

Dry Gas Sealing Systems for Axial, Centrifugal, Rotary Screw Compressors and Expanders

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Dry Gas Sealing Systems for Axial, Centrifugal, and Rotary Screw Compressors and Expanders

Part 1—General Requirements

1 Scope

1.1 General

This standard covers the minimum dry gas sealing system requirements in association with axial, centrifugal, and rotary screw compressors and expanders for use in the petroleum, chemical, and gas industry services as described in [API 617](#) and [API 619](#).

API 692 does not apply to other types of shaft seals such as clearance seals, restrictive ring seals, or oil seals.

1.2 Part 1—General Requirements

This part of API 692 contains information pertinent to all equipment covered by the other parts of API 692. It shall be used in conjunction with the following parts of API 692 as applicable.

- Part 2—Dry Gas Seals.
- Part 3—Dry Gas Seal Support Systems.
- Part 4—Installation and Commissioning.

2 Normative References

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

[API Recommended Practice 520, Sizing, Selection, and Installation of Pressure-relieving Devices—Part I: Sizing and Selection](#)

[API Recommended Practice 520, Sizing, Selection, and Installation of Pressure-relieving Devices—Part II: Installation](#)

[API Standard 521, Pressure-relieving and Depressuring Systems](#)

[API Standard 526, Flanged Steel Pressure-relief Valves](#)

[API Recommended Practice 551, Process Measurement](#)

[API Recommended Practice 571, Damage Mechanisms Affecting Fixed Equipment in the Refining Industry](#)

[API Standard 594, Check Valves: Flanged, Lug, Wafer, and Butt-welding](#)

[API Standard 600, Steel Gate Valves—Flanged and Butt-welding Ends, Bolted Bonnets](#)

[API Standard 602, Gate, Globe, and Check Valves for Sizes DN 100 \(NPS 4\) and Smaller for the Petroleum and Natural Gas Industries](#)

[API Standard 607, Fire Test for Quarter-turn Valves and Valves Equipped with Nonmetallic Seats](#)

[API Standard 608](#), *Metal Ball Valves— Flanged, Threaded, and Welding Ends*

[API Standard 617](#), *Axial and Centrifugal Compressors and Expander-compressors*, Eighth Edition

[API Standard 619](#), *Rotary-type Positive-displacement Compressors for Petroleum, Petrochemical and Natural Gas Industries*, Fifth Edition

[API Standard 660](#), *Shell-and-Tube Heat Exchangers*

[API Standard 661](#), *Petroleum, Petrochemical, and Natural Gas Industries—Air-cooled Heat Exchangers*, Seventh Edition

[API Recommended Practice 686](#), *Recommended Practice for Machinery Installation and Installation Design*, Second Edition

[API Recommended Practice 691](#), *Risk-based Machinery Management*, First Edition

ANSI ¹/ASME ² B31.3, *Process Piping*

ANSI/FCI 70-2, *Control Valve Seat Leakage*

ASME BPVC-VIII-1, *Section VIII Division 1 Rules For Construction Of Pressure Vessels*

ASME B1.1 ², *Unified Inch Screw Threads (UN and UNR Thread Form)*

ASME B1.20.1, *Pipe Threads, General Purpose (Inch)*

ASME B16.5, *Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard*

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

ASME B31.3, *Process Piping*

[ASTM D5445-05](#) ³, *Standard Practice for Pictorial Markings for Handling of Goods*

[ASTM E94](#), *Standard Guide for Radiographic Examination*, 2010

[ASTM E165/E165M](#), *Standard Practice for Liquid Penetrant Examination for General Industry*

[ASTM E709](#), *Standard Guide for Magnetic Particle Testing*

[ASTM E1417/E1417M](#), *Standard Practice for Liquid Penetrant Testing*

IEC 60079 ⁴ (all parts), *Electrical apparatus for explosive gas atmospheres*

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

ISA 18.1 ⁵, *Annunciator Sequences and Specifications*

¹ American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, New York 10036, www.ansi.org.

² ASME International, 2 Park Avenue, New York, New York 10016-5990, www.asme.org.

³ ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

⁴ International Electrotechnical Commission, 3 rue de Varembe, 1st floor, P.O. Box 131, CH-1211 Geneva 20, Switzerland, www.iec.ch.

⁵ International Society of Automation, 67 T.W. Alexander Drive, P.O. Box 12277, Research Triangle Park, NC 27709, www.isa.org.

ISO 1940-1 ⁶, *Mechanical vibration—Balance quality requirements for rotors in a constant (rigid) state—Part 1: Specification and verification of balance tolerances*

ISO 8501, *Preparation of steel substrates before application of paints and related products*

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

ISPM Publication 15 (FAO) ⁷, *Regulation of wood packaging material in international trade*

NACE ⁸ *Corrosion Engineer's Reference Guide*

NACE MR0175, *Petroleum and natural gas industries – Materials for use in H₂S-containing environments in oil and gas production*

NACE MR0103, *Petroleum, petrochemical and natural gas industries – Metallic materials resistant to sulfide stress cracking in corrosive petroleum refining environments*

NEMA 250 ⁹, *Enclosures for Electrical Equipment (1000 Volts Maximum)*

NFPA 70 ¹⁰, *National Electrical Code (NEC)*

SSPC SP 6 ¹¹/NACE No. 3, *Commercial Blast Cleaning*

TEMA ¹², *Standards of the Tubular Exchanger Manufacturers Association*, Ninth Edition

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

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

3.1.1

alarm point

Preset value of a measured parameter at which an alarm is activated to warn of a condition that requires corrective action.

3.1.2

approve

Written documentation confirming an agreement.

3.1.3

buffer gas

Gas supplied to the process side of a double seal and used to keep untreated process gas away from the seal.

NOTE Buffer gas does not flow through the seal faces.

⁶ International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland, www.iso.org.

⁷ Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, 00153 Rome, Italy.

⁸ NACE International, 15835 Park Ten Place, Houston, Texas, 77084, www.nace.org.

⁹ National Electrical Manufacturers Association, 1300 North 17th Street, Suite 900, Arlington, Virginia, 22209, www.nema.org.

¹⁰ National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts, 02169, www.nfpa.org.

¹¹ The Society for Protective Coatings, 800 Trumbull Drive, Pittsburgh, Pennsylvania, 15205, 222.sspc.org.

¹² Tubular Exchanger Manufacturers Association, 25 North Broadway, Tarrytown, New York 10591, www.tema.org.

3.1.4

cartridge seal

Self-contained unit, typically including seal faces, sealing elements, housings, and sleeves, which is pre-assembled and preset before installation. The cartridge may also include the process side seal and separation seal.

3.1.5

certified point

Point to which the performance tolerances will be applied.

3.1.6

design

Manufacturer's calculated parameter.

NOTE A term used by the equipment manufacturer to describe various parameters, such as design pressure, design temperature, or design speed. It is not intended for the purchaser to use this term.

3.1.7

diamètre nominal

DN

Alphanumeric designation of size for components of a pipework system.

EXAMPLE DN 20

NOTE 1 Adapted from ISO 6708:1995.

NOTE 2 The letters DN are followed by a dimensionless whole number that is indirectly related to the physical size, in millimeters, of the bore or outside diameter of the end connection.

NOTE 3 The number following the letters DN does not represent a measurable value.

NOTE 4 In those standards which use the DN designation system, any relationship between DN and component dimensions should be given, e.g. DN/OD or DN/ID. [ISO 6708:1995 (E).]

3.1.8

dynamic pressure rating

Highest sealing pressure that the seal assembly can continuously be operated at the maximum allowable temperature while the shaft is rotating.

cf **static pressure rating** (3.1.53)

3.1.9

dynamic sealing element

Pressure-retaining component designed to seal a joint with relative axial movement.

cf **static sealing element** (3.1.54)

3.1.10

failsafe

System or component that will cause the equipment to revert to a permanently safe condition (shutdown and/or depressurized) in the event of a component failure or failure of the energy supply to the system.

3.1.11

informative

Information only.

cf **normative** (3.1.32)

NOTE An informative reference or annex provides advisory or explanatory information. It is intended to assist the understanding or use of the document.

3.1.12

local

<Position of devices> on or near the equipment or dry gas seal support system.

cf **remote** (3.1.40)

3.1.13

maximum allowable temperature

Maximum continuous temperature for which the manufacturer has designed the equipment (or any part to which the term is referred).

NOTE The maximum allowable temperature is usually set by material considerations.

3.1.14

maximum allowable working pressure

MAWP

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

3.1.15

maximum continuous speed

MCS

Highest rotational speed [revolutions per minute (RPM)] at which the seal, as-built and tested, is capable of continuous operation.

3.1.16

maximum discharge pressure

Maximum suction pressure plus the maximum differential pressure the compressor is able to develop, when operating with the furnished impeller(s) and the fluid with the maximum density.

cf **maximum suction pressure** (3.1.20)

3.1.17

maximum flow

The highest flow that a system or component can pass under all conditions.

3.1.18

maximum operating temperature

Maximum temperature that the seal or system is expected to be subjected to.

NOTE 1 This is a process condition and is specified by the purchaser.

NOTE 2 Maximum operating temperature can be due to a process condition, a compressor discharge temperature, or a seal gas supply temperature.

3.1.19**maximum sealing pressure**

Highest pressure the seals are required to seal during any specified operating conditions including start-up, shutdown, settle-out, and standby.

3.1.20**maximum suction pressure**

Highest specified inlet pressure the equipment shall be subject to.

NOTE Relief valve setting on the suction system or settle-out pressure can affect the maximum suction pressure.

cf **maximum discharge pressure** (3.1.16)

3.1.21**minimum allowable speed**

Lowest speed (RPM) at which the manufacturer's design will permit continuous operation.

3.1.22**minimum allowable temperature**

Lowest temperature for which the manufacturer has designed the equipment (or any part to which the term is referred).

3.1.23**minimum design metal temperature**

Lowest mean metal temperature (through the thickness) expected, including operation upsets, auto-refrigeration, and temperature of the surrounding environment.

3.1.24**national pipe thread taper****NPT**

American National Standard Pipe Taper thread form designation for pipe threads.

EXAMPLE $\frac{3}{4}$ -14 NPT

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

3.1.25**nominal pipe size****NPS**

Value approximately equal to a diameter in inches.

EXAMPLE NPS $\frac{3}{4}$.

NOTE 1 Refer to ASME B31.3.

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

3.1.26**normal flow****3.1.26.1****buffer gas normal flow (double)**

Flow to satisfy the velocity requirements across the process side seal at normal operating point.

3.1.26.2

primary vent normal flow (tandem)

Expected primary seal leakage plus secondary seal gas normal flow minus expected secondary seal leakage at normal operating point.

3.1.26.3

seal gas normal flow (tandem)

Flow to satisfy the velocity requirements across the process side seal including expected primary seal leakage at normal operating point.

3.1.26.4

secondary seal gas normal flow (tandem)

Flow to satisfy the velocity requirements across the intermediate labyrinth including expected secondary seal leakage at normal operating point.

3.1.26.5

secondary vent normal flow (tandem)

Expected secondary seal leakage plus separation seal gas flowing into the vent cavity at normal operating point.

3.1.26.6

separation seal normal flow

Flow to satisfy the velocity requirements across the separation seal (both sides when applicable) at normal operating point.

3.1.26.7

vent normal flow (double)

Expected secondary seal leakage plus separation seal gas flow into the vent cavity at normal operating point.

3.1.27

normal operating point

Point at which usual operation is expected and optimum efficiency is desired.

NOTE Refer to [API 617](#), Eighth Edition.

3.1.28

normal sealing pressure

Sealing pressure at the normal operating point.

3.1.29

normal speed

Rotational speed (RPM) at which the seal will operate at the normal operating point.

3.1.30

normal vent pressure

Primary vent pressure control set point.

3.1.31

normally open

normally closed

<Manual hand valve> state during normal operation.

3.1.32

normative

Required.

cf **informative** (3.1.11)

NOTE A normative reference or annex enumerates a requirement or mandate of the specification.

3.1.33

observed

Inspection or test where the purchaser is notified of the timing of the inspection or test and the inspection or test is performed as scheduled even if the purchaser or his/her representative is not present.

3.1.34

owner

Final recipient of the equipment, who may delegate another agent as the purchaser of the equipment.

3.1.35

panel

Open structure supporting dry gas seal support system components, typically in a single plane.

NOTE 1 A panel is not a skid.

NOTE 2 In this standard, the term panel refers to a seal system panel and not a control panel.

3.1.36

positive material identification

PMI

Any physical evaluation or test of a material to confirm that the material that has been or will be placed into service is consistent with the selected or specified alloy material designated by the purchaser. These evaluations or tests may provide either qualitative or quantitative information that is sufficient to verify the nominal alloy composition.

NOTE Adapted from [API 578](#):2010.

3.1.37

primary seal

The set of dry gas seal faces closest to the process.

3.1.38

purchaser

Agency that issues the order and specifications to the vendor.

NOTE The purchaser can be the owner of the facility in which the equipment is installed, the owner's appointed agent, or the equipment manufacturer purchasing components.

3.1.39

relief valve set pressure

Pressure at which a relief valve starts to lift.

NOTE For information on relief valves, see [API 520, Parts I and II](#).

3.1.40

remote

Position of a device when located away from the equipment or dry gas seal support system, typically in a control room.

cf **local** (3.1.12)

3.1.41

seal face velocity

A measure of the linear distance with respect to time based on the seal face outside diameter and the shaft rotational speed.

NOTE The units for seal face velocity are meters/second [International System (SI) units] or feet/second [U.S. customary (USC) units].

3.1.42

seal gas

Gas supplied to the high-pressure side of a primary seal, which flows through the primary seal faces and acts as a sealing medium.

3.1.43

secondary seal

The set of dry gas seal faces furthest from the process gas.

3.1.44

secondary seal gas

Gas supplied between the primary and secondary seal of a tandem seal, which flows through the secondary seal faces, and through an intermediate labyrinth when one is present.

3.1.45

separation gas

Air or inert gas supplied to a separation seal, providing a barrier between the atmospheric bearing housing and the dry gas seal.

3.1.46

settle-out pressure

Highest pressure that the machine experiences when the machine is not running and equilibrium has been reached.

NOTE Determination of settle-out pressure requires consideration of the trapped volume of gas throughout the machine and its associated piping system.

3.1.47

shutdown set point

Pre-set value of a measured parameter at which automatic or manual shutdown of the system or equipment is required.

3.1.48

skid

Baseplate-type structure supporting gas seal support system components.

NOTE 1 Panels can be mounted on skids.

NOTE 2 Skids can be grouted.

3.1.49

slow roll speed

Rotational speed (RPM) typically less than 5 % of the normal operating speed or the minimum speed permitted by speed control. Typical speed values for slow roll are about 500 RPM.

3.1.50

special tool

Tool that is not a commercially available catalog item.

3.1.51**standby**

Service state in which a piece of equipment is normally idle or idling and is capable of immediate automatic or manual start-up for continuous operation.

3.1.52**standstill**

Zero RPM.

3.1.53**static pressure rating**

Highest sealing pressure that the seal assembly can continuously operate at the maximum allowable temperature while the shaft is not rotating.

cf **dynamic pressure rating** (3.1.8)

3.1.54**static sealing element**

Pressure-retaining component designed to seal a joint with no relative axial movement.

cf **dynamic sealing element** (3.1.9)

3.1.55**steady state**

Constant operating parameters.

3.1.56**total indicator reading****total indicated runout****TIR**

Difference between the maximum and minimum readings of a dial indicator or similar device, monitoring a face or cylindrical surface during one complete revolution of the monitored surface.

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

3.1.57**transient**

Operation outside the defined conditions or transition from one operating state to another such as normal start-up to running or running to shutdown.

3.1.58**turning gear speed****ratcheting/barring**

Temporary operating condition during start-up and shutdown. Typically 50 RPM or less.

3.1.59**unit responsibility**

Obligation for coordinating the documentation, delivery, and technical aspects of all of the equipment and all auxiliary systems included in the scope of the order.

3.1.60**vendor**

Manufacturer or manufacturer's agent that supplies the equipment.

3.1.61

vent gas

Gas flowing out of the seal through a designated vent connection.

3.1.62

witnessed

Inspection or test where the purchaser is notified of the timing of the inspection or test and a hold is placed on the inspection or test until the purchaser or the purchaser's representative is in attendance.

3.2 Acronyms and Abbreviations

ASME Code	ASME <i>Boiler and Pressure Vessel Code</i>
cf	(Latin conferre) confer or compare—cross-reference
DCS	distributed control system
DE	drive end
DGS	dry gas seal
DLC	diamond-like carbon
DN	diamètre nominal
FAT	factory acceptance test
FMEA	failure mode and effects analysis
HAZOP	hazard and operability study
HMI	human machine interface
ID	inside diameter
I/O	input/output
L, LL, H, HH	low, low low, high, high high
MAWP	maximum allowable working pressure
MCC	motor control center
MCS	maximum continuous speed
MRT	mechanical run test
NDE	non-drive end
NPS	nominal pipe size
NPT	national pipe thread taper
OD	outside diameter
PCD	polycrystalline diamond
PEEK	polyether ether ketone
P&ID	process and instrumentation diagram

PLC	programmable logic controller
PMI	positive material identification
PTFE	polytetrafluoroethylene
RGD/ED	rapid gas decompression/explosive decompression
RPM	revolutions per minute
RTD	resistance temperature detector
SI	International System
SiC	silicon carbide
SiN	silicon nitride
TIR	total indicator reading/total indicated runout
USC	U.S. customary
VDDR	vendor drawing and data requirements
VPI	vapor phase inhibitor
WC	tungsten carbide

4 General

4.1 Unit Responsibility

The vendor shall assume unit responsibility and shall assure that all subvendors comply with the requirements of this standard and all reference documents. The technical aspects to be considered by the vendor include, but are not limited to, such factors as the process conditions, power requirements, speed, rotation, general arrangement, couplings, dynamics, lubrication, sealing system, material test reports, instrumentation, piping, material compatibility, conformance to specifications, and testing of components.

Purchaser may specify a vendor responsible for each portion of the design, scope of supply, and installation of the dry gas sealing system.

4.2 Nomenclature

Dry gas seal nomenclature can be found in Annex C of Part 2.

5 Requirements

● 5.1 Standard Fasteners and Units of Measure

5.1.1 Purchaser shall specify whether data, drawings, hardware (including fasteners), and equipment supplied to this standard shall use the SI or USC system of measurements.

5.1.2 Use of an SI datasheet indicates that SI units shall be used.

5.1.3 Use of an USC datasheet indicates that USC units shall be used.

NOTE 1 The factors in [Chapter 15 of the API Manual of Petroleum Measurement Standards](#), formally API 2564, were used to convert from USC to SI units. The resulting exact SI units were then rounded off.

NOTE 2 Datasheets for SI and USC units are provided in Annex A in Parts 2 and 3.

5.2 Statutory Requirements

5.2.1 The purchaser and the vendor shall determine the measures to be taken to comply with any governmental codes, regulations, ordinances, directives, or rules that are applicable to the equipment its packaging and any preservatives used.

5.2.2 Equipment installed in the European Economic Area (EEA) shall comply with all applicable European Union Directives.

5.3 Alternative Designs

5.3.1 All designs shall comply with this standard, and any exceptions to the standard including alternate designs shall be clearly stated in the proposal.

5.3.2 Dry gas sealing systems shall be supplied by vendors qualified by experience in manufacturing the equipment proposed.

5.3.3 The vendor shall have manufactured, at the proposed point of manufacture, comparable speed, size, and pressure rating for a gas of comparable characteristics.

5.3.4 Proposed designs with less than 3 years of demonstrated successful operation shall be approved by the purchaser.

5.3.5 The extent of validation testing and design audits required shall be agreed.

● 5.4 Documentation Requirements

The hierarchy of documents shall be specified by the purchaser.

NOTE Typical documents include the purchase order or inquiry, purchaser and industry specifications, meeting notes, and modifications to these documents.

5.5 Conflicting Requirements

In case of conflict between this standard and the inquiry, the inquiry shall govern. At the time of the order, the order shall govern.

6 Basic Design

6.1 General

Normative and informative annexes are provided as part of the document. These annexes are as follows.

- Annex A—Vent Study (normative).
- Annex B—Phase Maps (informative).
- Annex C—Dry Gas Sealing System Retrofit Checklist (informative).

6.1.1 Dry gas sealing systems shall be provided to contain process gas within the equipment and venting systems.

6.1.1.1 The “dry gas sealing system” includes the dry gas seals as defined in Part 2 and the dry gas seal support systems as defined in Part 3.

6.1.1.2 In the event of a dry gas seal failure, the separation seal shall be designed to maintain sealing integrity and limit the amount of process gas entering the bearing housing.

- **6.1.2** The purchaser shall specify the period of uninterrupted continuous operation, during which time the equipment should not require shutdown to perform maintenance or inspection.

NOTE 1 It is realized there are some services where this objective is easily attainable and others where it is difficult.

NOTE 2 Auxiliary system design and conditions of the process in which the equipment is installed are very important in meeting this objective.

6.1.3 Vendor shall advise in the proposals any maintenance requirements or component replacements that may be required to achieve the continuous operation interval specified in 6.1.2, including maintenance performed in between intervals.

6.2 System Design

6.2.1 The dry gas sealing system shall be designed to operate under all defined transient and steady state operating conditions. These conditions may include but are not limited to the following:

- a) all conditions defined on the compressor datasheets;
 - b) shop compressor tests;
 - c) field run tests;
 - d) slow roll;
 - e) turning gear—ratcheting/barring;
 - f) transient conditions (e.g. start-up, shutdown, defined failure modes, start-up from settle-out, operation at relief valve settings).
- **6.2.2** Purchaser shall specify maximum sealing pressure, settle-out pressures, and process relief valve settings. The maximum sealing pressure shall be at least equal to the settle-out pressure.

NOTE Maximum suction pressure, system relief valve settings, test conditions, external gas sources, or buffer gas or seal gas pressure can all affect the maximum sealing pressure.

6.2.3 Dry gas seal support systems shall be designed to prevent reverse pressurization outside the allowable limits defined in Part 2, Section 6.14 under all conditions defined in 6.2.1 of Part 1.

6.2.4 Vendor shall supply a maximum depressurization rate to prevent explosive decompression damage.

6.2.5 The vendor shall identify the allowable range of gas supply temperatures for the dry gas seal and support system.

6.2.5.1 The maximum allowable temperature shall not be less than the maximum supply temperature of the seal gas and buffer gas, or any other temperatures associated with the conditions of 6.2.1.

6.2.5.2 The minimum allowable temperature shall not be greater than the minimum supply temperature of the seal gas and buffer gas, or any other temperatures associated with the conditions of 6.2.1.

6.2.5.3 Unless approved by the purchaser, the maximum allowable temperature of the dry gas seal shall not be less than the maximum compressor discharge temperature.

- **6.2.6** Purchaser shall specify the isolation and maintenance philosophy including the use and location of double block and bleed, car-sealed, or other valves for isolating a component and how they are arranged.

NOTE Double block valves are normally provided where there is safety or environmental issues associated with the reliability of a single block valve.

6.2.7 If specified, a vent study shall be performed in accordance with Annex A.

6.3 Seal Gas, Buffer Gas, Secondary Seal Gas, and Separation Gas

6.3.1 Purchaser shall specify all supply gas conditions (minimum, normal, and maximum) needed for the design of the dry gas sealing system. These conditions may include but are not limited to the following:

- a) supply conditions (e.g. source, gas composition, gas pressure, and gas temperature);
- b) alternate gas supply conditions (e.g. gas composition, gas pressure, and gas temperature).

6.3.2 Gas compositions shall fully define the components and saturation conditions. Heavy components shall be defined and not lumped as C6+.

- **6.3.3** The purchaser shall specify the presence of any corrosive agents (including trace quantities) in the process fluids and in the site environment.

NOTE 1 Typical agents of concern are hydrogen, oxygen, hydrogen sulfide, amines, chlorides, carbon dioxide, cyanide, mercury, fluoride, naphthenic acid, and polythionic acid.

NOTE 2 If amines are present, refer to [API RP 945](#) for information on amine cracking and its prevention.

NOTE 3 Guidelines to avoid caustic stress corrosion cracking can be found in NACE SP0403.

6.3.4 Buffer gas shall be used for double seals.

6.3.5 Seal gas for a double seal shall be nitrogen and supplied at the required differential pressure when the compressor is pressurized.

- **6.3.6** If specified, alternative seal gas supply for double seals shall be used.

6.3.7 Nitrogen shall be used as separation and secondary seal gas.

- **6.3.8** If specified, air shall be used as separation gas.

Caution—Air used as a separation gas can create an explosive mixture due to mixing with process hydrocarbons.

6.4 Site and Utility Conditions

- **6.4.1** Purchaser shall specify all site and utility conditions needed for the design of the dry gas sealing system. These conditions may include but are not limited to the following:

- a) ambient and environmental conditions;
- b) area classification;
- c) utility conditions (e.g. air, nitrogen, cooling water, electric power);
- d) other external gas supply conditions (e.g. gas composition, gas pressure, and gas temperature);
- e) minimum, normal, and maximum vent system pressure.

6.5 Gas Conditioning System

6.5.1 A seal gas conditioning system shall be supplied for all tandem seal systems.

NOTE Gas conditioning system requirements are defined in Part 3.

6.5.2 A gas conditioning system shall be supplied for single seal systems, double seal buffer gas, and/or seal gas that do not meet the cleanliness and dew point requirements for the application.

6.5.3 All seal gas and buffer gas streams (including alternate, backup, start-up sources) flowing into seal cavities shall be supplied at a temperature providing at least 20 °C (35 °F) margin from the dew point line in order to preclude the possibility of liquid entering or forming in the dry gas seal.

6.5.4 Vendor shall supply phase maps for all defined conditions.

NOTE 1 See Annex B for information on dew point margin.

NOTE 2 The discharge temperature of the compressor gas stream might not provide this dew point margin.

NOTE 3 The dew point margin is based on the temperatures and pressures in the seal and not just at the supply connections. The heater outlet temperature can be set higher in order to meet this requirement.

6.6 Gas Velocities

6.6.1 The dry gas seal support system shall be designed to provide no less than the minimum gas velocities listed in Table 1 for all labyrinths and clearance seals at 2 times maximum design clearance and expected eccentricity.

Table 1—Minimum Gas Velocities

	≤Slow Roll	>Slow Roll
Process side seal	3 m/s (10 ft/s)	5 m/s (16 ft/s)
Intermediate labyrinth	3 m/s (10 ft/s)	3 m/s (10 ft/s)
Separation seal	5 m/s (16 ft/s)	5 m/s (16 ft/s)
NOTE During static conditions with external seal gas or buffer gas and a fixed or blocked in compressor volume, the compressor pressure can rise reducing the labyrinth velocity.		

6.6.1.1 The vendor shall supply supporting calculations for gas velocity compliance. The calculation shall define the total inlet flow and define any expected leakage across seal faces, continuous drain holes, or other leakage sources.

6.6.2 Seal gas for a single or tandem seal shall be supplied at or above the specified minimum velocity limits whenever the compressor is pressurized.

6.6.3 Buffer gas shall be supplied at or above the specified minimum velocity limits whenever the compressor is pressurized.

6.7 System Drain Connections

6.7.1 Dry gas seal support system and interconnecting piping shall be arranged with low point drains so the entire system can be drained prior to start-up to avoid the possibility of liquids entering the seals.

6.7.2 Drains shall be provided for all cavities (i.e. separation seal supply, vent, primary vent, secondary vent, secondary seal gas, seal gas, buffer gas).

NOTE There can be insufficient space for small compressors to have dedicated drain lines.

6.7.3 Separation seal gas supply and drain shall not be combined unless approved by the purchaser.

NOTE Gas velocity in supply lines do not allow for collection of liquid and can only be used for cavity draining prior to operation.

6.7.4 Vent and secondary vent lines shall not be combined with drains unless approved by the purchaser.

6.7.5 Drains shall be selected and designed per requirements listed in Part 3 and system diagrams as shown in Annex B of Part 3.

6.8 Alarms and Shutdowns

Alarms and shutdowns are listed in Part 3.

NOTE Alarms and shutdowns are typically reviewed during a failure mode and effects analysis (FMEA) or hazard and operability study (HAZOP).

6.9 System Analysis Failures Modes

6.9.1 The vendor shall provide the minimum and maximum operating limits of the dry gas sealing systems.

- **6.9.2** If specified, all potential failure modes and combinations that can occur within the entire seal system shall be identified by the vendor, including but not limited to:
 - a) dry gas seal failure combinations (e.g. primary only, secondary only, primary and secondary);
 - b) separation seal failure;
 - c) failure of seal gas, secondary seal gas, buffer gas, and separation gas supply system components;
 - d) single point of failure.
- **6.9.3** If specified, mitigations addressing the identified failure modes to provide adequate response time, safe shutdown, and minimal outage time shall be agreed. The mitigations may include, but are not limited to:
 - a) adequately sized venting provisions to safe locations;
 - b) monitoring and alarming;
 - c) automatic shutdowns (if specified by the purchaser);
 - d) control valve bypasses;
 - e) sparing of seal assemblies, seal components, and seal gas system components.
- **6.9.4** The purchaser shall specify any requirements for additional information or vendor participation in FMEA and/or HAZOP activities.
- **6.9.5** If specified, [API 691](#) shall be applied for the dry gas sealing system.

7 Special Tools

7.1 If special tools or fixtures are required to disassemble, assemble, or maintain the equipment, they shall be included in the quotation and furnished as part of the initial supply of the equipment.

7.2 For multiple-unit installations, the requirements for quantities of special tools and fixtures shall be agreed between purchaser and vendor.

7.3 Use of special tools shall be demonstrated during shop assembly and post-test disassembly of the equipment.

7.4 When special tools are provided, they shall be packaged in a separate, rugged metal box or boxes and shall be marked "special tools for (tag/item number)."

7.5 Each tool shall be stamped or metal tagged to indicate its intended use.

8 Coatings, Insulation, and Heat Tracing

- **8.1** If specified, surfaces shall be coated as defined by the purchaser.

8.2 Insulation and heat tracing to maintain gas temperature requirements shall be identified on the piping and instrument diagrams. All lines downstream of the separator shall be insulated.

- **8.3** Purchaser shall specify who is responsible for the design, supply, and installation of the heat tracing and insulation system.

8.4 Insulated lines and all components shall have a minimum of 50 mm (2 in.) clearance.

- **8.5** Purchaser shall specify any special provisions for insulation or heat tracing.

- **8.6** If specified, heat tracing and insulation of all panel mounted components and lines shall be completed by vendor after cleanliness and leak test of the panel, but prior to pre-shipping inspection.

9 Inspection, Testing, and Preparation for Shipment

9.1 General

- **9.1.1** The purchaser shall specify the extent of participation in the inspection and testing.
- **9.1.2** If specified, the purchaser's representative, the vendor's representative, or both shall indicate compliance in accordance with the inspector's checklist (Annex J for Part 2 and Annex C for Part 3) by initialing, dating, and submitting the completed checklist to the purchaser before shipment.

9.1.3 After advance notification to the vendor, the purchaser's representative shall have entry to all vendor and subvendor plants where manufacturing, testing, or inspection of the equipment is in progress.

9.1.4 The vendor shall notify subvendors of the purchaser's and vendor's inspection and testing requirements.

9.1.5 If shop inspection and testing have been specified, the purchaser and the vendor shall coordinate manufacturing hold points and inspectors' visits.

9.1.6 At least 6 weeks prior to the first scheduled test, the vendor shall submit to the purchaser, for review and comment, detailed procedures for all testing, including acceptance criteria for all monitored parameters.

9.1.7 The expected dates of testing shall be communicated at least 30 days in advance of testing and the actual dates confirmed as agreed.

9.1.8 The vendor shall give at least 5 working days advanced notification of a witnessed or observed inspection or test.

9.1.9 A witnessed test requires written confirmation of the successful completion of a preliminary test.

- **9.1.10** If specified, an unwitnessed pre-test shall not be performed.

NOTE Some purchasers prefer to be present for initial preliminary tests prior to witnessed tests to understand any difficulties encountered during testing.

9.1.11 The purchaser's representative shall have access to the vendor's quality program for review.

9.1.12 The vendor shall keep the following data available for at least 20 years:

- a) necessary or specified certification of materials, such as mill test reports;
- b) test data and results to verify the requirements of the specification have been met;
- c) fully identified records of all heat treatments and radiography whether performed in the normal course of manufacture or as part of a repair procedure;
- d) results of quality control tests and inspections;
- e) details of all repairs;
- f) final assembly, maintenance, and running clearances;
- g) purchase specifications for all items on bills of material;
- h) other data specified by purchaser or required by applicable codes and regulations.

9.1.13 Pressure-containing parts shall not be painted until the specified inspection and testing of the parts is complete.

- **9.1.14** In addition to the industry material specifications, the purchaser shall identify:
 - a) parts to be subjected to surface and subsurface examination;
 - b) the type of examination required, such as magnetic particle, liquid penetrant, radiographic, and ultrasonic examination.

NOTE ASTM material specifications contain mandated and supplemental inspections.

9.2 Material Inspection

Radiographic, ultrasonic, magnetic particle, or liquid penetrant inspection of welds or materials shall be performed in accordance with 9.3 through 9.5.

9.3 Radiography

9.3.1 Radiography shall be in accordance with [ASTM E94](#), ASME Code, and ASME B31.3.

- **9.3.2** If specified, nondestructive examination maps shall be supplied.

9.4 Magnetic Particle Inspection

Both wet and dry methods of magnetic particle inspection shall be in accordance with [ASTM E709](#).

9.5 Liquid Penetrant Inspection

Liquid penetrant inspection shall be based upon the procedures of [ASTM E165/E165M](#) and [ASTM E1417/E1417M](#).

9.6 Positive Material Identification (PMI)

- **9.6.1** If specified, PMI testing shall be in accordance with 9.6.2 through 9.6.7.

9.6.2 PMI shall be performed on completed components prior to shipment. PMI should also be completed on incoming material to verify compliance with specifications prior to fabrication and assembly.

9.6.3 Components not accessible for PMI verification at shipment shall be verified prior to assembly.

9.6.4 PMI techniques providing quantitative results shall be used.

NOTE Additional information on PMI testing can be found in [API 578](#).

9.6.5 Mill test reports, material composite certificates, visual stamps, or markings shall not be considered as substitutes for PMI testing, or vice versa.

9.6.6 PMI results shall be within the material specification limits, allowing for the measurement uncertainty (inaccuracy) of the PMI device as specified by the device manufacturer.

9.6.7 PMI of piping shall include piping spool PMI record maps with unique identification of each sample point for correlation to the PMI data results.

9.7 Testing

Individual testing requirements are covered in Parts 2 and 3 of this standard.

9.8 Preparation for Shipment

- **9.8.1** Equipment shall be prepared for the type of shipment specified.

9.8.1.1 The preparation shall make the equipment suitable for 6 months of outdoor storage from the time of shipment.

9.8.1.2 If storage for a longer period is contemplated, the purchaser shall consult with the vendor regarding the recommended procedures to be followed.

NOTE Individual requirements are listed in Part 2 and Part 3.

9.8.2 The vendor shall provide the purchaser with the instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site and before start-up, as described in Part 4 of this standard and Chapter 3 of [API 686](#).

9.8.3 The equipment shall be prepared for shipment after all testing and inspections have been completed and the purchaser has released the equipment.

9.8.4 The equipment shall be identified with item and serial numbers.

9.8.5 Crated equipment shall be shipped with duplicate packing lists, one inside and one on the outside of the shipping container.

9.8.6 All spare parts shall be preserved and packaged per the purchase order requirements and the vendor recommended procedures.

9.8.7 Composition wood product such as particleboard, medium density fiberboard (MDF), and oriented strand board (OSB) shall not be used.

9.8.8 Wood used in export shipping shall comply with the requirements of ISPM Pub. No.15, March 2002, FAO, Rome.

9.9 Package Markings

- **9.9.1** All markings shall be in English and additional other specified language.

9.9.2 Permanent identification labeling shall be provided on two opposite sides of the shipping box or container.

9.9.3 Shipping units shall be marked with industry standard cautionary symbols indicating center of gravity, sling or lifting points, top heavy packages, fragile and liquid contents, moisture sensitive contents, etc. per [ASTM D5445-05](#).

9.9.4 Package markings shall include:

- a) purchaser's purchase order number;
- b) equipment tag number;
- c) gross weight;
- d) dimensions;
- e) purchaser's project name.

10 Vendor's Data

10.1 General

10.1.1 The information to be furnished by the vendor is specified in 10.2 and 10.3.

10.1.2 The following information shall be included on transmittal (cover) letters, title pages, and in title blocks or other prominent position on drawings:

- a) purchaser's/owner's corporate name;
- b) job/project number;
- c) equipment item number;
- d) service name;
- e) inquiry or purchase order number;
- f) any other identification specified in the inquiry or purchase order;

- g) vendor's identifying proposal number, shop order number, serial number, or other reference number required to identify for return correspondence.

10.1.3 A coordination meeting shall be held, preferably at the vendor's plant, within 4 to 6 weeks after order commitment. The vendor shall prepare and distribute an agenda prior to this meeting, which as a minimum shall include a review of the following items.

- a) Purchase order, scope of supply, unit responsibility, subvendor items, and lines of communications;
- b) Datasheets;
- c) Applicable specifications and previously agreed exceptions;
- d) Schedules for the transmittal of data, production, and testing;
- e) Quality assurance program and procedures;
- f) Expediting;
- g) Process and instrumentation diagrams (P&IDs) and bills of material;
- h) Physical orientation of the equipment, piping, and auxiliary systems, including access for operation and maintenance;
- i) Coupling selection with regard to seal installation and removal;
- j) Seal operation and controls;
- k) Rotordynamic lateral analysis;
- l) Equipment performance, alternate operating conditions, start-up, shutdown, and any operating limitations;
- m) Inspection, related acceptance criteria, and testing;
- n) Bearing clearance and shaft centerline position(s);
- o) Site utilities and conditions;
- p) Gas sources and conditions, including alternate gas;
- q) Flare/vent conditions.

10.2 Proposals

10.2.1 General

10.2.1.1 The vendor shall send the proposal to the addressee specified in the inquiry documents.

10.2.1.1.1 The proposal shall include, as a minimum, the data specified in 10.2.2 through 10.2.4 and a specific statement that the equipment and all its components and auxiliaries are in strict accordance with this standard.

10.2.1.1.2 If the equipment or any of its components or auxiliaries is not in strict accordance, the vendor shall include a list that details and explains each deviation.

10.2.1.1.3 The vendor shall provide sufficient detail to enable the purchaser to evaluate any proposed alternative designs.

10.2.1.1.4 All correspondence shall be clearly identified in accordance with 10.1.2.

10.2.1.2 The materials of construction of all major components shall be clearly stated in the vendor's proposal.

10.2.1.2.1 Materials shall be identified by reference to applicable international standards, including the material grade.

10.2.1.2.2 If no such designation is available, the vendor's material specification, giving physical properties and chemical composition, and test requirements shall be included in the proposal.

10.2.1.2.3 Where international standards are not available, internationally recognized national or other standards may be used.

10.2.1.3 Vendor shall define the location of manufacturing and testing facilities that will be used.

10.2.1.4 Vendor shall define the location of all repair facilities.

10.2.2 Proposal Drawings

10.2.2.1 The drawings indicated on the vendor drawing and data requirements (VDDR) form (see Part 2, Annex I for seals or Part 3, Annex E for systems) shall be included in the proposal. As a minimum, the following shall be included.

- a) A general arrangement or outline drawing, showing overall dimensions, maintenance clearance dimensions, overall weights, erection weights, and the largest maintenance weight for each item. The direction of rotation and the size and location of major purchaser connections shall also be indicated.
- b) Seal cross-sectional drawing including seal sleeve to shaft interface and the method for retaining and driving the seal sleeve with the rotor shaft.
- c) Cross-sectional drawings of coolers, boosters, heaters, filters, and separators.
- d) P&ID and bill of material of systems.
- e) Sketches that show methods of lifting. [This information may be included on the drawings specified in Item a) above.]
- f) Details of gas conditioning components sizing.
- g) Separator separation method.

10.2.2.2 If "typical" drawings, schematics, and bills of material are used, they shall be marked up to show the weight and dimension data to reflect the actual scope proposed.

10.2.3 Proposal Technical Data

The following data shall be included in the proposal.

- a) The purchaser's datasheets with complete vendor's information and literature to fully describe details of the offering.
- b) The VDDR form (see Part 2, Annex I for seals or Part 3, Annex E for systems), indicating the schedule according to which the vendor agrees to transmit all the data specified.
- c) A schedule for shipment in weeks after receipt of order.

- d) A list of spare parts recommended for start-up and normal maintenance purposes, capital spares.
- e) A list of the special tools furnished for maintenance.
- f) Description of any special weather protection and winterization required for start-up, operation, and periods of idleness under the site conditions specified on the datasheets. This description shall clearly indicate the protection to be furnished by the purchaser, as well as that included in the vendor's scope of supply.
- g) A complete tabulation of utility requirements (e.g. steam, water, electricity, air, and gas). Approximate data shall be clearly indicated.
- h) A description of any inspection procedures for materials as required by 9.1 to 9.6.
- i) Any start-up, shutdown, or operating restrictions required to protect the integrity of the equipment.
- j) A list of any components that can be construed as being of alternative design, hence requiring purchaser's acceptance (5.3).
- k) Guaranteed leakage rates (static and dynamic) for dry gas seal factory acceptance test.
- l) All seal system normal flows, temperatures, pressures. Expected and maximum flows, temperatures, and pressures per the conditions defined in 6.2.1 and 6.2.2.

10.2.4 Optional Tests

The vendor shall furnish an outline of the procedures to be used for each of the special or optional tests that have been specified by the purchaser or proposed by the vendor.

10.3 Contract Data

10.3.1 General

10.3.1.1 Contract data shall be furnished by the vendor in accordance with the agreed VDDR form.

10.3.1.2 Each drawing shall have a title block in the lower right-hand corner with the date of certification, identification data specified in 10.1.2, revision number and date, and title. Similar information shall be provided on all other documents, including subvendor items.

10.3.1.3 The purchaser shall promptly review the vendor's data upon receipt; however, this review shall not constitute permission to deviate from any requirements in the order unless specifically agreed upon in writing. After the data have been reviewed and accepted, the vendor shall furnish certified copies in the quantities specified.

10.3.1.4 A complete list of vendor data shall be included with the first issue of major drawings. This list shall contain titles, drawing numbers, and a schedule for transmittal of each item listed. This list shall cross-reference data with respect to the VDDR form in Part 2, Annex I or Part 3, Annex E.

10.3.2 Contract Drawings

The contract drawing and technical data requirements are found in Part 2 for seals and Part 3 for systems.

10.3.2.1 The drawings and data furnished by the vendor shall contain sufficient information so that together with the manuals specified in 10.3.5, the purchaser can properly install, operate, and maintain the equipment covered by the purchase order.

10.3.2.2 All contract drawings and data shall be clearly legible (8-point minimum font size even if reduced from a larger size drawing), shall cover the scope of the agreed VDDR form, and shall satisfy the applicable detailed descriptions in VDDR form in Part 2, Annex I or Part 3, Annex E.

- **10.3.3 Progress Reports**

If specified, the vendor shall submit progress reports to the purchaser at the intervals specified.

10.3.4 Parts Lists and Recommended Spares

10.3.4.1 The vendor shall submit complete parts lists for all equipment and accessories supplied.

10.3.4.1.1 These lists shall include part names, manufacturers' unique part numbers, and materials of construction (identified by applicable international standards).

10.3.4.1.2 Each part shall be completely identified and shown on appropriate cross-sectional, assembly-type cutaway or exploded view isometric drawings.

10.3.4.1.3 Interchangeable parts shall be identified as such.

10.3.4.1.4 Part number shall uniquely identify parts that have been modified from standard dimensions or finished to satisfy specific performance requirements.

10.3.4.1.5 The original manufacturer's name and part number shall identify standard purchased items.

10.3.4.2 The vendor shall indicate on each of the above identified complete parts lists all parts recommended as start-up or maintenance spares and the recommended stocking quantities of each. These should include spare parts recommendations of subvendors that were not available for inclusion in the vendor's original proposal.

10.3.4.3 The vendor shall provide recommended storage/preservation procedures.

10.3.5 Installation, Operation, Maintenance, and Technical Data Manuals

10.3.5.1 General

10.3.5.1.1 The vendor shall provide sufficient written instructions and all necessary drawings to enable the purchaser to install, operate, and maintain all of the equipment covered by the purchase order.

10.3.5.1.2 This information shall be compiled in a manual or manuals with a cover sheet showing the information listed in 10.1.2, an index sheet, and a complete list of the enclosed drawings by title and drawing number.

10.3.5.1.3 The manual pages and drawings shall be numbered.

10.3.5.1.4 The manual or manuals shall be prepared specifically for the equipment covered by the purchase order. "Typical" manuals are unacceptable.

- **10.3.5.1.5** If specified, a draft manual(s) shall be issued to purchaser 8 weeks prior to mechanical testing for review and comment.

10.3.5.1.6 Refer to the VDDR form for number of copies. Hard copies as well as electronic copies shall be provided.

10.3.5.2 Installation Manual

10.3.5.2.1 All information required for the proper installation of the equipment shall be compiled in a manual that shall be issued no later than the time of issue of final certified drawings.

NOTE For this reason, it can be separate from the operating and maintenance instructions.

10.3.5.2.2 This manual shall contain information on any grouting requirements, normal and maximum utility requirements, centers of mass, rigging provisions and procedures, and all other installation data.

10.3.5.2.3 All drawings and data specified in 10.3.1 and 10.3.2 pertinent to proper installation shall be included as part of this manual.

NOTE Refer to Part 4 for installation data requirements.

10.3.5.3 Operating and Maintenance Manual

10.3.5.3.1 A manual containing all required operating and maintenance instructions shall be supplied at shipment.

10.3.5.3.2 In addition to covering operation at all specified process conditions, this manual shall also contain separate sections covering operation under any specified extreme environmental conditions.

10.3.5.4 Technical Data Manual

The vendor shall provide the purchaser with a technical data manual at shipment.

Annex A **(normative)**

Vent Study

A.1 If specified by 6.2.7, a vent study shall be conducted to establish the venting system capacity during a seal failure to select and design a system to minimize potential damage and uncontrolled leakage to atmosphere. The study results define the pressure, flow, and temperature profile in the seal cavity and associated vents. The analysis shall consist of a steady state and dynamic modeling. For the purpose of this annex, the scope is limited to the dry gas sealing systems as defined in Part 2 and Part 3. Effects of the process stream and venting system outside of the defined scope are not addressed here. The analysis will assist in establishing piping designs, components, and compressor porting requirements.

A.2 The study is coordinated between the purchaser and the vendor.

A.3 The typical data needed for this study are (where applicable) as follows.

- 1) Vent line P&IDs.
- 2) Vent line instrumentation datasheets.
- 3) Valve datasheets.
- 4) Vent piping isometrics.
- 5) Vent line relief valve datasheet.
- 6) Dry gas seal information with porting and annulus dimensions to define flow area and restriction.
- 7) Separation seal information with porting and annulus dimensions to define flow area and restriction.
- 8) Compressor porting and cavity information with annulus dimensions to define flow area and restriction.
- 9) Process side seal drawing with defined maximum and 2 times maximum seal clearance.
- 10) Bearing housing venting details and expected operating pressure.

A.4 Study shall include the normal shutdown, emergency shutdown, and settle-out conditions. Additional operational conditions to be provided shall be agreed.

A.5 Study shall include the following failure cases. Additional failure cases shall be agreed.

NOTE In a seal failure event, the seal face or seal faces provide no restriction.

- 1) Failure of the primary seal.
- 2) Failure of the secondary seal.
- 3) Failure of the primary seal and the secondary seal.
- 4) Primary vent restriction and/or blockage.
- 5) Vent/secondary vent restriction and/or blockage.
- 6) Blockage of both vents.

Annex B (informative)

Phase Maps

B.1 General

Seal gas has to maintain its gaseous state throughout the dry gas seal including the vent system to prevent seal damage due to liquids. Gas flowing through the seal gas system undergoes pressure and temperature changes, which can cause gas to condense.

The phase map is a graphical representation of the condition or state (liquid and vapor) of a gas mixture at any pressure and temperature (see Figure B.1). The phase diagram contains the following regions:

- a) region encompassed by bubble and dew point lines (also known as a dome) that contains fluid in a two-phase state;
- b) region to the left of the bubble line that contains fluid in a liquid state;
- c) region to the right of the dew point line that contains a superheated gas state;
- d) region above that contains dense phase where the fluid is in a gaseous form but starts to behave more like a liquid.

Gas conditions at various pressure and temperature points are calculated by empirical equations of state. The equations provide a range of results based on the gas mixture and should be selected based on experience or industry recommendations. Typically, for oil and gas industry applications, modified Peng Robinson equation of state is used.

To prevent liquid condensation within the seal gas system, a safety margin/superheat of 20 °C (35 °F) to the right of the dew point line has to be maintained.

B.2 Terms and Definitions (Related to Phase Maps)

B.2.1

bubble point line

The bubble point line is the curve on the phase map where the gas mixture changes state from vapor and liquid to liquid with changing pressure and temperature.

B.2.2

critical point

The critical point (Cp) is located at the junction of the dew point line and the bubble point line.

B.2.3

depressurization curve

When no heat is added to the gas (e.g. static condition), the depressurization of the gas inside the gas seal interface is isenthalpic there is a single depressurization curve, which is tangent to the dew point line.

B.2.4

dew point line

The dew point line is the curve on a phase map where the gas mixture changes state from vapor to vapor and liquid with changing pressure and temperature.

B.2.5

supercritical region

The gas is supercritical when it is in a vapor condition and when its behavior becomes similar to that of a liquid: its density is high and its viscosity is decreasing as the temperature increases; the region of the phase map where the vapor meets these conditions is called the supercritical region (or the dense phase region).

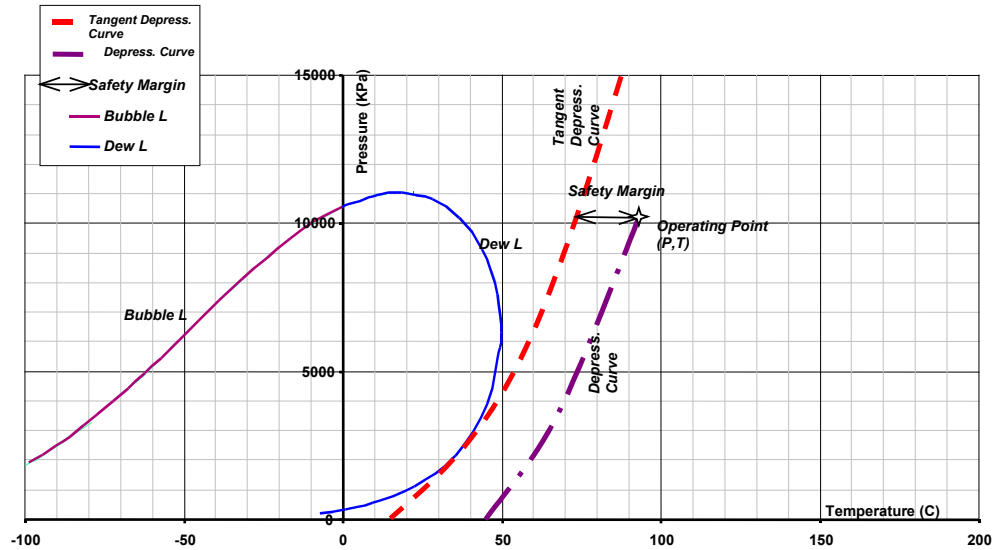


Figure B.1—Typical Phase Diagram

Annex C (informative)

Dry Gas Sealing System Retrofit Checklist

This annex provides information for retrofitting an oil seal system to a dry gas sealing system.

Dry gas seal technology has been adopted as a standard and default choice for new centrifugal compressors. However, there are many older centrifugal compressors still operating with oil lubricated mechanical seals or labyrinth seals. There are many factors that play a role in making the decision to proceed with a retrofit. Some of the main factors to consider when retrofitting a machine to dry gas seals are reliability, economics, operability, safety, and environmental considerations.

Heritage equipment may not allow compliance due to physical limitations requiring the purchaser to approve exceptions and deviations. Detailed design work may be required to confirm the retrofit is acceptable for a given service or equipment. This detailed design work may identify that a conversion is not feasible because of the compressor design and/or operational requirements.

Table C.1 should be used when considering a retrofit to confirm a conversion is possible.

Table C.1—Dry Gas Sealing System Retrofit Checklist

Evaluation Areas	Recommended Actions
Dimensional Accurate dimensional analysis and features for seal design, to understand modifications (if any) to the rotor shaft and seal to shaft attachment.	i. Verify existing seal cavity has sufficient axial and radial space for the gas seal including the process side seal and separation seal or if modifications are required. ii. Verify if the rotor has sufficient axial and radial space to fit the seal or if modifications are required. iii. Check for appropriate surface finish on stepped bores and shaft ODs. iv. Check for proper and smooth chamfers on stepped bores and shaft ODs. v. Sufficient area for seal maintenance, installation, and removal. Verify the distance between shaft ends of the involved unit and connected units. vi. Verify consistent dimensions on all rotors [in-service and spare(s)] and between drive end (DE) and NDE seal cavities.
Rotordynamic Oil seals act as dampers and removal of existing oil seals will result in reduced rotor dampening, which can have an adverse effect on the rotordynamic characteristics of the compressor.	A full rotordynamic analysis (RDA) to be performed for each compressor casing comparing rotor stability and running characteristics prior to retrofitting to and after retrofitting to dry gas seals. Requirements set out in API 617 and API 619 for comparing critical speed separation margins, amplification factors, and expected shaft vibration levels. If the outcome of the RDA is unsatisfactory modifications may be necessary.
Seal Gas Suitability/selection of seal gas. Process or external gas composition, which will be used as sealing gas.	Checked for its suitability for the application. Dew point analysis completed to identify if any conditioning equipment is required to ensure the seal gas is clean and stays dry as it flows through the dry gas seal system.
Compressor Connections The availability and sizing of ports to support gas seal operation.	Are there sufficient connections? Can any additional connections be added? Check rating, sizing, and position of all supply, vent, and drain ports for the specific type seal selected.

Evaluation Areas	Recommended Actions
Available Utility	Adequate air and/or nitrogen. Adequate cooling water. Electrical power/MCC.
Availability of Plant Process Connections	Seal gas supply. External seal gas supply. Vent connections. Drain connections.
Removal of Seal Oil System	Is it a combined system? Is the seal oil reservoir integral to the base or lube oil system? Verify impact on lube/control oil system, e.g. a) ensure adequate lube oil/control oil supply flow/pressure; b) coolers, pumps, control, and relief valve sizing; c) seal oil/lube oil pump start-up/trip logics/permissive.
Extent of Modification/Additions for Instrumentation and Control	I/O capacity. Control system modifications for alarm/trip, start-up sequence, permissive/interlocks. Field wiring/junction boxes.
Civil	Plot space and location of skid/panel close to compressor. NOTE Gas conditioning system and panel size can exceed legacy plot space.
Environmental	Impact of inert gas in gas collection systems.

Bibliography

- [1] [API 578](#), *Positive Material Identification (PMI)*
- [2] [API Standard 614](#), *Lubrication, Shaft-sealing and Oil-control Systems and Auxiliaries*
- [3] [API Manual of Petroleum Measurement Standards, Chapter 15](#)
- [4] [API Recommended Practice 945](#), *Avoiding Environmental Cracking in Amine Units*
- [5] ISO 16889, *Hydraulic fluid power – Filters – Multi-pass method for evaluating filtration performance of a filter element*
- [6] ISO 4406, *Hydraulic fluid power – Fluids – Method for coding the level of contamination by solid particles*
- [7] ISO 6708:1995, *Pipework components – Definition and selection of DN (nominal size)*
- [8] ISO 12500-1, *Filters for compressed air – Test methods, Oil aerosols*
- [9] ISO 12500-2, *Filters for compressed air – Test methods, Oil vapours*
- [10] ISO 12500-3, *Filters for compressed air – Test methods, Particulates*
- [11] ISO 12500-4, *Filters for compressed air – Test methods, Water mist*
- [12] NACE SP0403, *Avoiding Caustic Stress Corrosion Cracking of Refinery Equipment and Piping*
- [13] Pressure Equipment Directive (PED) 2014/68/EU
- [14] SAE AS 4059E, *Aerospace Fluid Power – Cleanliness Classification for Hydraulic Fluids*

Dry Gas Sealing Systems for Axial, Centrifugal, and Rotary Screw Compressors and Expanders

Part 2—Dry Gas Seals

1 Scope

This part of API 692, in conjunction with API 692, Part 1, specifies requirements for compressor dry gas seals for axial, centrifugal, expander, and rotary screw compressors for use in the petroleum, chemical, and gas industry services as described in [API 617](#) and [API 619](#).

2 Normative References

For the purposes of this document, normative references are listed in Part 1.

3 Terms, Definitions, Acronyms, and Abbreviations

For the purposes of this document, the terms, definitions, acronyms, and abbreviations given in Part 1 apply.

4 General

For the purposes of this document, unit responsibility given in Part 1 applies.

5 Requirements

5.1 Standard Fasteners and Units of Measure

For the purposes of this document, standard fasteners and units of measure given in Part 1 apply.

5.2 Statutory Requirements

For the purposes of this document, statutory requirements given in Part 1 apply.

5.3 Alternative Designs

For the purposes of this document, alternative design requirements given in Part 1 apply.

5.4 Documentation Requirements

For the purposes of this document, documentation requirements given in Part 1 apply.

6 Basic Design

6.1 General

Normative and informative annexes are provided in the document. The annexes are as follows.

- Annex A—Datasheets (informative).
- Annex B—Dry Gas Seal Test Procedures (normative).
- Annex C—Seal Nomenclature (informative).
- Annex D—Dry Gas Seal Selection Guide (informative).

- Annex E—Separation Seals (informative).
- Annex F—Process Side Seal (informative).
- Annex G—Hysteresis Test (informative).
- Annex H—Dry Gas Seal Materials (informative).
- Annex I—Vendor Drawing and Data Requirements (VDDR) (normative).
- Annex J—Inspector's Checklist (informative).
- Annex K—Post-test Dry Gas Seal Visual Inspection (normative).

6.2 Seal Types

The dry gas seal is a pressure-balanced, gas-lubricated end face seal in which the sealing mechanism is comprised of two faces, one stationary and one rotating. One seal face is etched with grooves partially across the face. These grooves in conjunction with the seal balance create face separation by both hydrostatic (pressure) and hydrodynamic (shear) forces. Face separation is typically a 3 to 5 micron gap. Leakage across the faces is a function of pressure differential, temperature, physical properties of the gas, seal size, seal geometry, and rotational speed for a given seal design.

NOTE Annex C provides dry gas seal nomenclature.

6.3 Tandem Seal with Intermediate Labyrinth

A tandem seal with intermediate labyrinth consists of two single seals arranged in series separated by a labyrinth. Tandem seals with intermediate labyrinth are suitable for medium- and high-pressure applications where leakage of process/seal gas to the atmosphere is unacceptable. Seal gas is injected between the process side seal and the primary seal faces. The majority of the seal gas flows into the compressor and a slight amount flows across the primary seal faces. The seal gas pressure is reduced across the primary seal to primary vent pressure. The intermediate labyrinth provides a restriction between the primary and secondary seal. Secondary seal gas is supplied between the intermediate labyrinth and secondary seal to provide a barrier and prevent primary seal leakage from reaching the secondary seal. Leakage from the primary seal is diluted with secondary seal gas and routed to a vent system. Secondary seal leakage is reduced across the secondary seal to atmospheric pressure and typically routed to the atmosphere. In case of primary seal failure, the secondary seal is designed to operate at primary seal conditions, which prevents uncontrolled leakage to the atmosphere and achieves a safe shutdown of the compressor. An example of a tandem seal with intermediate labyrinth configuration with a process side seal and a non-contacting bushing separation seal is shown in Figure 1.

6.4 Tandem Seal

A tandem seal consists of two single seals arranged in series. Tandem seals are suitable for medium- and high-pressure applications where some leakage of process/seal gas to the atmosphere is acceptable. This configuration is used where axial space constraints do not allow the installation of an intermediate labyrinth. Seal gas is injected between the process side seal and the primary seal faces. The majority of the seal gas flows into the compressor and a slight amount flows across the primary seal faces. The seal gas pressure is reduced across the primary seal to vent pressure. Primary seal leakage is reduced from vent pressure across the secondary seal to atmospheric pressure. In case of primary seal failure, the secondary seal is designed to operate at primary seal conditions, which prevents uncontrolled leakage to the atmosphere and achieves a safe shutdown of the compressor. Leakage from the primary seal is routed to a vent system, and leakage from the secondary seal is typically routed to the atmosphere. An example of a tandem seal configuration with a process side seal a non-contacting bushing separation seal is shown in Figure 2.

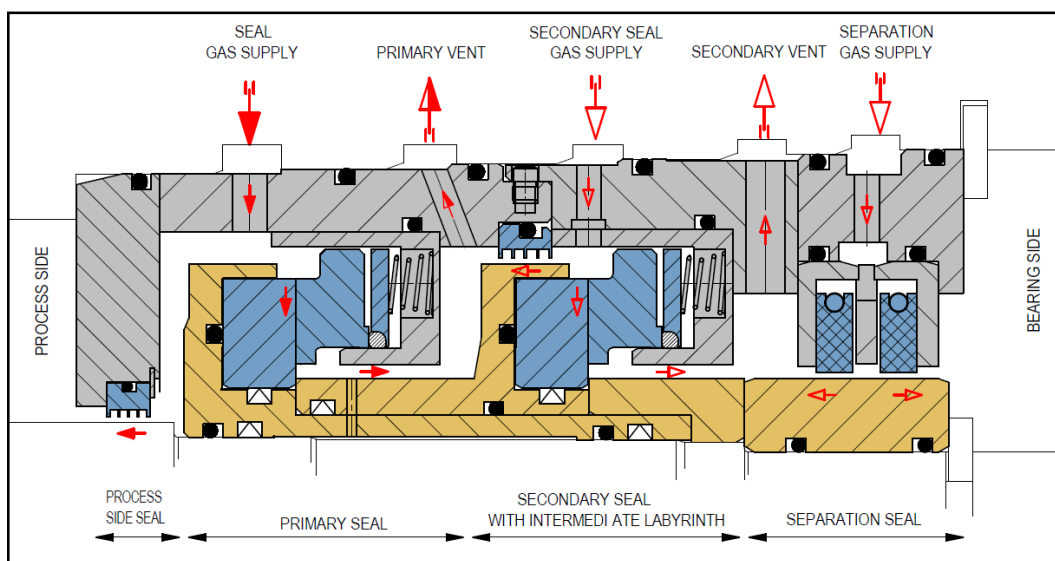


Figure 1—Tandem Seal with Intermediate Labyrinth Schematic

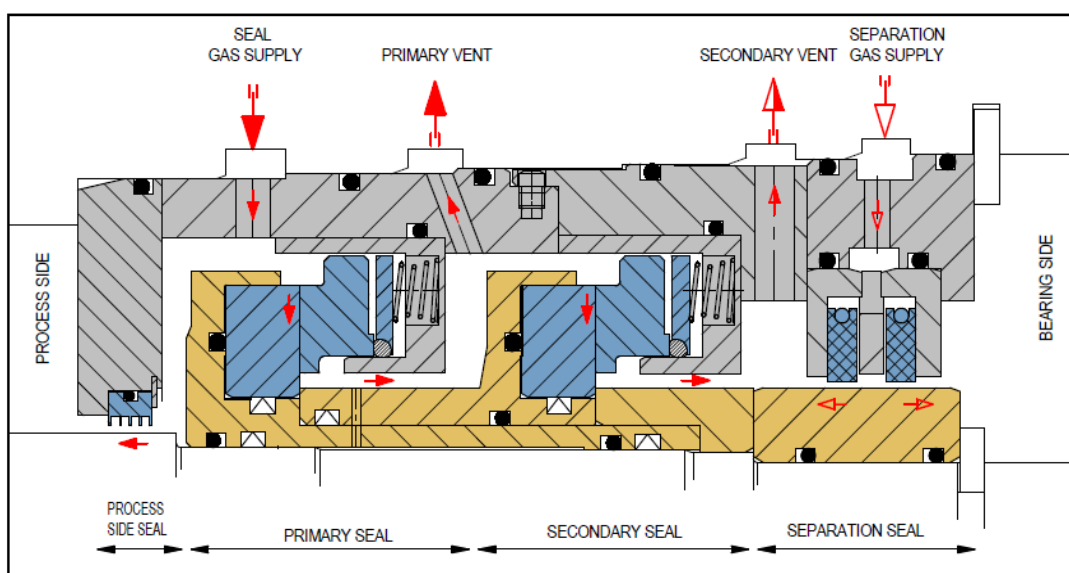


Figure 2—Tandem Seal Schematic

6.5 Double Seal

A double seal consists of two sets of single seals arranged in an opposed configuration. Double seals are suitable for low-pressure applications and where leakage of process gas to the atmosphere is unacceptable. Seal gas at a pressure higher than the process gas is supplied between the opposed seals. Seal gas leakage across the primary seal, along with any buffer gas, is introduced into the compressor/process. Seal gas leakage across the secondary seal is typically routed to the atmosphere. In case of primary seal failure, the secondary seal is designed to operate at primary seal conditions, which prevents uncontrolled leakage to the atmosphere. An example of a double seal configuration with a process side seal and a non-contacting bushing separation seal is shown in Figure 3.

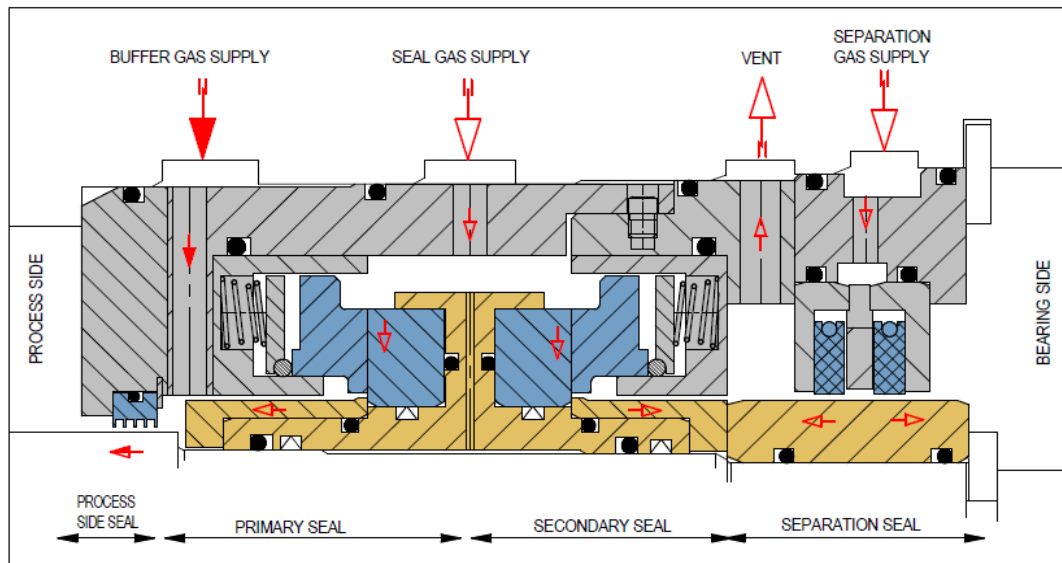


Figure 3—Double Seal Schematic

6.6 Single Seal

A single seal consists of a single set of seal faces separating process gas from the atmosphere. Single seals are suitable for applications where the gas sealed, such as air or nitrogen, is neither flammable nor harmful to the environment. Seal gas is injected between the process side seal and the primary seal faces. The majority of the seal gas flows into the compressor and a slight amount flows across the primary seal faces. The seal gas pressure is reduced across the seal faces to vent pressure. Seal leakage is typically vented to the atmosphere. An example of a single seal configuration with a process side seal and a non-contacting bushing separation seal is shown in Figure 4.

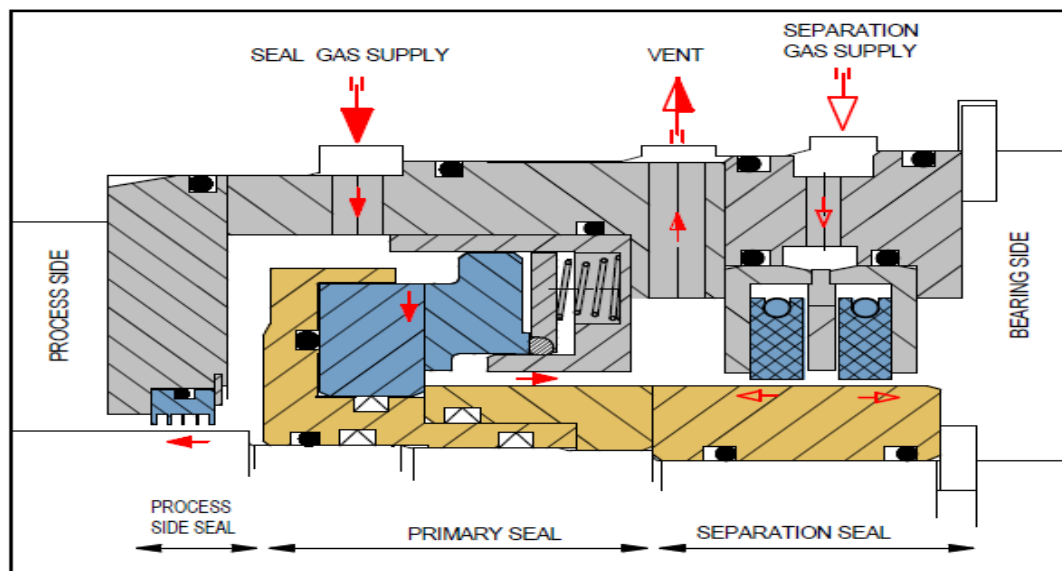


Figure 4—Single Seal Schematic

6.7 Separation Seals

6.7.1 General

The separation seal is located between the dry gas seal and bearing cavity and supplied with separation gas to prevent bearing oil migration to the seal cavity and seal leakage to the bearing cavity.

6.7.2 Non-contacting Bushing Seal

Non-contacting bushings consist of two sets of segmented rings (typically made of carbon) with a garter spring around the OD of the ring to hold the segments together. These segmented rings are positioned unconstrained within the stationary housing to allow for radial movement. The segmented rings typically have an anti-rotation device. As the segmented rings are able to float radially, the ID of the segmented ring is designed to achieve a minimal clearance above the rotating sleeve during normal operation. A separation gas is supplied to the central tap at a pressure greater than the downstream bearing housing and seal vent cavity pressures. The separation gas flows through the annulus created between the segmented rings and rotating ring surface. An example of a non-contacting bushing separation seal is shown in Figure 5.

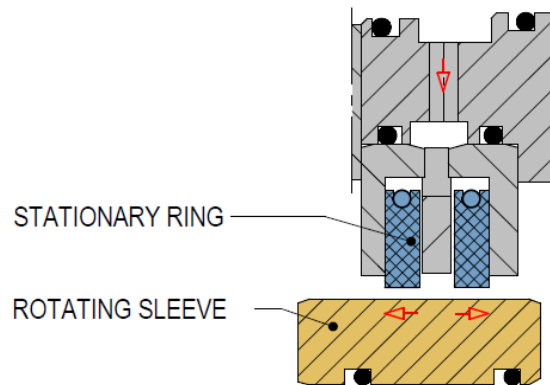


Figure 5—Non-contacting Bushing Seal Schematic

6.7.3 Labyrinth Seal

The separation labyrinth consists of two sections of teeth divided by a central tap to accommodate the introduction of separation gas. Typically, the separation labyrinth teeth are stationary, rigidly mounted with a fixed clearance (non-contacting) to the rotating sleeve. A separation gas is supplied to the central tap at a pressure greater than the downstream bearing housing and seal vent cavity pressures. The separation gas flows through the annulus created between the teeth and rotating surface. An example of a separation labyrinth seal is shown in Figure 6.

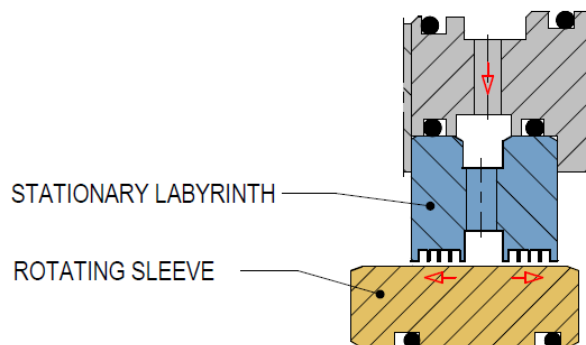


Figure 6—Separation Labyrinth Seal Schematic