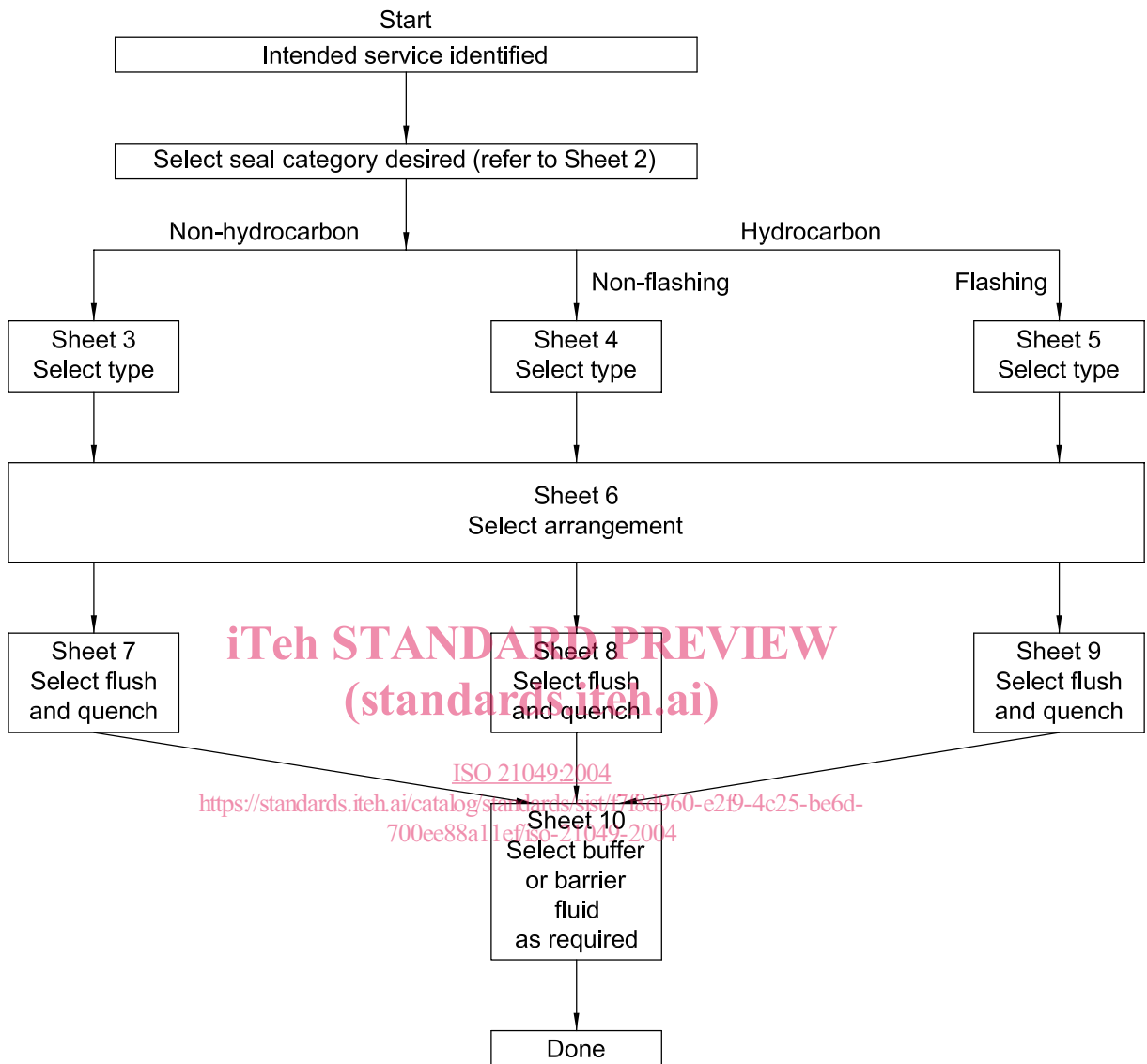


**RECOMMENDED SEAL SELECTION PROCEDURE (US CUSTOMARY UNITS)
SHEET 1 OF 10**



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

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

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

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

SHEET 2 OF 10 (continued)

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

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

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

SHEET 2 OF 10 (continued)

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

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

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

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

	Fluids	Operating conditions, recommended seal types and special features							
		1	2	3	4	5	6	7	8
		Water	Water	Water	Sour water	Sour water	Caustic, amines crystallize	Caustic, amines crystallize	Acids ^a H ₂ SO ₄ , H ₃ PO ₄
Pumping temp., °F		< 180	< 180	> 180	< 180	< 180	< 180	< 180	< 180
Seal chamber gauge pressure, psig Category 1 seals		< 300		< 300	< 300		< 300		< 300
Seal chamber gauge pressure, psig Category 2 and 3 seals		< 300	300 to 600	< 600	< 300	300 to 600	< 300	300 to 600	< 300
Standard seal type		Type A	Type A	Type A	Type A	Type A	Type A	Type A	Type A
Options when specified		Type B Type C	ES ^b	ES ^b	Type B Type C	ES ^b	Type B Type C	ES ^b	Type B Type C
Required special features				Circulating device	Perfluoro-elastomer	Perfluoro-elastomer	Amine-resistant perfluoro-elastomer	Amine-resistant perfluoro-elastomer	Perfluoro-elastomer and single spring for Type A seals
Special features for contaminants ^c	Abrasive particulates	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface
<p>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.</p> <p>^a Up to 20 % H₂SO₄ at 77 °F only. Up to 20 % H₃PO₄ at 176 °F only. All other acids, including hydrofluoric acid, fuming nitric acid and hydrochloric acid require special engineering agreed between purchaser and vendor.</p> <p>^b Totally engineered sealing system. Consult vendor to ensure special design considerations are accounted for.</p> <p>^c Special features listed apply only in mixtures having pH between 4 and 11.</p>									

**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 contaminants^c	Caustic			Perfluoro-elastomer	Perfluoro-elastomer				
	Abrasive particulates	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface
	Aromatics and/or H ₂ S			Perfluoro-elastomer	Perfluoro-elastomer				
	Amines			Amine-resistant perfluoro-elastomer	Amine-resistant perfluoro-elastomer				
This selection procedure chooses seal designs consistent with the default positions throughout this International Standard. Listed options meeting this International Standard might perform equally well.									
^a Totally engineered sealing system. Consult vendor to ensure special design considerations are accounted for. ^b Engineered (high pressure) bellows. ^c Special features listed apply only in mixtures having pH between 4 and 11.									

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

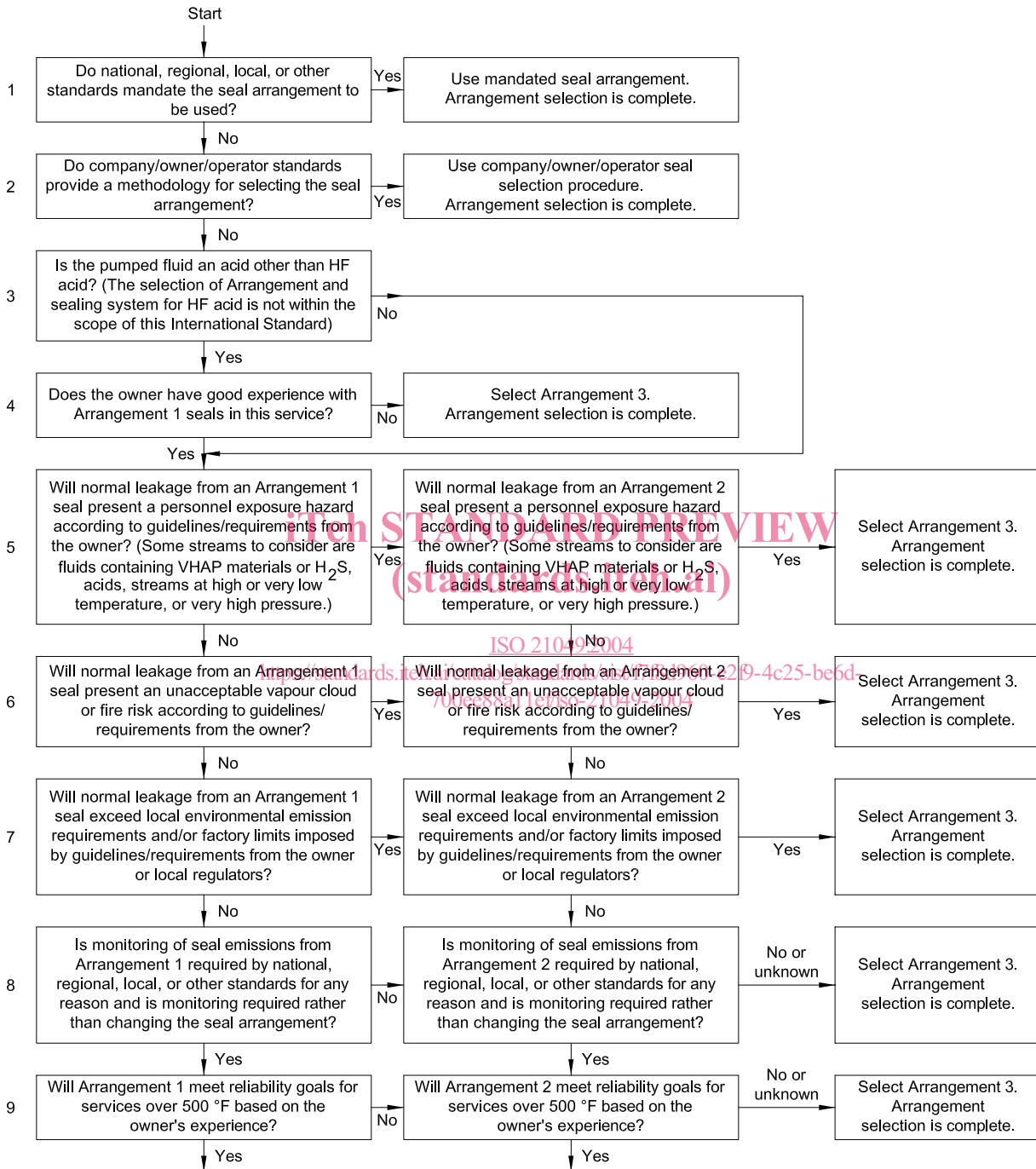
	Operating conditions, recommended seal types and special features								
	Fluids	1	2	3	4	5	6	7	8
Pumping temp., °F	- 40 to 20	- 40 to 20	20 to 350	20 to 350	350 to 500	350 to 500	500 to 750	500 to 750	500 to 750
Seal chamber gauge pressure, psig Category 1 seals	< 300		< 300		< 300		N/A	N/A	
Seal chamber gauge pressure, psig Category 2 and 3 seals	< 300	300 to 600	< 300	300 to 600	< 300	300 to 600	< 300	300 to 600	
Standard seal type	Type A	Type A	Type A ^d	Type A ^d	Type C	ES ^{a, b}	Type C	ES ^{a, b}	
Option when specified	ES ^a	ES ^{a, b}	ES ^a	ES ^{a, b}	ES ^a		ES ^a		
Required special features	Nitrile O-rings	Nitrile O-rings							
Special features for contaminants^c	Caustic		Perfluoro-elastomer	Perfluoro-elastomer					
	Abrasive particulates	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface	Hardface vs hardface
	Aromatics and/or H ₂ S			Perfluoro-elastomer	Perfluoro-elastomer				
	Amines			Amine-resistant perfluoro-elastomer	Amine-resistant perfluoro-elastomer				
	Ammonia	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite	NH ₃ -resistant carbon graphite

This selection procedure chooses seal designs consistent with the default positions throughout this International Standard. Listed options meeting this International Standard might perform equally well.

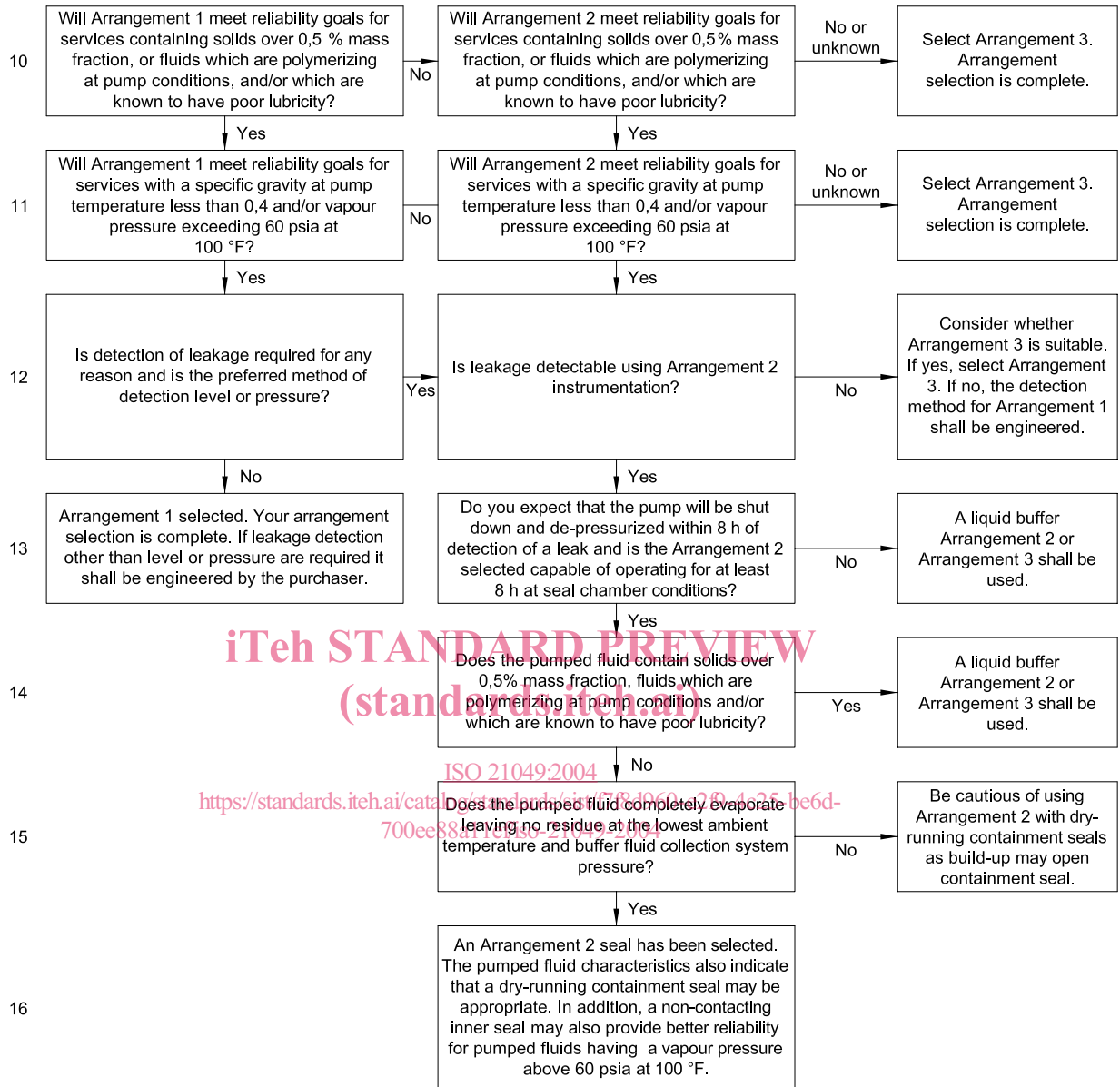
^a Totally engineered sealing system. Consult vendor to ensure special design considerations are accounted for.
^b Engineered bellows.
^c Special features listed apply only in mixtures having pH between 4 and 11.
^d Requires special feature (circulating device) above 140 °F, and special feature (perfluoroelastomer) if pumping temperature is above 350 °F.

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

Assume Arrangement 1 to begin



SHEET 6 OF 10 (continued)



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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.

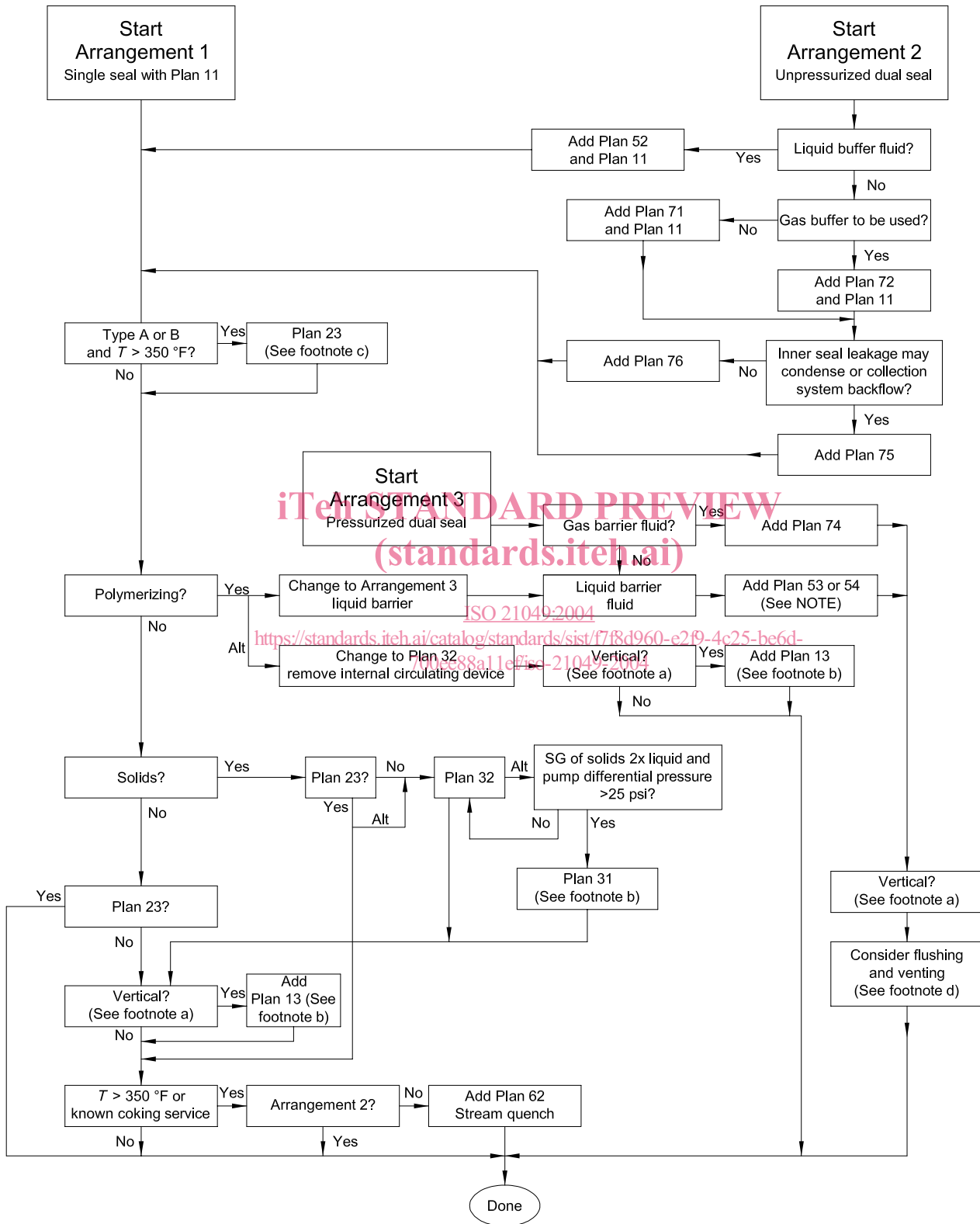
^d Consider the need to add additional flushing to the process side of the inner seal. Flushing is sometimes needed for Arrangement 3 FB orientation to provide additional cooling and Plan 11 or 13 may be a suitable choice. Other services may require a Plan 32 flush if the pumped fluid is extremely corrosive, 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.

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



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

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

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

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

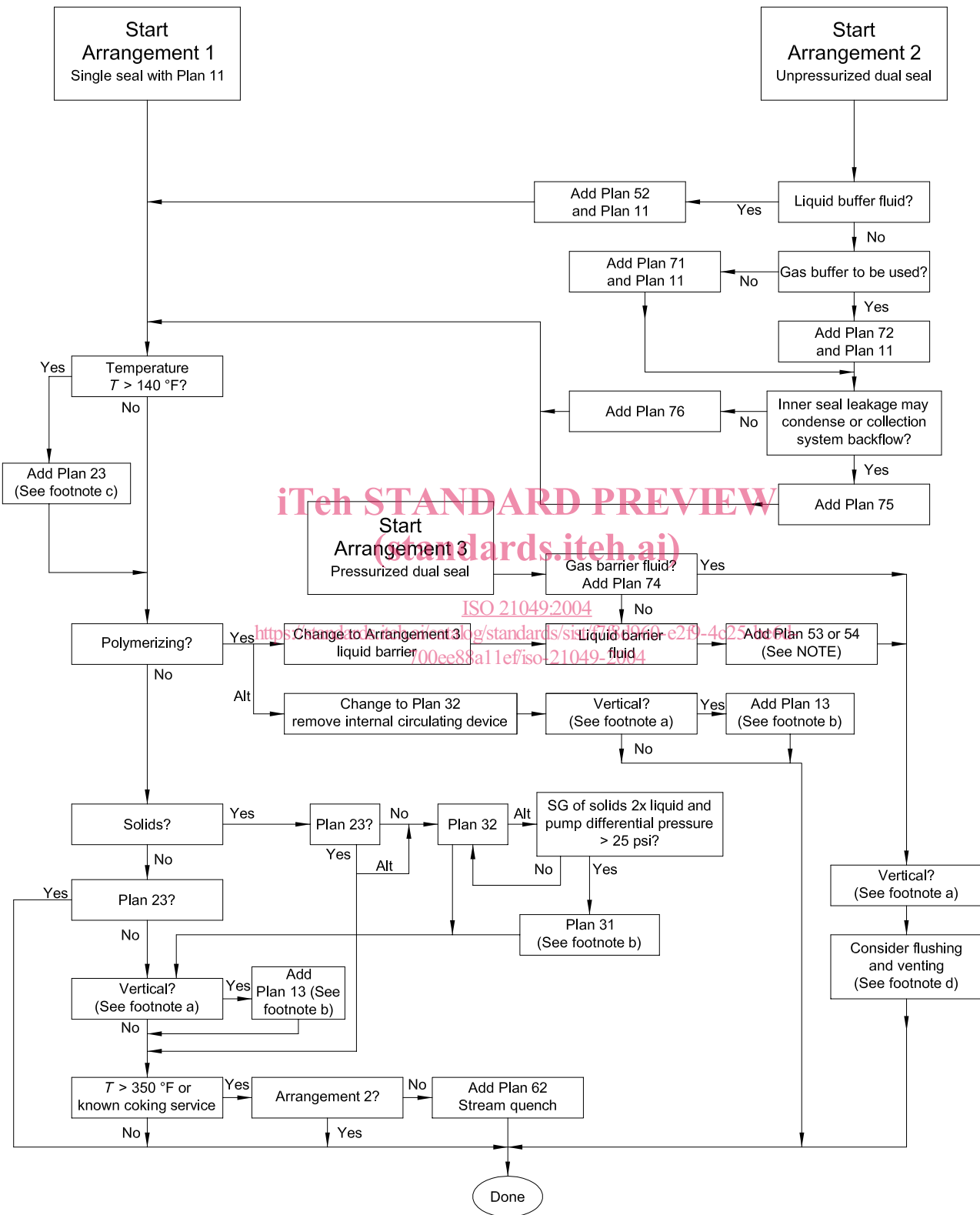
^d Consider the need to add additional flushing to the process side of the inner seal. Flushing is sometimes needed for Arrangement 3 FB orientation to provide additional cooling, and Plan 11 or 13 may be a suitable choice. Other services may require a Plan 32 flush if the pumped fluid is extremely corrosive,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

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



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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.

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