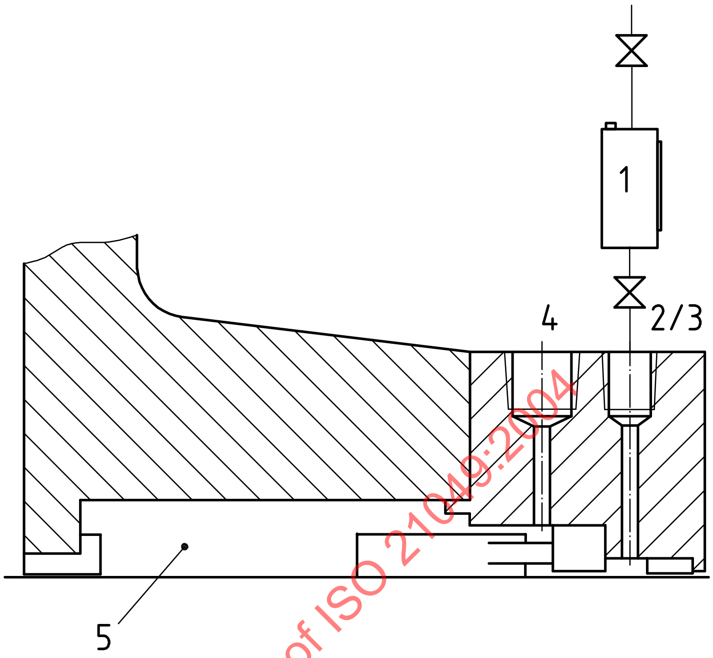
1 from pump discharge
2 to pump suction
3 flush (F)
4 quench/drain (Q/D)
5 seal chamber
TI temperature indicator

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



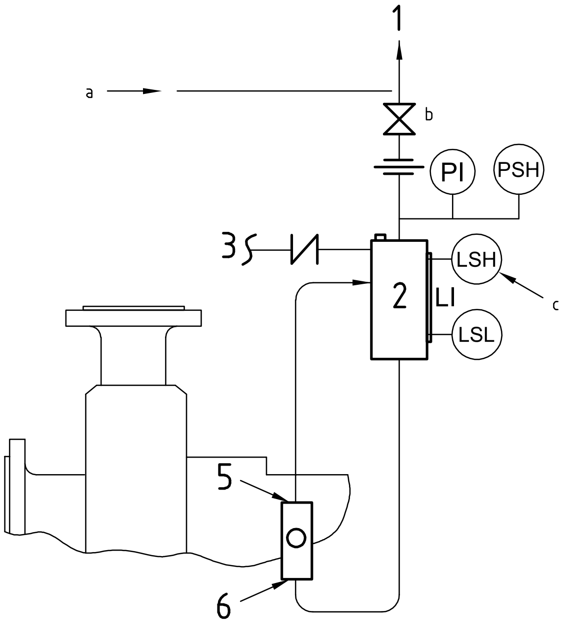
b) Seal chamber details

Key

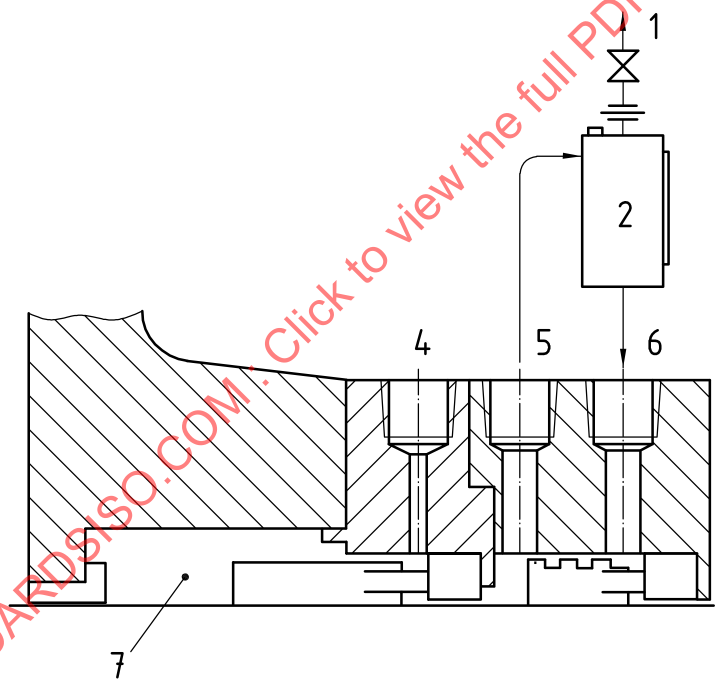
1 reservoir
2 quench (Q)
3 drain (D), plugged
4 flush (F)
5 seal chamber

External reservoir providing a dead-ended blanket for fluid to the quench connection of the gland.

Figure G.13 — Standard seal flush plan 51



a) Piping and instrumentation schematic



b) Seal chamber details

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)						

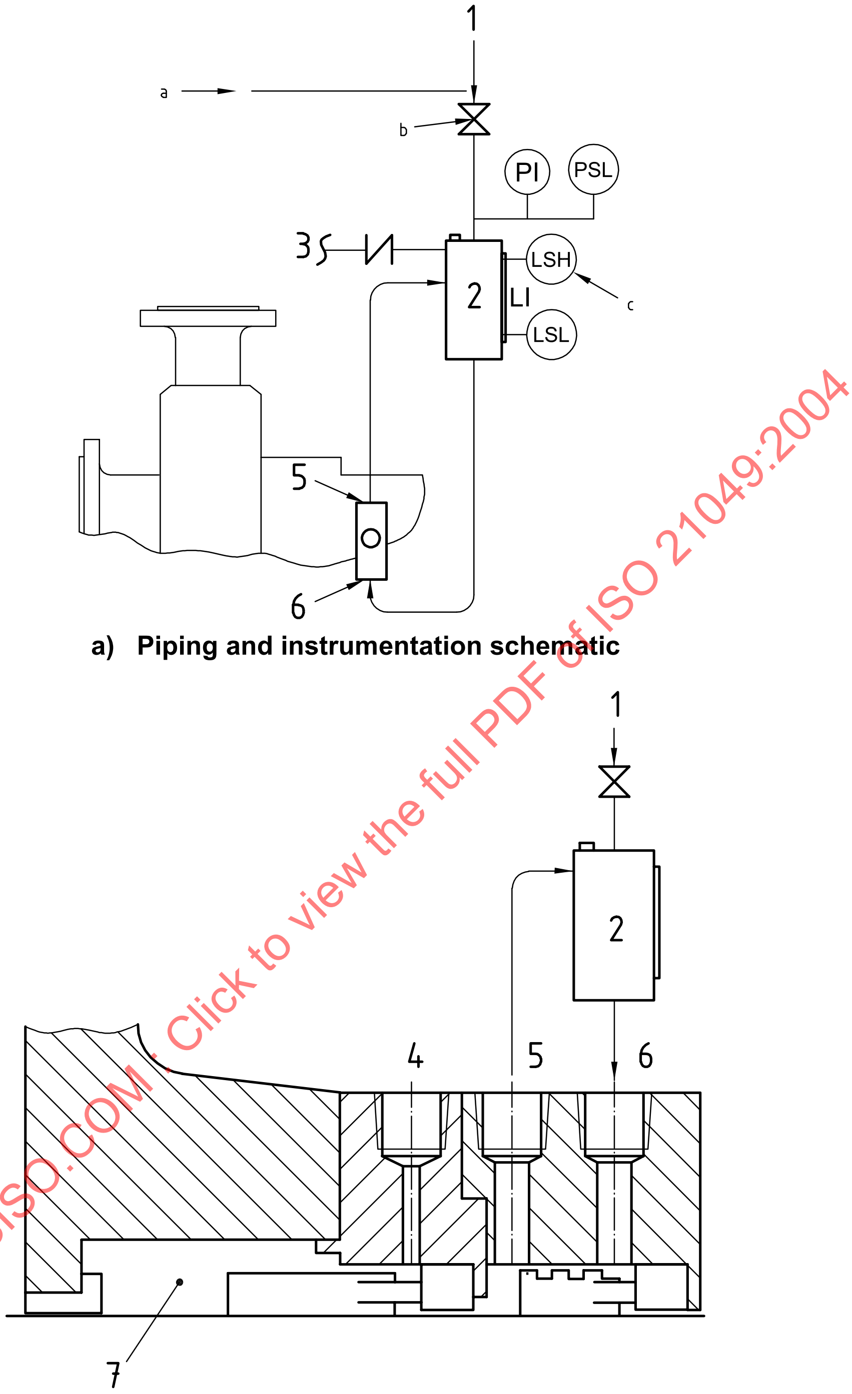
External reservoir providing buffer liquid for the outer seal of an Arrangement 2 seal. During normal operation, circulation is maintained by an internal pumping ring. The reservoir is usually continuously vented to a vapour recovery system and is maintained at a pressure less than the pressure in the 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
2 reservoir
3 make-up barrier fluid
4 flush (F)
5 liquid barrier outlet (LBO)
6 liquid barrier inlet (LBI)
7 seal chamber
LSH level switch high
LSL level switch low
LI level indicator
PI pressure indicator
PSL pressure switch low

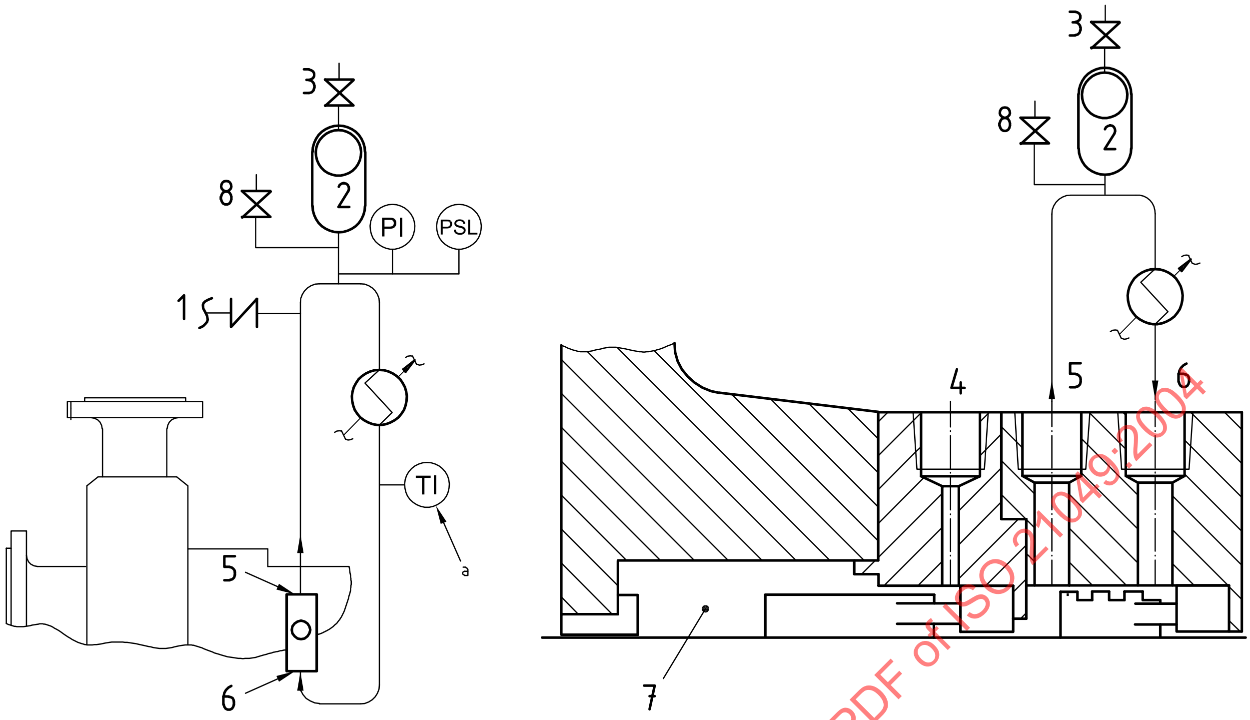
Pressurized external barrier fluid reservoir supplying clean fluid to the seal chamber. Circulation is by an internal pumping ring. Reservoir pressure is greater than the process pressure being sealed. This plan is used with an Arrangement 3 seal.

[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



a) **Piping and instrumentation schematic** b) **Seal chamber details**

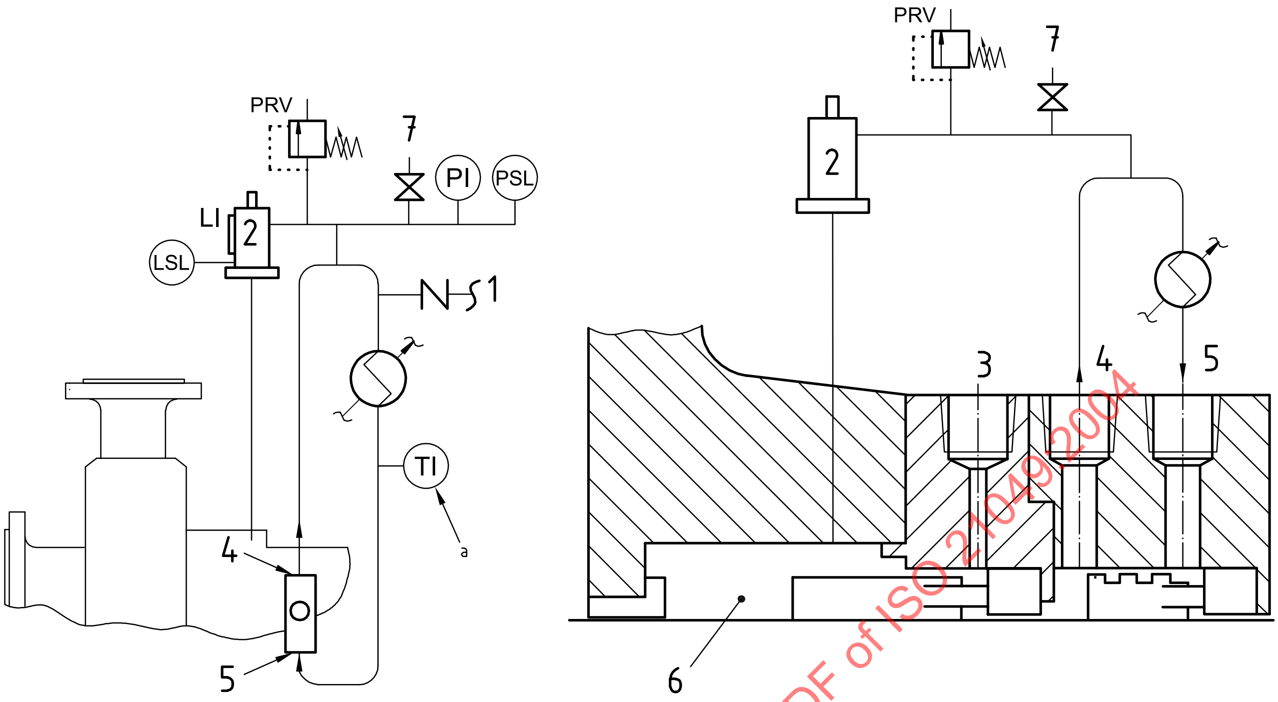
Key

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**

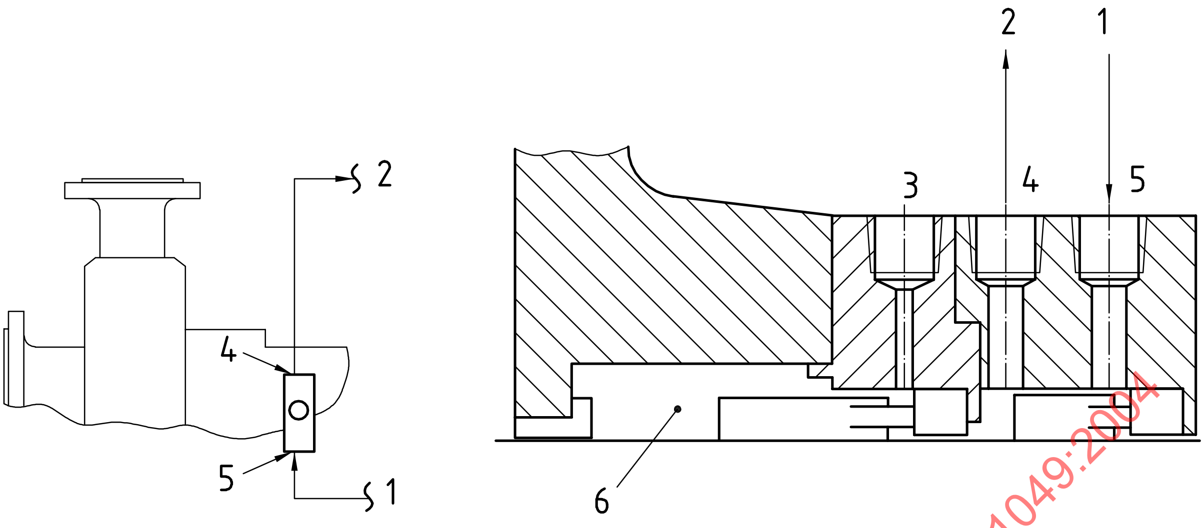
Key

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



a) Piping and instrumentation schematic **b) Seal chamber details**

Key

1 from external source

2 to external source

3 flush (F)

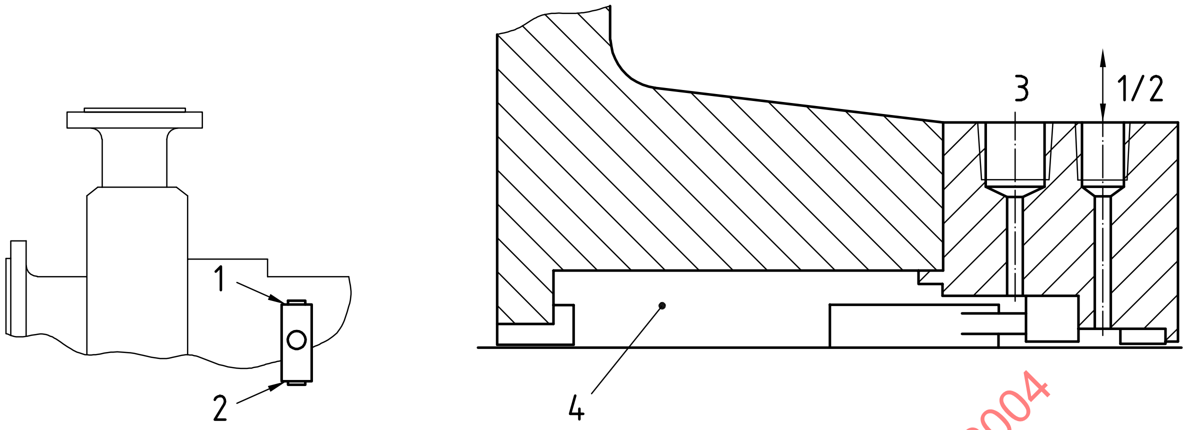
4 liquid barrier outlet (LBO)

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

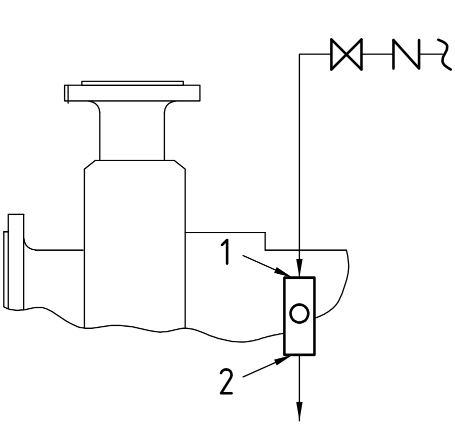
2 drain (D), plugged

3 flush (F)

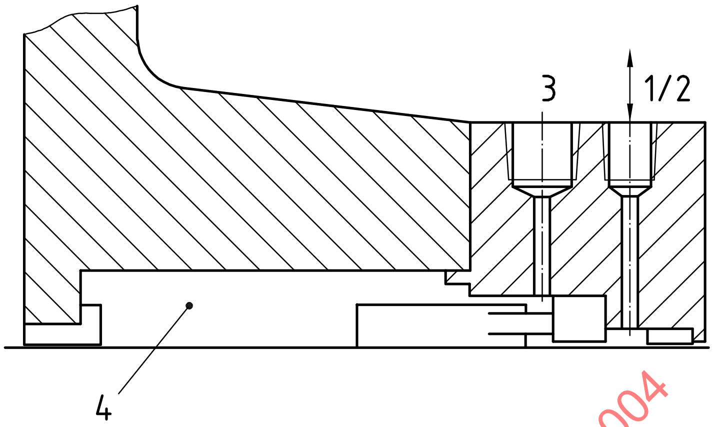
4 seal chamber

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)

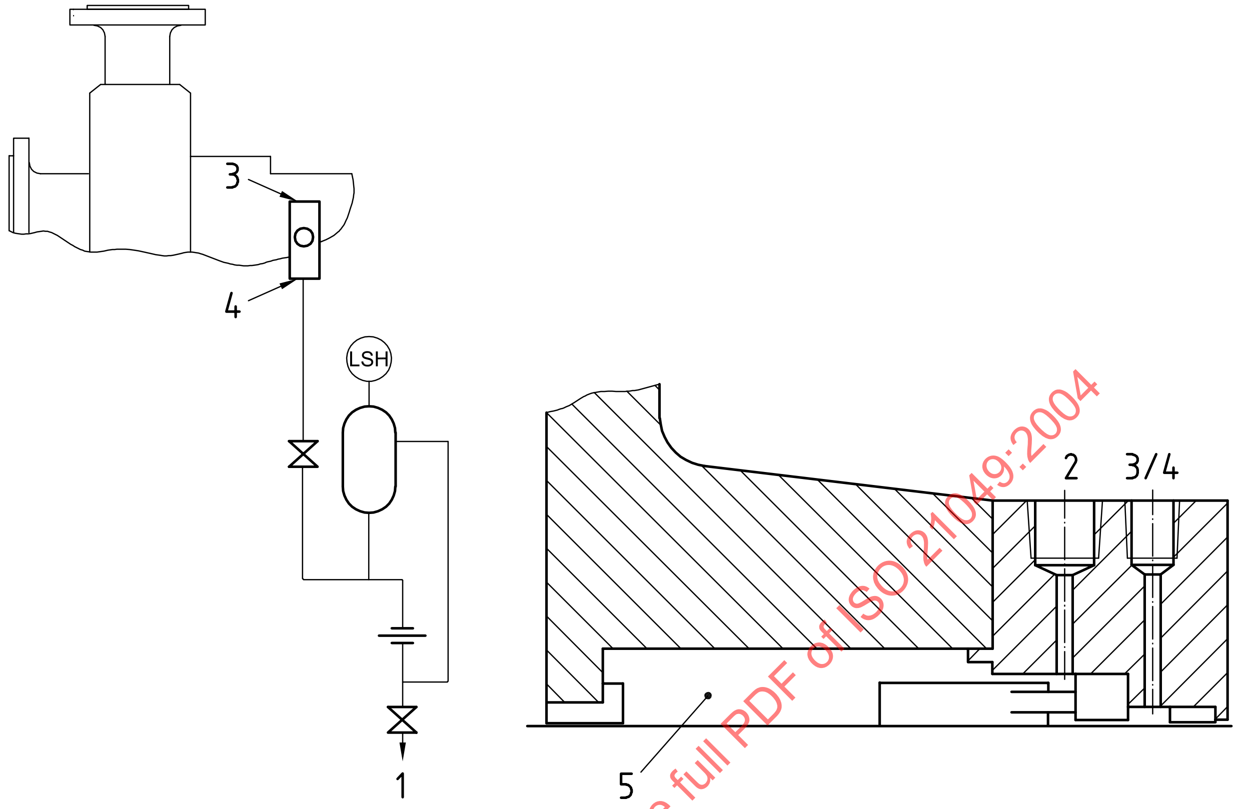
2 drain (D)

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