Petroleum, petrochemical and natural gas industries — Rotary-type positive-displacement compressors —

6th Edition 1st Ballot Draft – March 2024

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Foreword

API Editing to Provide Forward

Introduction

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

This Standard requires the purchaser to specify certain details and features.
A bullet [●] at the beginning of a subclause or paragraph indicates that either a decision by, or further information from, the purchaser is required. Further information should be shown on the data sheets or stated in the quotation request and purchase order.

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

Dedicated datasheets for SI units and for USC units are provided in Annex A of Parts 2, 3, and 4.

Petroleum, petrochemical and natural gas industries — Rotary-type positive-displacement compressors —

Part 1: General Requirements

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1 Scope

This standard specifies minimum requirements and gives recommendations for rotary-type positive displacement compressors used for vacuum or pressure or both in special purpose applications that handle gas or process air in the petroleum, chemical, and gas industries. This part of API 619 specifies general requirements applicable to all such machines.

It is not applicable to general-purpose air compressors, liquid-ring compressors, or vane-type compressors.

NOTE Standard air compressors are covered in ISO 10440-2.

This part of API 619 contains information pertinent to all equipment covered by the other parts of this document. It shall be used in conjunction with the following parts, as applicable to the specific equipment covered:

- *Part 2 – Dry Screw Compressors*
- *Part 3 – Oil Flooded Screw Compressors*
- *Part 4 – Rotary Lobe Blowers*

The term “compressor” as used in this standard also refers to rotary lobe blowers.

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.

ANSI/ABMA Standard 7, *Shaft and Housing Fits for Metric Radial Ball and Roller Bearings (Except Tapered Roller Bearings) Conforming to Basic Boundary Plan* [1)]

ANSI/ABMA Standard 9, *Load Ratings And Fatigue Life For Ball Bearings*

ANSI B11.19 (2010), *Performance Criteria for Safeguarding*

API RP 500, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class 1, Division 1 and Division 2* [2)]

1) American Bearing Manufacturers Association, 2025 M Street, NW, Suite 800, Washington, DC 20036, USA.

2) American Petroleum Institute, 1220 L Street NW, Washington, DC 20005-4070, USA.

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

API 541, Form-Wound Squirrel-Cage Induction Motors – 500 Horsepower and Larger

API 547, *General-purpose Form-wound Squirrel Cage Induction Motors 250 Horsepower and Larger*

API RP 551, *Process Measurement Instrumentation*

API RP 578*, Guidelines for a Material Verification Program (MVP) for New and Existing Assets*

ANSI/API 611, *General-Purpose Steam Turbines for Petroleum, Chemical and Gas Industry Services*

API 612, *Petroleum, petrochemical and natural gas industries—Steam turbines—Special-purpose applications*

ANSI/API 614, *Petroleum, petrochemical and natural gas industries – Lubrication, shaft-sealing and oil-control systems and auxiliaries*

ANSI/API 670, *Machinery Protection Systems*

API 676, Positive Displacement Pumps - Rotary

API 677, *General-Purpose Gear Units for Petroleum, Chemical and Gas Industry Services*

API 682, *Pumps—Shaft Sealing Systems for Centrifugal and Rotary Pumps*

API 688

API 692, *Dry Gas Sealing Systems for Axial, Centrifugal, Rotary Screw Compressors and Expanders*

API RP 686:1996, *Machinery Installation and Installation Design*

API RP 691 (2017), *Risk-based Machinery Management – First Edition*

ASME B1.1, *Unified Inch Screw Threads, UN and UNR Thread Form* [3)]

ASME B1.13M, Metric Screw Threads: M Profile

ASME B1.20.1-1983, *Pipe Threads, General Purpose (Inch)*

ASME B16.1, *Cast Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250*

ASME B16.5, *Pipe Flanges and Flanged Fittings*

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

ASME B16.42, *Ductile Iron Pipe Flanges and Flanged Fittings, Classes 150 and 300*

ASME B16.47, *Large Diameter Steel Flanges: NPS 26 Through NPS 60*

ASME B17.1, *Keys and Keyseats*

ASME B31.3, *Process Piping*

ASME Boiler and Pressure Vessel Code: Section V, *Nondestructive Examination*

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

ASME Boiler and Pressure Vessel Code: Section VIII, Rules for Construction of Pressure Vessels

ASME Boiler and Pressure Vessel Code: Section IX, *Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators*

ASTM4 A193/A193M, *Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications*

ASTM A194, *Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both*

ASTM A247, *Standard Test Method for Evaluating the Microstructure of Graphite in Iron Castings* [4)]

ASTM A278, *Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650 °F*

ASTM A307, *Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength*

ASTM A320/A320M-05, *Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low-Temperature Service*

ASTM A388/A388M-19, *Standard Practice For Ultrasonic Examination Of Steel Forgings*

ASTM A395/A395M-99, *Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*

ASTM A515/A515M, *Standard Specification For Pressure Vessel Plates, Carbon Steel, For Intermediate- And Higher-Temperature Service*

ASTM A536, *Standard Specification for Ductile Iron Castings*

ASTM A563, *Standard Specification for Carbon and Alloy Steel Nuts*

ASTM A609/A609M-12, *Standard Practice For Castings, Carbon, Low-Alloy, And Martensitic Stainless Steel, Ultrasonic Examination Thereof*

ASTM D4304-22, *Standard Specification For Mineral And Synthetic Lubricating Oil Used In Steam Or Gas Turbines*

ASTM D5445-05, *Standard Practice For Pictorial Markings For Handling Of Goods*

ASTM E10-18, *Standard Test Method For Brinell Hardness Of Metallic Materials*

ASTM E94, *Standard Guide for Radiographic Examination*

ASTM E125-63, *Standard Reference Photographs For Magnetic Particle Indications On Ferrous Castings*

ASTM E165/E165M-18, *Standard Practice For Liquid Penetrant Testing For General Industry*

ASTM E709, *Standard Guide for Magnetic Particle Examination*

ASTM E1003, *Standard Test Method for Hydrostatic Leak Testing*

ASTM E1417 *Standard Practice For Liquid Penetrant Testing*

AWS D1.1/D1.1M, *Structural Welding Code — Steel* [5)]

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4) American Society for Testing and Materials, 100 Bar Harbor Drive, West Conshohocken, PA 19428-2959, USA.

5) American Welding Society, 550 North LeJeune Road, Miami, FL 33136, USA.

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

IEC 60529, *Degrees Of Protection Provided By Enclosures (IP Code)*

IEEE 841, *IEEE Standard for the Petroleum and Chemical Industry — Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors — Up to and Including 500 HP (370 kW)* [6)]

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

ISO 228-1, Pipe Threads Where Pressure-Tight Joints Are Not Made On The Threads -- Part 1: Dimensions, Tolerances And Designation

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

ISO 281, *Rolling bearings — Dynamic load ratings and rating life*

ISO 286, *Geometrical Product Specifications Package*

ISO 582, *Rolling Bearings - Chamfer Dimensions - Maximum Values*

ISO 1217, *Displacement compressors — Acceptance tests*

ISO 1328-1:1995, *Cylindrical gears — ISO system of accuracy — Part 1: Definitions and allowable values of deviations relevant to corresponding flanks of gear teeth*

ISO 2151, *Acoustics - Noise Test Code For Compressors And Vacuum Pumps - Engineering Method (Grade 2)*

ISO 3448:1992 , *Industrial liquid lubricants — ISO viscosity classification*

ISO 3740, *Acoustics - Determination Of Sound Power Levels Of Noise Sources - Guidelines For The Use Of Basic Standards*

ISO 3744, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering method for an essentially free field over a reflecting plane*

ISO 3746, *Acoustics - Determination Of Sound Power Levels And Sound Energy Levels Of Noise Sources Using Sound Pressure - Survey Method Using An Enveloping Measurement Surface Over A Reflecting Plane*

ISO 6708, *Pipework components — Definition and selection of DN (nominal size)*

ISO 7005-2, *Metallic flanges — Part 2: Cast iron flanges*

ISO 8068, *Petroleum products and lubricants – Petroleum lubricating oils for turbines (categories ISO-L- TSA and ISO-L-TGA)-Specifications*

ISO 8501 (all parts), *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness*

ISO 8821, *Mechanical vibration — Balancing — Shaft and fitment key convention*

ISO 9606-1 *Qualification Testing Of Welders - Fusion Welding - Part 1: Steels*

ISO 10440-2, *Petroleum and natural gas industries - Rotary-Type Positive-Displacement Compressors - Part 2: Packaged Air Compressors (Oil-Free*)

6) Institute of Electrical & Electronic Engineers, 445 Hoes Lane, Piscataway, NJ 08855-1331, USA.

ISO 13443, *Natural Gas – Standard reference conditions*

ISO 14120, *Safety Of Machinery - Guards - General Requirements For The Design And Construction Of Fixed And Movable Guards*

ISO 15607, *Specification And Qualification Of Welding Procedures For Metallic Materials - General Rules*

ISO 15614-1, *Specification And Qualification Of Welding Procedures For Metallic Materials - Welding Procedure Test - Part 1: Arc And Gas Welding Of Steels And Arc Welding Of Nickel And Nickel Alloys*

ISO 21940-11, *Mechanical Vibration - Rotor Balancing - Part 11: Procedures And Tolerances For Rotors With Rigid Behaviour*

ISO 21940-32, Mechanical Vibration - Rotor Balancing - Part 32: Shaft And Fitment Key Convention

ISO 80079-36, *Explosive Atmospheres - Part 36: Non-Electrical Equipment For Explosive Atmospheres - Basic Method And Requirements*

ISPM Pub. No.15-March 2002, FAO, Rome.

NACE MR0103 / ISO 17945, *Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments* 7)

NACE MR0175 / ISO 15156, Petroleum And Natural Gas Industries—Materials For Use In H2S-Containing Environments In Oil And Gas Production

NEMA 250, *Enclosures for Electrical Equipment (1 000 Volts Maximum)* 8)

NEMA SM 23, *Steam Turbines for Mechanical Drive Service*

3 Terms, Definitions, Acronyms, Abbreviations, and Symbols

3.1 Terms and Definitions

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

3.1.1
AFD
adjustable frequency drive
a device to allow speed adjustment accomplished by electrical frequency variation in an AC motor.

3.1.2
alarm point
preset value of a measured parameter at which an alarm is actuated to warn of a condition that requires corrective action.

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7) NACE international, the corrosion society, 1440 South Creek Drive, Houston, Texas 77084-4906, USA.

8) National Electrical Manufacturers Association, 1300 N. 17th Street, Suite 1847, Rosslyn, VA 22209, USA.

3.1.3
alloy steel
Steel that is alloyed with a variety of elements in total amounts between 1.0% and 50% by weight.

3.1.4
anchor bolts
Used to attach the mounting surface to the support structure (concrete foundation or steel structure).

cf. hold-down bolt

3.1.5
approve
Provide written documentation confirming an agreement.

3.1.6
axially split
Joint split with the principal face parallel to the shaft centerline.

NOTE Axially split is also commonly referred to as horizontally split joint.

3.1.7
baseplate
skid
Fabricated steel structure designed to support the driver and/or driven equipment and other ancillaries that may be mounted upon it

NOTE The term “mounting plate” was used to refer to soleplate or baseplate and is no longer used.

3.1.8
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.

3.1.9
certified point
Point to which the performance tolerances will be applied.

3.1.10
cold start
a machine start when the rotor and casing are at the ambient temperature specified

NOTE In certain applications, machine ambient can be different than minimum site ambient.

3.1.11
critical speed
Shaft rotational speed at which the rotating element is in a state of resonance.

3.1.12
depressurization valve
blowdown valve
Valve, external to the compressor, used to relieve the gas pressure within the compressor or compressor package to atmospheric or flare pressure.

3.1.13
design
Manufacturers calculated parameter.

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

3.1.14
DGS
dry gas seal
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.

3.1.15
dry screw compressor
Twin screw compressor that uses no liquid for sealing the rotor clearances and driving the non-coupled rotor.

NOTE 1 The rotor-to-rotor relationship is maintained by timing gears on each rotor and the non-coupled rotor is driven by the coupled rotor through the timing gears.

NOTE 2 No rotor-to-rotor contact occurs in the dry screw compressor.

NOTE 3 Dry screw compressors are also commonly referred to as oil-free screw compressors.

3.1.16
expansion joint
Flexible piping union assembly normally installed on main process gas flanges.

3.1.17
external seal
Shaft seal located on the drive shaft that restricts process gas or oil from leaking to atmosphere.

3.1.18
gas/oil separator
Pressure-containing device, usually a vessel, used to separate entrained oil from the process gas.

3.1.19
gas power
Power consumed by the compressor without mechanical losses.

3.1.20
gauge board
Bracket or plate used to support and display gauges, transmitters and other instruments.

cf. panel

NOTE 1 A gauge board can be a metal plate or an open metal structure.

NOTE 2 A gauge board is not a panel. A gauge board is open and not enclosed. A panel is an enclosure.

3.1.21
general-purpose application
Application that is usually spared or is in non-critical service.

3.1.22
hold-down bolts
mounting bolts
Bolts holding the equipment to its mounting surface.

3.1.23
hydrodynamic bearings
Bearings that incorporate a fluid film to form an oil wedge, or wedges, that support the load without shaft-to-bearing contact.

3.1.24
informative
For advice only.
cf. normative

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

3.1.25
inlet separator
device, usually a filter or vessel, used to separate entrained solid and liquid contaminants from the process gas inlet steam.

3.1.26
inlet volume flow
Flow rate expressed in volumetric flow units at the conditions of pressure, temperature, compressibility and gas composition, including moisture content, at the compressor inlet flange.

NOTE Inlet volume flow is a specific example of actual volume flow. Actual volume flow is the volume flow at any location such as interstage or compressor discharge. Actual volume flow should not be used interchangeably with inlet volume flow.

3.1.27
internal seal
Internal shaft seal that restricts process gas and oil from mixing.

3.1.28
maximum allowable differential pressure
Highest differential pressure that can be permitted in the compressor under the most severe operating conditions.

3.1.29
MAWP
maximum allowable working pressure
Maximum continuous pressure for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified maximum operating temperature.

3.1.30
maximum allowable working temperature
Maximum continuous temperature for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified maximum operating pressure.

3.1.31
MCS
maximum continuous speed
N_{mc}
Highest rotational speed (revolutions per minute) at which the machine, as built and tested, is capable of continuous operation.

3.1.32
maximum power
Highest power the compressor and any shaft-driven appurtenances require for any of the specified operating conditions, including the effect of any equipment (e.g. pulsation suppression devices, process piping, intercoolers, after-coolers, and separators) furnished by the compressor vendor.

NOTE The maximum power case can differ from the maximum torque case.

3.1.33
maximum sealing pressure
Highest pressure at which the seals are required to seal during any specified static or operating condition and during start-up and shutdown.

3.1.34
minimum allowable speed
Lowest rotational speed (revolutions per minute) at which the manufacturer's design will permit continuous operation.

3.1.35
minimum design metal temperature
Lowest mean metal temperature (through the thickness) expected in service, including operation upsets, auto-refrigeration, and temperature of the surrounding environment, for which the equipment is designed.

Note: Adapted from ASME Boiler and Pressure Vessel Code

3.1.36
normal operating point
Point at which usual operation is expected and optimum efficiency is desired. This point is usually the point at which the vendor certifies that performance is within the tolerances stated in this standard.

3.1.37
NPS
nominal pipe size

Value approximately equal to a diameter in inches.

EXAMPLE- NPS 3/4

NOTE 1 Refer to ASME B 31.3

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

3.1.38
normative
Required

cf. informative

NOTE A normative reference or Annex invokes a requirement or mandate of the specification.

3.1.39
observed

A classification of inspection or test where the purchaser is notified of the schedule and the inspection or test is performed even if the purchaser or their representative is not present.

3.1.40
oil circulation system

An oil system per API 614 configuration code: Code LO-PRS00-R0-H0-BP0-CS0-F1-A0-PV0-TV0-0T0.

3.1.41
oil-flooded screw compressor
Twin screw compressor with a lubricant (compatible with the process gas) injected into the rotor area after the closed thread position of the rotor.

NOTE This lubricant helps seal rotor clearances, removes heat of compression from process gas, and establishes a lubricant film between the rotors. One rotor drives the other in the absence of a timing gear.

NOTE Oil-flooded screw compressors are also commonly referred to as wet screw compressors or oil-injected screw compressors.

3.1.42
owner
Final recipient of the equipment who can delegate another agent as the purchaser of the equipment.

3.1.43
panel
Enclosure used to mount, display, and protect gauges, switches, transmitters and other instruments.

cf gauge board

3.1.44
PPF
pocket-passing frequency
Frequency at which the gas is discharged from the rotor lobes into the discharge port.

NOTE Pocket-passing frequency, expressed in hertz, is calculated by multiplying the rotor rotational speed, expressed in revolutions per minute, by the number of lobes on that rotor and dividing the product by 60.

3.1.45
pressure casing
Composite of all stationary pressure-containing parts of the unit, including all nozzles and other attached parts.

3.1.46
pressure design code
Recognized pressure vessel standard specified or agreed by the purchaser.

3.1.47
purchaser
Agency that issues the order and specifications to the vendor.

NOTE The purchaser can be the owner of the plant in which the equipment is to be installed or the owner's appointed agent.

3.1.48
purge gas

A gas used to sweep a contained area as a means to eliminate another gas.

NOTE An example is gas used to purge a distance piece on a recip or nitrogen introduced above the oil in a reservoir.

3.1.49
radially split
Split with the principal joint perpendicular to the shaft centerline.

NOTE Radially split is commonly referred to as vertically split.

3.1.50
rated speed
100 % speed
Highest rotational speed (revolutions per minute) required to meet any of the specified operating conditions.

3.1.51
relief valve set pressure
Pressure at which a relief valve starts to lift.

3.1.52
remote
Location of a device when located away from the equipment or console, typically in a control room.

3.1.53
rotary lobe blower

Straight-lobe rotary blower with no internal compression that uses no liquid for sealing the rotor clearances and driving the non-coupled rotor.

NOTE 1 The rotor-to-rotor relationship is maintained by timing gears on each rotor and the non-coupled rotor is driven by the coupled rotor through the timing gears.

NOTE 2 No rotor-to-rotor contact occurs in the rotary lobe blower.

NOTE 3 Lack of internal compression typically limits the pressure ratio to 2:1. Above this, screw compressors are commonly used.

NOTE 4 Rotary lobe blowers can also be referred to as rotary lobe compressors, vacuum pumps and vacuum exhausters.

3.1.54
rotor
Rotating male or female assembly, including rotor body, shaft and shrunk-on sleeves (if furnished), timing gears, thrust collars and balance pistons.

3.1.55
rotor body
rotor lobe

Helical or straight profile section on or integral with the shaft.

NOTE Helical profiles are used for screw compressors. Straight profiles are used for rotary lobe blowers.

3.1.56
rotor set
Set consisting of male and female rotors.

3.1.57
roughness magnitude
Ra

Arithmetic average of the absolute value of the profile height deviations recorded within the evaluation length and measured from the mean line.

NOTE 1 Adapted from ASME B46.1-2009 para 1-4.1.1

NOTE 2 It is the average height of the entire surface, within the sampling length, from the mean line.

3.1.58
seal gas

Gas on the high pressure side of a seal which flows through the seal segments and acts as a sealing media.

NOTE 1 This can be process gas, or an alternate gas.

NOTE 2 For a DGS tandem primary seal this, is normally filtered process gas. The tandem secondary seal and double DGS normally use filtered nitrogen.

3.1.59
separation gas

Air or inert gas used to separate an atmospheric bearing housing from the seal housing.

cf. separation seal

NOTE – this is to prevent oil mist from contacting the seal face.

3.1.60
settle-out pressure
Highest pressure which the compressor experiences when not running and after equilibrium has been reached.

NOTE This can be a function of ambient temperature, relief valve setting and piping-system volume.

3.1.61
shutdown
Condition as determined by the equipment user that requires action to stop the equipment, may be automated or manual.

3.1.62
slide valve
Device integral to the compression chamber for varying the volumetric flow through an oil-flooded screw compressor.

3.1.63
soleplate
Sub-soleplate

Plate attached to the foundation, with a mounting surface for equipment or for a baseplate.

NOTE The term “mounting plate” was used to refer to soleplate or baseplate and is no longer used.

3.1.64
special purpose application
Application for which the equipment is designed for uninterrupted, continuous operation in critical service, and for which there is usually no installed spare equipment.

3.1.65
special tool
Tool which is not a commercially available catalog item.

3.1.66
standby
Service state in a piece of equipment is normally idle or idling and is capable of immediate automatic or manual start-up and continuous operation.

3.1.67
standard volume flow
flow rate expressed in volume flow units at one of the specified standard conditions as follows:

3.1.68
thermal relief valve
Valve for relieving pressure caused by thermal expansion of liquid within a closed volume.

3.1.69
sealing strips
Seals located on the edge of screws or lobes for the purpose of reducing internal clearances.

NOTE 1 Sealing strips are typically renewable.

NOTE 2 Sealing strips are also referred to as tip seals.

3.1.70
tie bar
Shipping bars provided on expansion joint to prevent damage in shipment and/or ease installation. Tie bars are removed prior to operation.

3.1.71
tie rods
Rods used on expansion joints to prevent over compression and over extension. Tie rods remain installed in service.

3.1.72
trip
Automated shutdown to ensure personnel safety (safety critical).

3.1.73
trip speed
Speed at which the independent emergency overspeed device operates to shut down the driver.

3.1.74
ultimate load rating (hydrodynamic thrust bearing)
Load that will produce the minimum acceptable oil film thickness without inducing failure during continuous service, or the load that will not exceed the creep initiation or yield strength of the babbitt or bearing material.

3.1.75
unit responsibility
Obligation for coordinating the documentation, delivery, and technical aspects of all the equipment and all auxiliary systems included in the scope of the order.

3.1.76
upset condition
Deviation from normal operating conditions or equipment operation.

3.1.77
vendor
Manufacturer or manufacturer's agent that supplies the equipment.

3.1.78
witnessed
A classification of inspection or test where the purchaser is notified of the schedule of the inspection or test and a hold is placed until the purchaser or the purchaser's representative is in attendance or they waive their presence at the inspection or test.

3.2 Abbreviations

AB	alkyl benzene
ASME BPVC	ASME Boiler and Pressure Vessel Code
cf	(Latin conferre) confer or compare – cross reference
DBSE	distance between shaft ends
DCS	distributed control system
DN	nominal diameter
FEA	finite element analysis
HMI	human machine interface
MDF	medium density fiberboard
OSB	oriented strand board
MW	mole weight
NNT	no negative tolerance

OEM	original equipment manufacturer
PAG	polyalkylene glycol
PAO	polyalphaolefin
PLC	programmable logic controller
PMI	positive material identification
PN	pressure nominale
POE	polyol ester
PTFE	polytetrafluoroethylene
PVE	polyvinyl ether
PWHT	post weld heat treat
SCC	stress corrosion cracking
SDS	safety data sheet
SI	International System of Units
SS	stainless steel
TIC	temperature indicator and controller
TFE	tetraflouroethylene
TRL	technology readiness level
USC	Unites States customary

3.3 Symbols

ß	beta ratio, filter element micron size rating
Cp	heat capacity at constant pressure
Cv	heat capacity at constant volume
SMr	the forced response analysis required separation margin, %
Z	compressibility factor

4 Dimensions and Units

4.1 Drawings and maintenance dimensions shall be in the International System of Units (SI) or United States customary (USC) units.

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

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

NOTE Dedicated datasheets for SI units and for USC units are provided in Annex A of Parts 2, 3, and 4.

5 Requirements

5.1 Statutory Requirements

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 Unit responsibility

The vendor shall assume unit responsibility and assure that all sub-vendors comply with the requirements of this standard and all reference documents for all equipment and all auxiliary systems included in the scope of the order.

5.3 [●] Documentation Requirements

The purchaser shall specify the hierarchy of documents.

NOTE Typical documents include company and industry specifications, meeting notes, and modifications to these documents.

6 Basic Design

6.1 General

6.1.1 Equipment Reliability

6.1.1.1 [●] Only equipment that is field proven is acceptable. The purchaser shall specify the TRL level from API RP 691 for qualified equipment.

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

6.1.1.2 [●] If specified, the vendor shall provide the documentation to demonstrate that all equipment proposed qualifies as field proven.

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

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

6.1.1.4 [●] The purchaser shall specify if equipment will be supplied in accordance with API RP 691.

6.1.1.5 If API RP 691 has been specified, the vendor shall identify all machinery components that have a TRL < 7 per API RP 691 Section 4.3.2 Table 1.

6.1.1.6 [●] The purchaser shall specify the period of uninterrupted continuous operation.

6.1.1.7 Shutting down the equipment to perform required maintenance or inspection during the specified uninterrupted operation period is not acceptable.

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

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

6.1.1.8 Vendor shall advise in the proposal any component designed for a finite life.

NOTE It is recognized that these are design criteria.

6.1.2 Performance

6.1.2.1 [●] The purchaser shall specify the equipment's normal operating point.

6.1.2.2 [●] The purchaser shall specify gas composition(s).

6.1.2.3 [●] The purchaser may provide estimated molecular weight, ratio of specific heats (Cp/Cv) and compressibility factor (Z) for reference.

NOTE The chemical and physical properties of the gas mixture being compressed, such as the dew points on suction and discharge side, auto ignition temperature, polymerization criteria, reactivity, and any other relevant process conditions to be considered in the package design are important to consider for safe and reliable operation.

6.1.2.4 The purchaser shall specify the presence of any solids or liquids in the gas stream and their amount, size, and composition.

6.1.2.5 The vendor shall use the specified values of flow, the specified gas composition, and the gas conditions to calculate molecular weight, ratio of specific heats (Cp/Cv) and compressibility factor (Z). The compressor vendor shall indicate the values on the datasheets with the proposal and use them to calculate performance data.

6.1.2.6 [●] The purchaser shall specify all other operating points, including start-up and upset conditions, and shall indicate the certified operating point.

6.1.2.7 [●] The purchaser shall specify the settle-out pressure. If this pressure is not available at the time of inquiry, the normal discharge pressure shall be assumed.

NOTE If the actual settle-out pressure is higher than the assumed pressure, the seal system, drive-train components, s and piping system can be adversely affected.

6.1.2.8 [●] If specified, the compressor vendor shall confirm that the unit is capable of start-up at settle-out or other elevated suction pressure.

6.1.2.9 [●] Fluids that are flammable, hazardous, or toxic shall be identified by the purchaser.

6.1.2.10 The equipment (machine, driver, and ancillary equipment) shall perform on the test stand within the specified acceptance criteria. The performance of the machine shall also take into account the following.

a) The flow at the certified point shall have no negative tolerance.

b) The power at the certified point shall not exceed 104% of the quoted value.

c) The compressor vendor shall confirm that the unit is capable of continuous operation at any specified conditions.

6.1.2.11 After installation, the performance of the combined units shall be the joint responsibility of the purchaser and the vendor who has unit responsibility.

6.1.3 General Requirements

6.1.3.1 [●] If specified by the purchaser, the equipment shall also be designed to operate at rated suction pressure with a discharge pressure equal to the downstream relief valve set pressure.

NOTE 1 Sizing system equipment to operate with discharge pressure at relief valve set pressure may result in excessive over-sizing of equipment relative to normal and rated conditions.

NOTE 2 For machines operating with variable suction and discharge pressure levels, maximum allowable temperature or maximum allowable differential pressure can occur before maximum allowable discharge pressure occurs. In such cases, the manufacturer and the purchaser should jointly consider and apply suitable safeguarding and controls to avoid any damage.”

6.1.3.2 Major parts such as casing components and bearing housings shall be designed and manufactured with the use of shouldering, dowels, or keys to ensure correct alignment on reassembly.

6.1.3.3 [●] If an installation location is classified as hazardous then motors, electrical instrumentation, equipment, components, and electrical installations shall be suitable for the hazardous electrical area classification designation as specified.

6.1.3.4 [●] All applicable electrical codes shall be specified. Local electrical codes that apply shall be provided by the purchaser upon request.

NOTE Locations for installed equipment can be classified as hazardous electrical areas or they can be unclassified. An unclassified area is considered non-hazardous; therefore, motors, electrical instrumentation, equipment, components, and electrical installations for unclassified areas are not governed by hazardous area electrical codes.

6.1.3.5 Control of the sound pressure level (SPL) of all equipment furnished shall be a joint effort of the purchaser and the vendor having unit responsibility.

6.1.3.6 [●] The equipment furnished by the vendor shall conform to the maximum allowable sound pressure level specified.

6.1.3.7 The vendor shall provide expected values for maximum sound pressure level per octave band for the equipment.

NOTE The installed SPL depends on the installation.

6.1.3.8 [●] If specified, sound power levels shall be supplied based on calculation methods.

NOTE ASME PTC 36 or ISO 2151, ISO 3740, ISO 3744, and ISO 3746 can be consulted for guidance.

6.1.3.9 [●] If specified, the vendor shall supply acoustical treatment. The type of treatment and safety requirements shall be agreed by the vendor and the purchaser, refer to 7.11 for enclosure requirements.

NOTE These compressors typically require acoustical treatment to meet allowable noise limits. Potential methods for noise reduction include lowering compressor running speed, nozzle velocities, compression ratio and/or volume ratio, the use of lagging or acoustical blankets, resonance avoidance and dampening, and acoustical enclosures or walls.

6.1.3.10 If equipment for liquid separation in the discharge gas stream is required, the specifications shall be developed jointly by the purchaser and the vendor. Liquid separation is always required for oil-flooded screw compressors (see 7.8.5) and can be required for dry screw compressors or rotary lobe blowers if liquid injection is utilized either in process or through seals.

6.1.3.11 [●] The equipment, including all auxiliaries, shall be suitable for operation under the environmental conditions specified by the purchaser.

NOTE 1 These conditions normally include whether the installation is indoors (heated or unheated) or outdoors (with or without a roof), maximum and minimum temperatures, sun metal temperature, unusual humidity and dusty or corrosive conditions.

NOTE 2 Refer to the Site and Utilities data sheet for the site conditions.

6.1.3.12 [●] The equipment, including all auxiliaries, shall be suitable for operation, using the utility stream conditions specified by the purchaser.

6.1.4 [●] Pressure vessels shall comply with ASME BPVC, or other pressure vessel design code specified by the purchaser.

6.1.5 Speed Requirements

6.1.5.1 Equipment driven by induction motors shall be rated at the actual motor speed for the rated load condition.

6.1.5.2 Equipment shall be capable of operation up to trip speed (see 6.1.5.4), without damage, at rated suction pressure with a discharge differential pressure that is 110% of maximum specified differential pressure.

NOTE 1 Sizing system equipment to operate with discharge pressure at relief valve set pressure may result in excessive over-sizing of equipment relative to normal and rated conditions.

NOTE 2 For machines operating with variable suction and discharge pressure levels, maximum allowable temperature or maximum allowable differential pressure can occur before maximum allowable discharge pressure occurs.

6.1.5.3 [●] If specified, equipment shall be designed to run, without damage, at the relief valve set pressure.

NOTE 1 There can be insufficient driver power to operate under these conditions.

NOTE 2 This requirement is not applicable to rotary lobe blowers.

6.1.5.4 The equipment's trip speed shall not be less than the values in Table 1.

Table 1 — Driver Trip Speeds

Driver Type	**Trip Speed** (% of maximum continuous speed)
Steam turbine	
— NEMA class A[a]	115
— NEMA class B, C and D[a]	110
Variable-speed motor	110
Reciprocating engine	110
[a] Indicates governor class as specified in NEMA SM 23.	

6.1.6 Additional Requirements

6.1.6.1 Spare and replacement parts for the machine and all furnished auxiliaries shall meet all the criteria of this standard.

6.1.6.2 Oil reservoirs and housings that enclose moving, lubricated parts, such as bearings, shaft seals, highly polished parts, instruments, and control elements, shall be designed to minimize contamination by moisture, dust, and other foreign matter during periods of operation and idleness.

6.1.6.3 [●] If specified, the vendor shall review and comment on the purchaser's piping and foundation drawings.

6.2 Pressure casings

6.2.1 The pressure casing shall be designed to:

a) operate without leakage or internal contact between rotating and stationary components while subject simultaneously to the MAWP (and corresponding temperature) and the worst-case combination of maximum allowable nozzle loads applied to all nozzles; and

b) withstand the hydrostatic test.

6.2.2 The allowable tensile stress used in the design of the pressure casing (excluding bolting) for any material shall not exceed either 25% of the minimum ultimate tensile strength or 67% of the minimum yield strength for that material at the maximum allowable working temperature.

NOTE The published design-allowable stresses for materials manufactured in accordance with the ASME BPVC and ANSI standards or other internationally recognized standard as approved by the purchaser are based on minimum tensile properties.

6.2.3 For cast materials, the allowable tensile stress shall be multiplied by the appropriate casting factor as shown in Table 2.

Table 2 — Material Casting Factors

Type of NDE	**Casting factor**
Visual, magnetic particle, liquid penetrant	0.8

Spot radiography	0.9
Ultrasonic	0.9
Full radiography	1,0

NOTE In general deflection is the determining consideration in the design of casings. Ultimate tensile or yield strength is seldom the limiting factor.

6.2.4 A corrosion allowance of at least 3 mm (0.12 in.) shall be added to the casing thickness used in 6.2.1. This corrosion allowance also applies to all auxiliary connections exposed to the same fluid as the pressure containing casing.

6.2.5 For casing-joint bolting, the allowable tensile stress, as determined in 6.2.2 shall be used to determine the total bolting area based on hydrostatic load and gasket preload as applicable. The preload stress shall not exceed 75% of the bolting material minimum yield. If internal hexagonal head or socket head cap screws are used, the preload stress shall not exceed 60% of bolting material minimum yield.

NOTE 1 Preloading the bolting is required to prevent unloading the bolted joint due to cyclic operation.

NOTE 2 Thread stresses in the nut or case can be the limiting factor.

6.2.6 Bolting shall be furnished as follows.

a) The threading shall conform either to ASME B1.1, ASME B1.13M or ISO 261 as specified.

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

c) Hexagonal head or socket head cap screws may be used for ease of maintenance provided that the stress is limited to 60% of bolt material yield.

d) Studs shall be used instead of cap screws except where hexagonal head cap screws are essential for assembly purposes and have been approved by the purchaser.

e) For limited space locations, an integrally flanged fastener can be required.

f) Fasteners (excluding washers and headless set screws) shall have the material grade and manufacturer's identification symbols applied to one end of studs 10 mm (3/8 in.) in diameter and larger and to the heads of bolts ¼ in (6 mm) in diameter and larger. If the available area is inadequate, the grade symbol may be marked on one end and the manufacturer's identification symbol marked on the other end. Studs shall be marked on the exposed end.

6.2.7 The maximum allowable working pressure of the pressure casing shall be at least equal to the specified relief valve set pressure. If a relief valve set pressure is not specified by the purchaser, the MAWP shall be specified by the vendor. (See 6.1.5.3)

6.2.8 Casings shall be made of steel if the gas is flammable or toxic.

NOTE In cases where cast-iron casings are acceptable, other considerations such as repairability of the casing due to close rotor/casing clearances can be a consideration in specifying a steel casing.

6.2.9 Pressure casings designed for more than one maximum allowable working pressure shall not be used.

6.2.10 If a cooling jacket is utilized, this jacket shall have only external connections between the upper and lower housings.

NOTE In case of catastrophic seal failure, bearing housings can be exposed to process gas pressure.

6.2.11 [●] If the bearing housing can be exposed to process gas pressure, the bearing housing shall be considered part of the pressure casing and shall have the same MAWP.

6.2.12 The main joint of axially split casings shall use a metal-to-metal joint that is tightly maintained by bolting.

a) The joint shall be sealed with a compound that is compatible with the specified service. Gaskets (including string-type) shall not be used.

b) The main joints of radially split casings may incorporate a gasket compatible with the specified service. Gaskets (including O-rings) shall be fully confined in machined grooves.

6.2.13 Each axially split casing shall be sufficiently rigid to allow removal and replacement of its upper half without disturbing rotor-to-casing running clearances.

6.2.14 Casings and supports shall be designed to have sufficient strength and rigidity to limit any change in the relative position of the shaft ends at the coupling flange caused by the worst combination of allowable pressure, torque and piping forces and moments, to 50 µm (0.002 in.).

6.2.15 Jackscrews, guide rods, casing-alignment dowels and/or other appropriate devices shall be provided to facilitate disassembly and reassembly.

6.2.16 The length of guide rods shall prevent damage to the internals or casing studs by the casing during disassembly and reassembly.

6.2.17 Lifting lugs or eyebolts shall be provided for lifting only the top half of the casing.

6.2.18 Methods of lifting the assembled machine or components shall be specified by the vendor.

6.2.19 If jackscrews are used as a means of parting contacting faces, one of the faces shall be relieved (counterbored or recessed) to prevent a leaking joint or an improper fit caused by marring of the face.

6.2.20 [●] If specified corrosion resistance, overlay cladding shall be applied to the casing wall. This procedure can require an overbore of the casing during manufacture prior to final machining.

EXAMPLE For wet CO_2 service (carbonic acid), a stainless overlay 2.5 mm to 3.2 mm (0.100 in. to 0.125 in.) thick can be applied to the cast steel casing wall. The casing would be overbored to allow for a multilayer weld overlay lining consisting of a barrier pass of AISI Type 308/309 stainless steel followed by a cover pass of 308/316. The casing would be finish machined after the stainless overlay. The end wall could be overlayed similarly or have compatible stainless steel end plates provided.

6.2.21 The vendor shall include details of this cladding procedure in the casing design proposal.

6.2.22 In addition to the requirements of 6.2.6, pressure-casing bolting shall be furnished as specified in 6.2.23 through 6.2.25.

6.2.23 Studs shall be supplied on the main joint of axially split casings and bolted end covers of radially split casings unless cap screws are specifically approved by the purchaser.

6.2.24 Studs shall be used instead of cap screws on all other joints, except where hexagonal head cap screws are essential for assembly purposes and have been approved by the purchaser.

NOTE Flooded screw compressors are typically designed to use cap screws.

6.2.25 [●] If specified, the main casing-joint studs and nuts shall be designed for the use of hydraulic bolt tensioning. Procedures and extent of special tools provided by the vendor shall be mutually agreed upon.

6.2.26 The use of threaded holes in pressure parts shall be minimized.

a) To prevent leakage in pressure sections of casings, metal equal in thickness to at least half the nominal bolt diameter, in addition to the allowance for corrosion, shall be left around and below the bottom of drilled and threaded holes.

b) The depth of the threaded holes shall be at least 1.5 times the stud diameter.

6.2.27 Mounting surfaces shall meet the following criteria.

a) They shall be machined to a finish of 6 µm (250 µin) *Ra* (arithmetic average roughness) or better.

b) To prevent a soft foot, they shall be in the same horizontal plane within 125 µm (0.005 in.).

c) Each mounting surface shall be machined within a flatness of 75 µm/ linear m (0.001 in/linear ft) of mounting surface.

d) Different mounting planes shall be parallel to each other within 125 µm (0.005 in.).

e) The upper machined or spot-faced surface shall be parallel to the mounting surface.

f) Hold-down bolt holes shall be drilled perpendicular to the mounting surface or surfaces.

g) If spot-faced, the spot face diameter shall be suitable for washer positioned eccentrically around the bolt. Holes shall not be slotted.

6.2.28 The equipment feet shall be provided with vertical jackscrews and shall be drilled with pilot holes that are accessible for use in final doweling.

6.3 Casing Appurtenances

Slide valves may be provided with oil-flooded screw compressors. Refer to Part 3 for requirements.

6.4 Casing connections

6.4.1 General

6.4.1.1 All openings or nozzles for piping connections on pressure casings shall be DN 20 (NPS ¾) or larger.

NOTE: Tubing connections can be smaller than DN 20 (NPS ¾).

6.4.1.2 Connections shall be in accordance with ISO 6708. Sizes NPS 1-1/4, 2-1/2, 3-1/2, 5, 7, and 9 (DN 32, DN 65, DN 90, DN 125, DN 175 and DN 225) shall not be used.

6.4.1.3 All the purchaser’s connections shall be accessible for disassembly without requiring the machine, or any major part of the machine, to be moved.

6.4.1.4 All connections shall be flanged or machined and studded, except where threaded connections are permitted by 6.4.3.4.

6.4.1.5 All connections shall be suitable for the maximum allowable working pressure of the casing as defined in 6.2.7.

6.4.1.6 Flanged connections may be integral with the casing or, for casings of weldable material, may be formed by a socket-welded or butt-welded pipe nipple or transition piece, and shall terminate with a welding-neck or socket-weld flange.

6.4.1.7 Connections welded to the casing shall meet the material requirements of the casing, including impact values, rather than the requirements of the connected piping.

6.4.1.8 All welding of connections shall be completed before the casing is hydrostatically tested (see 8.3.2).

6.4.2 Main Process Connections

6.4.2.1 **[●]** Main inlet and outlet process connections shall be oriented as specified.

6.4.2.2 The CLASS system applies, and all flanges shall conform to ASME B16.1, ASME B16.5 or ASME B16.42 or ASME B16.47, series B, as applicable.

6.4.2.3 **[●]** If the PN system is specified, all flanges shall conform to EN 1092-1 or EN 1092-2 as applicable.

NOTE EN 1092-1 flanges are PN 6, 10, 16, 25, 40, 63, 100, 160, 250, 320, and 400

6.4.2.4 Steel flanges shall conform to the dimensional requirements of ASME B16.5 or B16.47 Series B or EN 1092-1 or 1092-1 as applicable.

6.4.2.5 [●] If specified, ASME B16.47 Series A steel flanges shall be provided for Class system flanges.

NOTE ASME B16.47 covers flange diameters from NPS 26 through NPS 60.

6.4.2.6 Ductile iron flanges shall be flat-faced and conform to the dimensional requirements of ISO 7005-2 or ASME B16.1 or ASME B16.42 or EN 1092-2 as applicable.

6.4.2.7 Class 125 flanges shall have a minimum thickness equal to class 250 for sizes NPS 8 and smaller.

6.4.2.8 PN16 flanges shall have a minimum thickness equal to PN25 for sizes DN 200 and smaller.

6.4.2.9 Flat face flanges with full raised face thickness are acceptable on casings of all materials.

6.4.2.10 Flanges in all materials that are thicker or have a larger outside diameter than required by ASME or EN standard are acceptable.

6.4.2.11 Non-standard (oversized) flanges shall be completely dimensioned on the arrangement drawing. If oversized flanges require studs or bolts of non-standard length, this requirement shall be identified on the arrangement drawing.

6.4.2.12 Flanges shall be full-faced or spot-faced on the back and shall be designed for through bolting.

6.4.2.13 Machined and studded connections shall conform to the facing and drilling requirements of ASME B16.1, ASME B16.5, ASME B16.42 ASME B16.47 EN 1092-1, or EN 1092-2, as specified.

6.4.2.14 Studs and nuts shall be furnished installed, and the first 1.5 threads at both ends of each stud shall be removed.

NOTE DIN 93-9 studs have tapered ends which eliminates the need to remove threads.

6.4.2.15 Machined and studded connections and flanges not in accordance with ASME B16.1, ASME B16.5, ASME B16.42, ASME B16.47, EN 1092-1, or EN 1092-2 require purchaser's approval. The vendor shall supply mating flanges, studs, and nuts for these non-standard connections.

6.4.2.16 To minimize nozzle loading and facilitate installation of piping, machine flanges shall be parallel to the plane shown on the general arrangement drawing to within 0.5°.

6.4.2.17 Studs or bolt holes shall straddle centerlines parallel to the main axes of the flange.

6.4.3 Auxiliary Connections

6.4.3.1 A casing drain shall be provided.

NOTE Process connections located at a low point in the casing can serve the purpose of a casing drain.

6.4.3.2 Butt-welded connections, size NPS 1-1/2 (DN 40) and smaller, shall be reinforced by using forged welding inserts or gussets.

6.4.3.3 When gussets are provided, the piping shall be gusseted in two orthogonal planes to increase the rigidity of the piped connection, in accordance with the following criteria:

a) Gussets shall be of a material compatible with the pressure casing and the piping and shall be made of either flat bar with a minimum cross section of 25 mm by 3 mm (1 in. by 0.12 in.) or round bar with a minimum diameter of 9 mm (0.38 in.).

b) Gusset design shall be as shown in Figure 1.

c) Gussets shall be located at or near the connection end of the piping and fitted to the closest convenient location on the casing to provide maximum rigidity. The long width of gussets made with bar shall be perpendicular to the pipe and

d) Gusset welding shall meet the fabrication requirements (see 6.11.4), including PWHT if required, and the inspection requirements of this Standard.

e) Gussets may also be bolted to the casing if drilling and tapping is done prior to hydrotest.

f) Proposals to use clamped or bolted gusset designs shall be submitted to the purchaser for approval.

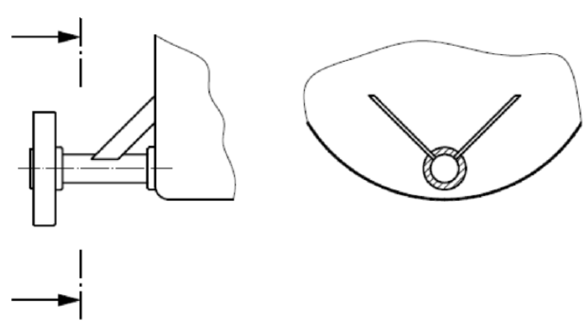


Figure 1 - Typical Gusset Design

6.4.3.4 For connections other than main process connections, if flanged or machined and studded openings are impractical, threaded connections for pipe sizes not exceeding DN 40 (NPS 1-1/2) may be used with purchaser’s approval as follows:

a) on non-weldable materials, such as cast iron;

b) if essential for maintenance (disassembly and assembly);

c) if space is limited.

6.4.3.5 Pipe nipples screwed or welded to the casing shall not be more than 150 mm (6 in.) long and shall be a minimum of schedule 160 seamless for sizes DN 25 (NPS 1) and smaller and a minimum of schedule 80 for DN 40 (NPS 1-1/2).

6.4.3.6 The pipe nipple shall be provided with a welding-neck flange.

6.4.3.7 The nipple and flange material shall meet the requirements of 6.4.1.7.

6.4.4 Requirements for Threaded Connections

6.4.4.1 Threaded openings shall be tapered in accordance with ASME B1.20.1 or ISO 7-1 or alternatively, cylindrical in accordance with ISO 228-1.

6.4.4.2 [●] If ISO 7 Part 1 has been specified, tapered or straight internal threads shall also be specified. Flanges shall be steel and in accordance with 6.4.4.4.

6.4.4.3 If straight threads are used, they shall have another sealing method such as O-rings or metal crush washer.

6.4.4.4 For connections other than main process connections, if flanged or machined and studded openings are impractical, threaded connections for pipe sizes not exceeding DN 40 (NPS 1-1/2) may be used with purchaser's approval as follows:

a) On non-weldable materials, such as cast iron,

b) Where essential for maintenance (disassembly and assembly).

6.4.4.5 Threaded openings not required to be connected to piping shall be plugged with solid, steel plugs in accordance with ASME B16.11.

a) As a minimum, these plugs shall meet the material requirements of the pressure casing.

b) Plugs that may later require removal shall be of a corrosion-resistant material.

c) Plastic plugs are not permitted.

6.4.4.6 A process-compatible thread sealant/lubricant of rated for the maximum allowable working temperature shall be used on all threaded connections. Thread tape shall not be used.

6.5 External Forces and Moments

External forces and moments information can be found in Parts 2, 3, and 4 of this standard.

6.6 Rotating Elements

6.6.1 Shafts not integral with rotor bodies shall be forged steel.

6.6.2 [●] If specified or if vibration or axial-position probes are furnished, the rotor shaft-sensing areas that are observed by the probes shall meet the requirements specified in API 670.

6.6.3 Each rotor set shall be clearly marked with a unique identification number on each male and female rotor. This number shall be on the end of the shaft opposite the coupling or in an accessible area that is not prone to maintenance damage.

6.6.4 Shafting shall be capable of transmitting torque at least equal to the rated torque of the coupling.

6.6.5 Rotor stiffness shall be adequate to prevent contact between the rotor bodies and the casing and between rotor bodies at all operating conditions.

6.6.6 All shaft keyways shall have fillet radii conforming to ASME B17.1, or other applicable national or international standard.

6.6.7 Shaft shoulders against which rolling element bearings seat shall have filets conforming to ISO 582. If inch series tapered roller bearings are used, the filets shall be in accordance with ABMA 19.2

NOTE For the purpose of this provision ABMA 20 and 19.1 are equivalent to ISO 582.

6.6.8 Location of plating or coatings on shafts shall be stated in the proposal.

6.6.9 For shafts that require sleeve gaskets to pass over threads, at least 1.5 mm (0.06 in.) radial clearance shall be provided between the threads and the internal diameter of the gasket, and the diameter transition shall be chamfered.

6.6.10 The shaft-to-seal sleeve fit(s) shall be F7/h6 in accordance with ISO 286 (all parts).

6.6.11 Areas of shafts that can be damaged by set screws shall be relieved to facilitate the removal of sleeves or other components.

6.7 Shaft Seals

6.7.1 General

6.7.1.1 Shaft seals shall be provided to restrict or prevent process gas leakage to the atmosphere.

6.7.1.2 Shaft seals may also be provided to restrict or prevent process gas from entering the bearing housing or lube oil from mixing with the process gas.

NOTE Shaft seals can be internal or external seals, depending on location, and can be process or oil seals, depending on function.

6.7.1.3 Seal operation shall be suitable for specified variations in suction or discharge conditions that may prevail during start-up, shutdown or settling out and during any other special operation specified by the purchaser.

NOTE Whether the seals are exposed to suction or discharge conditions depends on seal location and on seal system configuration.

6.7.1.4 [●] The purchaser may specify an alternate sealing pressure.

6.7.1.5 The shaft seals and seal support system shall be designed to permit safe compressor pressurization with the seal system in operation prior to process start-up.

6.7.2 For low-temperature services, systems shall have provision for maintaining the seal fluid above its pour-point temperature at the inner-seal drain.

6.7.3 External seals shall be accessible for inspection and replacement without removing the top half of the casing of an axially split compressor or the end housings of a radially split unit.

NOTE It is recognized that casing disassembly can be required for access to internal seals on most designs.

6.7.4 Seal Types

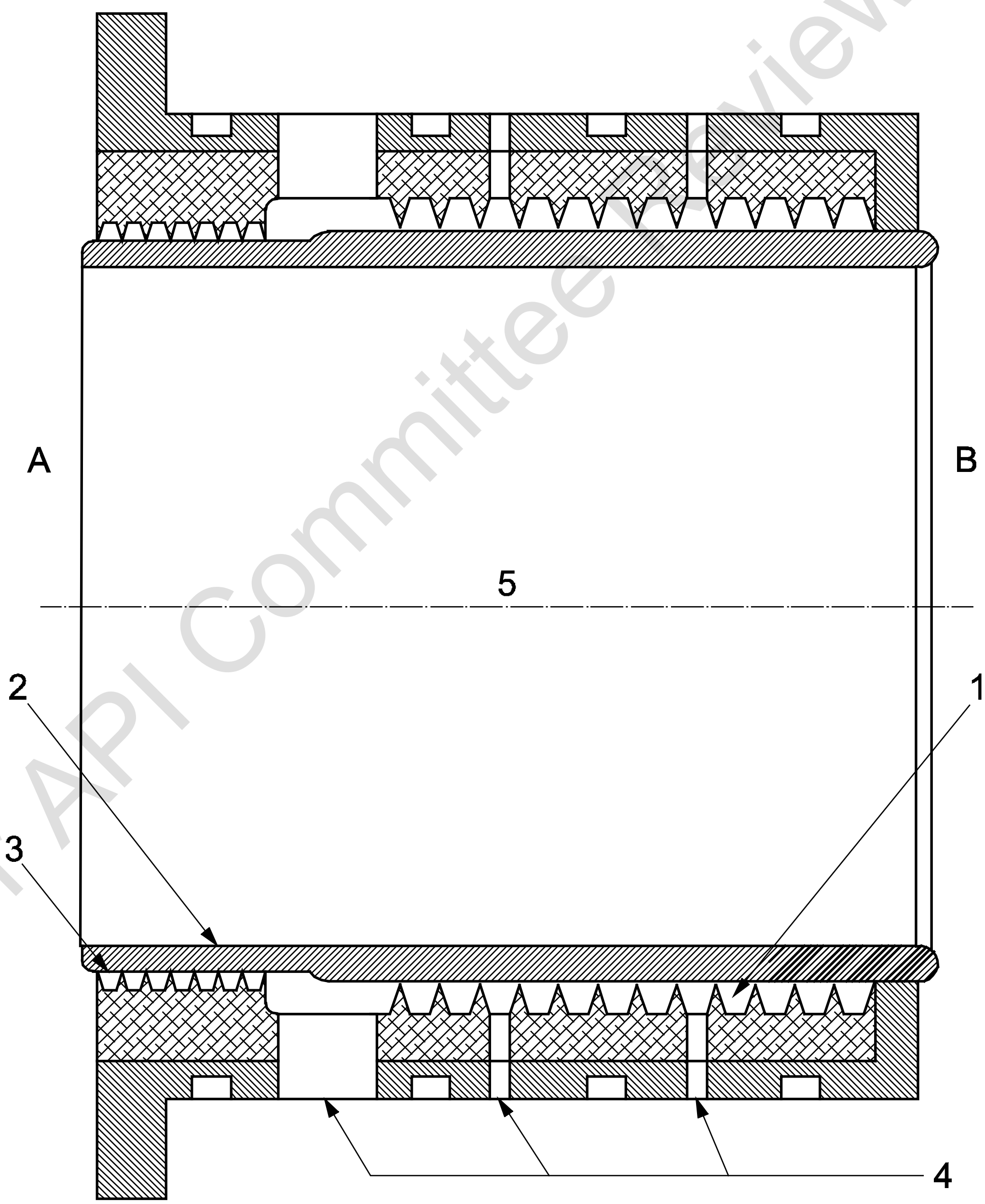
6.7.4.1 [●] Shaft seals may be one of the types described in 6.7.4.2 through 6.7.4.6, as specified.

6.7.4.2 If either the process or seal-support fluid are hazardous, toxic, or flammable, a secondary seal shall be provided in addition to the primary seal to prevent leakage to the atmosphere or to the bearing housing. This secondary seal shall be capable of acting as a backup seal should the primary seal fail during operation. The second seal in a tandem seal or a separate single or double seal may be used as a secondary seal.

6.7.4.3 Clearance Seals

6.7.4.3.1 Clearance seal may be labyrinth, restrictive-ring, or a combination of both.

6.7.4.3.2 Labyrinths may be stationary or rotating A typical labyrinth seal is shown in Figure 2.



Key

A atmosphere side

1 labyrinth

B gas side

2 shaft sleeve

3 wind-back oil seal

4 ports for venting, purging or scavenging as required

5 compressor rotor centerline

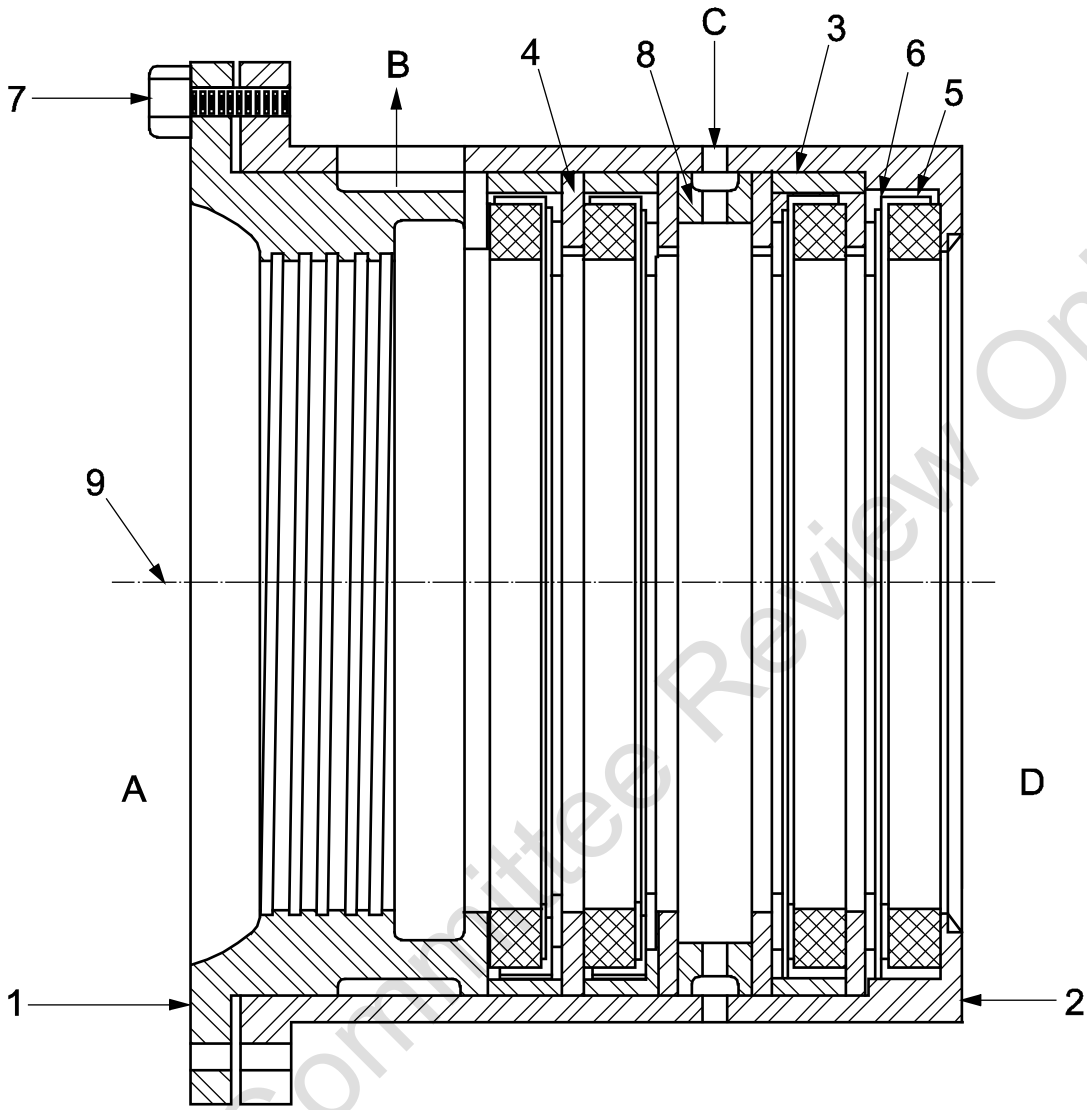
Figure 2 — Labyrinth shaft seal

6.7.4.3.3 Restrictive-ring-type seals shall include rings of carbon or other suitable material mounted in retainers or spacers. A typical restrictive-ring seal is shown in Figure 3.

6.7.4.3.4 The seals may be operated dry or with a sealing fluid.

6.7.4.3.5 [●] If specified, clearance seals shall be provided with provision(s) to inject conditioned buffer gas between the seal and the process gas.

6.7.4.3.6 [●] If specified, sealing fluid contaminated by the process gas shall be piped away separately to allow disposal or reconditioning.



Key

A	atmosphere side	1	windback labyrinth
B	vent to atmosphere	2	seal cage
C	purge	3	spacer ring
D	gas side	4	spacer washer
		5	seal assembly
		6	washer spring
		7	capscrew
		8	spacer ring
		9	compressor rotor centerline

Figure 3— Restrictive-ring-type seal (purged)

6.7.4.4 Oil Seals

Refer to Part 4 for oil seal requirements.

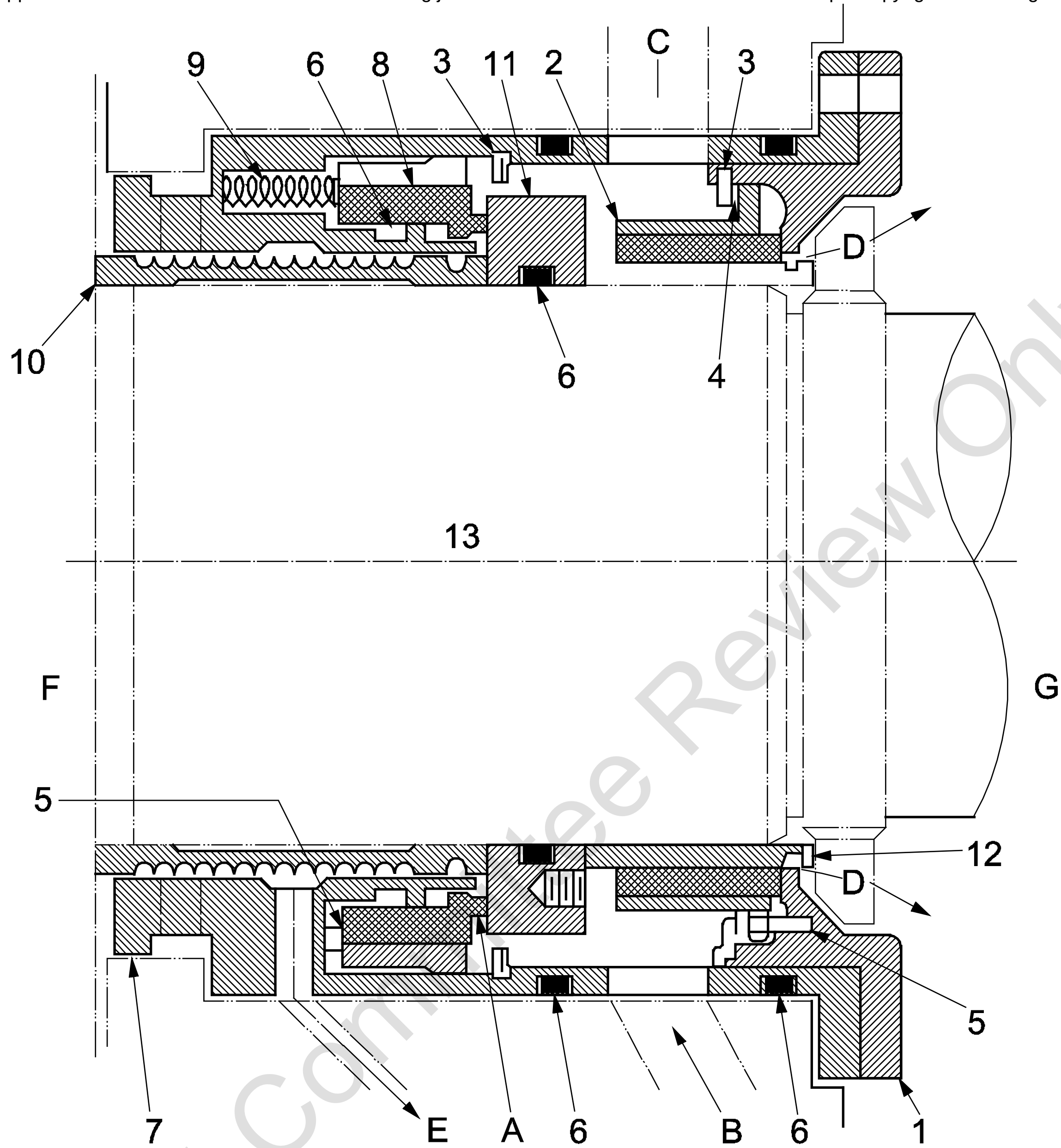
6.7.4.5 Mechanical Contact Seals

6.7.4.5.1 Mechanical contact type seals shall be provided with labyrinths, slingers, restrictive rings, or other features to minimize oil leakage to the atmosphere or into the compressor. A typical single seal is shown in Figure 4.

6.7.4.5.2 Double mechanical contact type seals shall be provided for hazardous, toxic, or flammable gases. A typical double seal is shown in Figure 5.

6.7.4.5.3 [●] If specified or for hazardous, toxic, or flammable gases, an independent seal-fluid system shall be provided.

6.7.4.5.4 Mechanical-type seals shall incorporate a self-closing feature to prevent uncontrolled gas leakage from the compressor on shutdown and loss of seal oil pressure.



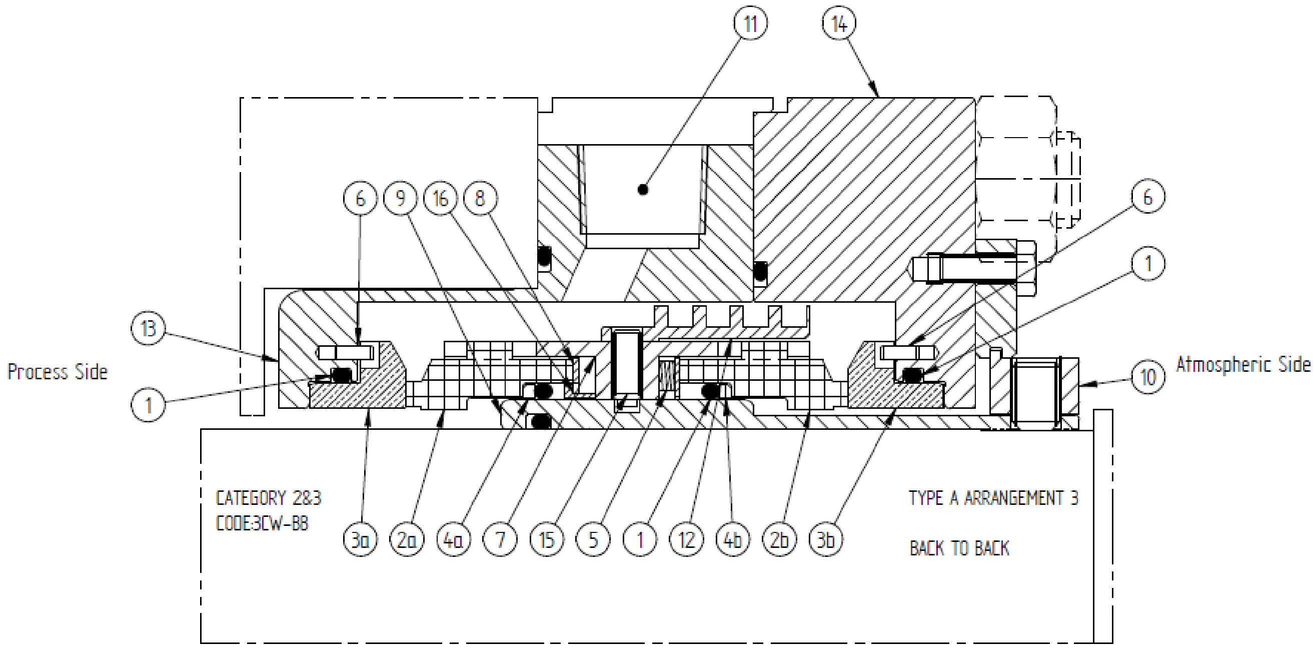
Key

A seal face
B seal oil inlet
C seal oil return
D seal oil return
E leakage oil drain
F gas side
G atmosphere side

1 bushing retainer
2 bushing seal ring
3 snap ring
4 wave washer spring
5 rotation lock pin
6 o-ring
7 seal housing

8 stationary seal ring
9 compression spring
10 sleeve
11 rotating face
12 runner
13 compressor rotor centerline

Figure 4 — Single Oil-cooled mechanical-(contact-)seal assembly



Key			
1	O ring	8	Thrust ring
2a	Inboard Primary ring	9	Sleeve
2b	Outboard Primary ring	10	Drive collar
3a	Inboard Stationary ring	11	Barrier fluid porting
3b	Outboard Stationary ring	12	Pumping scoll
4a	Inboard Anti X ring	13	Inner gland
4b	Outboard Anti X ring	14	Outer gland
5	Spring	15	Dog point grub screw
6	Pin	16	Retaining sleeve
7	Retainer		

Figure 5 — Double Oil-cooled mechanical-(contact-)seal assembly

6.7.4.6 Dry Gas Seal

6.7.4.6.1 **[•]** Dry gas seal arrangement shall be double or as specified by the purchaser.

6.7.4.6.2 Dry gas seals shall be in accordance with API 692, Parts 1 and 2.

NOTE Refer to API 692, Part 2, Annex C for dry gas seal nomenclature.

6.7.4.6.3 Seal support systems for dry gas seals shall be in accordance with API 692, Parts 1 and 3.

NOTE Refer to API 692, Part 3, Annex A for dry gas seal support system datasheets.

6.7.4.6.4 Seal vents and drains shall conform to the following.

a) Seal cavities shall be designed to keep liquid from the dry gas seals. Drains shall be located in the bottom of all seal cavities to fully drain the cavity.

b) The compressor vendor shall define the sizing criteria (pressure drop and maximum flow) for primary and secondary vents.

c) Drain sizing shall be such to prevent blockage of the line.

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

6.7.4.6.5 Pins or keys shall be replaceable without compressor disassembly other than seal cartridge removal.

6.8 Dynamics

6.8.1 General

6.8.1.1 Design of rotor-bearing systems, shall consider all potential sources of periodic forcing phenomena (excitation) including, but not limited to, the following sources:

a) unbalance in the rotor system;

b) oil-film instabilities (whirl);

c) internal rubs;

d) pocket-passing frequencies;

e) gear-tooth meshing and side bands;

f) coupling misalignment;

g) loose rotor-system components;

h) hysteretic and friction whirl;

i) asynchronous whirl;

j) ball and race frequencies of rolling element bearings;

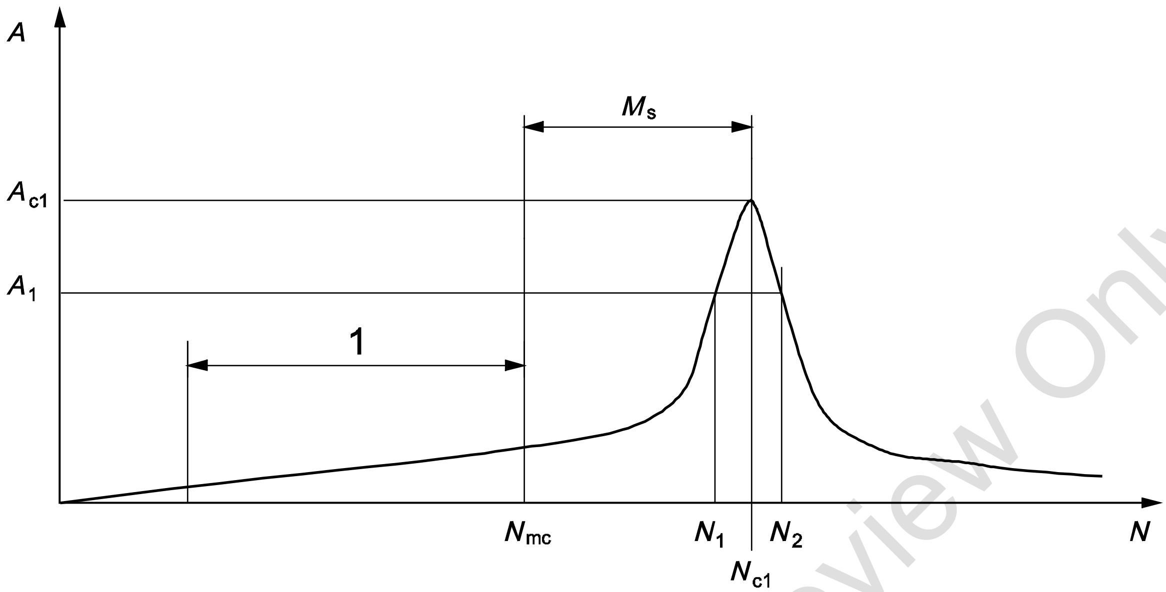
k) electrical line frequency;

l) driver induced dynamics.

NOTE 1 The frequency of a potential source of excitation can be less than, equal to or greater than the rotational speed of the rotor.

NOTE 2 When the frequency of a periodic forcing phenomenon (excitation) applied to a rotor-bearing-support system coincides with a natural frequency of that system, the system is in a state of resonance. A rotor-bearing-support system in resonance can have the magnitude of its normal vibration amplified. The magnitude of amplification and, in the case of critical speeds, the rate of change of the phase-angle with respect to speed are related to the amount of damping in the system.

6.8.1.2 If the rotor-amplification factor (see Figure 6) as measured at the shaft radial-vibration probes is greater than or equal to 2.5, the corresponding frequency is called a critical speed and the corresponding shaft rotational frequency is also called a critical speed. For the purposes of this part of API 619, a critically damped system is one in which the amplification factor is less than 2.5.



Key

1 operating speeds

A vibration amplitude

A_{c1} vibration amplitude at N_{c1}

A_1 0.707 of vibration amplitude at N_{c1}

M_s separation margin

N rotor speed

N_{c1} rotor first critical speed, center frequency

N_{mc} maximum continuous speed, 105 % of rated speed

N_1 initial (lesser) speed at 0.707 × peak amplitude (critical)

N_2 final (greater) speed at 0.707 × peak amplitude (critical)

$N_2 - N_1$ peak width at the half-power point

NOTE The amplification factor, A_F, is equal to $N_{c1} / (N_2 - N_1)$.

Figure 6 — Rotor-response plot

6.8.1.3 Resonances of structural-support systems that are within the vendor’s scope of supply and that affect the rotor vibration amplitude shall not occur within the specified operating speed range or the required separation margins (SMr) (see 6.8.1.5).

6.8.1.4 The dynamic characteristics of the vendor's structural support shall be considered in the analysis of the dynamics of the rotor-bearing-support system.

NOTE Resonances of structural-support systems can adversely affect the rotor vibration amplitude.

6.8.1.5 Rotors shall be of a stiff-shaft construction with the first actual lateral critical speed at least 120% of the maximum continuous speed.

6.8.1.6 [●] If specified or if the requirement of 6.8.1.5 is not met, a lateral critical analysis shall be performed.

6.8.2 Torsional analysis

6.8.2.1 [●] For variable speed units, units including external gears, units comprising three or more coupled machines or if specified, the vendor having unit responsibility shall ensure that a torsional vibration analysis of the complete coupled train is carried out and shall be responsible for directing any modifications necessary to meet the requirements of 6.8.2.2 through 6.8.2.8.

6.8.2.2 The torsional analysis shall include but not be limited to the following:

a) Torsional stiffness and inertia of rotors;

b) Effects of operating temperature on material properties;

c) Calculation and distribution of polar mass moment of inertia;

d) Nonlinear effects from sources such as:

    1) Elastomeric or torque limiting couplings

    2) Gear mesh backlash

e) Coupling torsional stiffness boundary;

f) Electromechanical stiffness and damping in motor/generator air-gap;

g) Gear tooth stiffness;

h) Fluid drive behavior;

i) Penetration factor effects on torsional stiffness due to;

    1) Shaft diameter changes;

    2) Keyways

    3) Shrink fits;

    4) Bolted assemblies;

j) Damping from sources such as:

    1) Material and frictional damping within assemblies

    2) Fluid/viscous devices

6.8.2.3 Excitation of torsional natural frequencies can come from many sources that might or might not be a function of running speed and should be considered in the analysis. These sources shall include, but are not limited to, the following:

a) gear characteristics such as unbalance, pitch line runout and cumulative pitch error;

b) torsional transients such as start-up of electric motors phase-to-phase or phase-to-ground faults;

c) torsional excitation resulting from electric motors and rotary-type positive-displacement machines;

d) control loop resonances from hydraulic, electronic governors and variable frequency drives;

e) one- and two-times line frequency;

f) running speed or speeds of all rotating elements;

g) pocket passing frequency;

h) harmonic frequencies from variable frequency drives.

6.8.2.4 The torsional natural frequencies of the complete train shall be at least 10% above or 10% below any possible excitation frequency within the specified operating speed range (from minimum to maximum continuous speed).

6.8.2.5 Torsional criticals at two or more times running speeds should be avoided or, in systems in which corresponding excitation frequencies occur, shall be shown to have no adverse effect.

6.8.2.6 In addition to multiples of running speeds, torsional excitations that are not a function of operating speeds or that are non-synchronous in nature shall be considered in the torsional analysis, if applicable, and shall be shown to have no adverse effect.

NOTE If a variable-speed driver is used, there is the possibility of not being able to avoid torsional criticals at multiples of all speeds in the operating range.

6.8.2.7 If torsional resonances are calculated to fall within the margin specified in 6.8.2.4 (and the purchaser and the vendor have agreed that all efforts to remove the critical from within the limiting frequency range have been exhausted), a stress analysis shall be performed to demonstrate that the resonances have no adverse effect on the complete train.

6.8.2.8 For AFD driven equipment trains, the vendor shall extend the analysis defined in 6.8.2.2 through 6.8.2.7 to include the following:

6.8.2.8.1 In addition to the excitations of 6.8.2.3, the following shall also be considered but is not limited to:

a) integer orders of the drive output frequency,

b) sidebands of the pulse width modulation.

NOTE AFD produced broad band noise floor and feedback generated excitations can cause harmful torsional pulsations. Transient, and/or mechanical/electrical coupled analyses, or combination can be required to understand the effects of these excitations.

6.8.2.8.2 A steady state response analysis shall be performed from 0 to N_{mc} to quantify the effects of the AFD excitation of 6.8.2.8.1.

6.8.2.8.3 For intersections of the torsional natural frequencies and the AFD excitations occurring below 90% of the minimum operating speed, an agreed criteria shall be used to establish acceptability of the train.

6.8.2.8.4 For intersections of the torsional natural frequencies and the AFD excitations occurring within the operating speed range including the 10% separation margins, the criteria set forth in 6.8.2.4 shall be used.

6.8.2.9 [●] If specified, for motor-driven equipment and trains, a transient short circuit fault analysis shall be performed in accordance with 6.8.2.9.1 through 6.8.2.9.2.

6.8.2.9.1 The following fault conditions shall be considered but are not limited to:

a) short circuits:

   1) line-to-line,

   2) two phase,

   3) three phase,

   4) line-to-ground,

   5) line-to-line-to-ground.

b) synchronization (generators):

   1) single phase,

   2) three phase.

6.8.2.9.2 For these fault conditions, generated stresses in the shafting shall not exceed the low cycle fatigue limit and in couplings, the torque shall not exceed the vendor’s peak torque rating.

NOTE The analysis for these fault conditions assumes a onetime event. It is possible that some components identified by the analysis will need to be replaced following the fault event.

6.8.2.9.3 [●] If specified, alternating torques produced by breaker reclosure shall be shown to have no negative impact on the intended operating life of the equipment train.

6.8.3 Balancing

6.8.3.1 Major parts of the rotating element, such as the shaft and timing gears, shall be individually dynamically balanced to ISO 21940-11, grade G1.0 or less.

6.8.3.2 If a bare shaft with a single keyway is dynamically balanced, the keyway shall be filled with a fully crowned half key, in accordance with ISO 21940-32:2012.

6.8.3.3 Keyways 180° apart, but not in the same transverse plane, shall also be filled.

6.8.3.4 The initial balance correction to the bare shaft shall be recorded.

6.8.3.5 The components to be mounted on the shaft shall also be balanced in accordance with the “half-key convention” as described in ISO 8821.

6.8.3.6 The rotors and timing gears shall be match-marked or keyed.

a) This assembly shall be check-balanced (including keys).

b) There shall be no exposed keys or unfilled keyways.

6.8.3.7 The maximum unbalance shall be in accordance with ISO 21940-11, grade G1.0.

6.8.3.8 [●] If specified, the maximum allowable residual unbalance, Ur, expressed in gram·millimeters (ounce·inches), for each plane (journal) shall be calculated as given in Equation 1:

In SI units $$U_r = 6\,350\ W/N_{mc} \tag{1a}$$

In USC units $$U_r = 4\ W/N_{mc} \tag{1b}$$

where

U_r is the input unbalance for the unbalance response analysis, in g-mm (oz-in.)

W is the journal static load in kg (lbf), or for bending modes where the maximum deflection occurs at the shaft ends, the overhung mass (that is, the mass of the rotor outboard of the bearing), in kg (lbf)

N_{mc} is the maximum continuous operating speed, expressed in revolutions per minute.

NOTE For this equipment, the gas forces and variations in gas forces are orders of magnitude higher than the forces resulting from unbalance.

6.8.3.9 The calibration of the rotor-balancing machine shall be verified in accordance with the balancing machine manufacturer’s procedure and frequency, or once a year as a minimum.

6.8.4 Vibration

6.8.4.1 During the shop test of the machine, assembled with the balanced rotor operating at maximum continuous speed or at any other speed within the specified operating speed range, the casing vibration velocity shall be measured.

6.8.4.2 Vibration limits shall be as described in Parts 2, 3, and 4.

6.9 Bearings and Bearing Housings

6.9.1 Bearings - General

6.9.1.1 Bearings type and arrangement shall be one of the following variants:

1. rolling element radial and thrust bearings;

2. hydrodynamic radial and rolling element thrust bearing;

3. hydrodynamic radial and thrust bearings.

NOTE Hydrodynamic bearings (radial or thrust) are not used for rotary lobe blowers.

6.9.1.2 Each shaft shall be supported by two radial bearings and one double-acting axial (thrust) bearing that might or might not be combined with one of the radial bearings.

6.9.1.3 The bearing type and arrangement shall be selected in accordance with the requirements of Tables 3 and 4.

6.9.1.4 [●] If specified for screw compressors, hydrodynamic bearings shall be supplied.

Table 3 — Bearing Selection

Condition	Bearing type and arrangement
Radial and thrust bearing speed and life within limits for rolling element bearings	Rolling element radial and thrust
Radial bearing speed or life outside limits for rolling element bearings and Thrust bearing speed and life within limits for rolling element bearings	Hydrodynamic radial and rolling element thrust or Hydrodynamic radial and thrust
Radial and thrust bearing speed or life outside limits for rolling element bearings	Hydrodynamic radial and thrust

Table 4 – Bearing Limits

Limiting Factor	Conditions			
Rolling element bearing speed	Factor[a] $N \cdot dm$ shall exceed the following values for oil-lubricated bearings:			
	Lubrication Method >	Bath / Splash	Circulating / Pressurized	Directed Jet[c]

Table 4 — Bearing Limits

NOTE 1 The calculated bearing life is based on lubrication with clean, filtered oil. In oil-flooded screw compressors, aggressive and/or contaminated process gases can significantly shorten bearing life.

NOTE 2 The bearing life of the rolling element bearings of oil-flooded screw compressors can also be calculated using the L_{1m} method accounting for viscosity, oil cleanliness, bearing speed and load (See Part 3, Annex I).

NOTE 3 Bearings with higher N-d_m limit can have a lower time interval between an alarm and bearing failure.

6.9.1.5 Thrust bearings shall be sized for continuous operation through the full operating range including the most adverse specified operating conditions.

6.9.1.6 Calculation of the thrust load shall include, but shall not be limited to, the following factors:

a) step thrust from all diameter changes;

b) stage reaction and stage differential pressure;

c) variations in pressure at all inlet and outlet nozzles;

d) external loads from the driver or driven equipment, as described in 6.9.1.7 and 6.9.1.8;

e) highest transient load.

6.9.1.7 Thrust forces from metallic flexible element couplings shall be calculated on the basis of the maximum allowable deflection permitted by the coupling manufacturer.

6.9.1.8 If two or more rotor thrust forces are to be carried by one thrust bearing (such as in a gear box), the resultant of the forces shall be used, provided the directions of the forces make them numerically additive. If the forces are, by design, in opposite directions, they may be subtracted from each other (e.g. gear forces vs. clearly defined gas forces).

6.9.1.9 The induced load shall be determined by the bearing vendor. The induced load shall be added to the thrust load.

Note: For rolling element bearings, an induced axial load is produced by the backup bearing by centrifugal load.

6.9.2 Rolling element bearings

6.9.2.1 Rolling element bearings shall be located, retained, and mounted in accordance with the following.

a) Bearings shall be located on the shaft using shoulders, collars, or other positive locating devices; snap rings and spring-type washers shall not be used.

b) Bearings shall be retained on the shaft with an interference fit and fitted into the housing with a diametrical clearance, both in accordance with the recommendations of the bearing manufacturer.

c) Bearings shall be mounted directly on the shaft; bearing carriers (sleeves) shall not be used.

6.9.2.2 Rolling element bearings shall be selected in accordance with the following:

a) For screw compressors, separate radial and thrust bearings shall be used such that the thrust bearing only takes axial load and the radial bearing only takes radial load.

b) Thrust bearings shall be mounted in a paired bi-directional arrangement. The need for bearing clearance or preload shall be determined by the vendor to suit the application and meet the bearing life requirements; see Table 4.

c) Rolling element thrust bearings shall be secured to the shaft with a nut and a tongue-type lock washer.

d) Four-point contact (split race) ball bearings shall not be used for radial loads.

e) Bearings with filling slots shall not be used.

f) Angular contact ball bearings shall be arranged with a radial gap between the outer rings and the housing, to allow radial displacement, preventing the thrust bearings from taking radial load.

g) The outer rings of angular contact ball bearings, if arranged face to face with the backup bearing, shall be clamped with the necessary load to prevent separation of the rings by the effect of centrifugal load and prevent reverse axial rotor displacement in case of reverse thrust load.

6.9.3 Hydrodynamic bearings

6.9.3.1 Hydrodynamic radial bearings shall be in accordance with 6.9.3.2 to 6.9.3.7.

6.9.3.2 Hydrodynamic radial bearings shall be precision-bored and of the sleeve or pad type, with steel-backed, babbitted, replaceable liners, pads, or shells.

6.9.3.3 The bearings shall be equipped with anti-rotation pins.

6.9.3.4 The bearings and shall be positively secured against a shoulder or with a key in the axial direction.

6.9.3.5 The bearing design shall suppress hydrodynamic instabilities and provide sufficient damping over the entire range of allowable bearing clearances to limit rotor vibration to the maximum specified amplitudes (see vibration limits in Parts 2, 3, and 4) while the unit is operating loaded or unloaded at specified operating speeds including operation at any resonant condition.

6.9.3.6 Bearings shall be designed to prevent incorrect positioning.

6.9.3.7 Bearings shall be designed with a device (e.g., anti-rotation pin or key) to prevent circumferential movement and to provide proper orientation with respect to location and shaft rotation.

6.9.3.8 Hydrodynamic thrust bearings shall be in accordance with 6.9.3.8.1 to 6.9.3.8.6.

6.9.3.8.1 The active sides of hydrodynamic thrust bearings shall be of the babbitted, multiple-segment, self-leveling, tilting-pad type or other types approved by the purchaser, sized for continuous operation under all specified operating conditions (including the maximum allowable differential pressure).

6.9.3.8.2 The inactive side thrust pads or segments shall be babbitted and arranged for positive lubrication.

6.9.3.8.3 Replaceable thrust collars shall be furnished and shall be positively locked to the shaft to prevent fretting.

6.9.3.8.4 Thrust bearings shall be arranged to allow axial positioning of each rotor relative to the casing and setting of the bearings' clearance or preload.

6.9.3.8.5 Hydrodynamic thrust bearings shall be selected at no more than 50 % of the bearing manufacturer's ultimate load rating. In sizing thrust bearings, consideration shall be given to the following for each specific application:

a) shaft speed;

b) temperature of the bearing babbitt;

c) feed rate, viscosity, and supply temperature of the oil;

d) design configuration of the bearing;

e) babbitt alloy.

6.9.3.8.6 The sizing of hydrodynamic thrust bearings shall be reviewed and approved by the purchaser.

6.9.4 Bearing housings

NOTE Bearings on oil flooded compressors are integral part of the compressor casing and there is no separate housing.

6.9.4.1 Bearing housings for pressure-lubricated hydrodynamic bearings shall be arranged to minimize foaming.

6.9.4.2 The drain system shall be adequate to maintain the oil and foam level below shaft end seals.

6.9.4.3 Oil outlets from thrust bearings shall be tangential and in the upper half of the control ring or, if control rings are not used, in the thrust bearing cartridge.

6.9.4.4 Oil connections on bearing housings shall be in accordance with 6.4.

6.9.4.5 For pressurized or circulating oil systems, the bearing oil drain temperature shall not exceed 28 °C (50 °F) above oil supply temperature.

NOTE The combined oil return temperature can include returning oil from bearing housings, timing gear, cooling jackets and seals.

NOTE Oil-flooded screw compressors can require a relatively high oil inlet temperature to prevent formation of condensate from the process gas. Failure to maintain an adequate oil temperature can result in emulsified or contaminated lubricating oil.

6.9.4.6 When bearing metal temperature sensors are supplied for hydro dynamic bearings, bearing metal temperatures shall not exceed 93 °C (200 °F).

Note: For rolling element bearing, the metal temperature may be considerably higher than this limit.

6.9.4.7 Sufficient cooling, including an allowance for fouling, shall be provided to maintain oil and bearing temperatures during shop testing and in field operation under the most adverse specified operating condition as follows:

a) For pressurized or circulating fluid film bearing systems, the bearing oil drain temperature shall not exceed 28 K (50 °F) above oil supply temperature.

b) If bearing metal temperature sensors are supplied, bearing metal temperatures shall not exceed 93 °C (200 °F).

c) If the above design criteria cannot be met, the purchaser and the vendor shall agree on acceptable bearing metal temperatures.

6.9.4.8 If the inlet oil temperature exceeds 50 °C (120 °F), special consideration shall be given to bearing design, oil flow and allowable temperature rise.

6.9.4.9 If water cooling is required, water jackets shall have only external connections between upper and lower housing jackets and shall have neither gasketed nor threaded connection joints that can allow water to leak into the oil reservoir.

6.9.4.10 If cooling coils (including fittings) are used, they shall be of non-ferrous, metallic material and shall have no internal pressure joints.

6.9.4.11 Cooling coils made from tubing or piping shall have a minimum wall thickness of 1.0 mm (0.040 in.) and shall have an outside diameter of at least 12 mm (0.50 in.).

6.9.4.12 Compressors shall have bearing-housing-shaft seals and deflectors where the shaft passes through the housing; lip-type seals shall not be used.

6.9.4.12.1 The seals and deflectors shall be made of non-sparking materials.

6.9.4.12.2 The design of the seals shall effectively retain oil in the housing and prevent entry of foreign material into the housing.

6.9.4.13 [●] If specified, for dry screw and oil-flooded screw compressors, provision shall be made for mounting two radial-vibration probes on each bearing, axial position probe(s) on each rotor and a one-event-per-revolution probe. The probe installation shall be as specified in API 670.

NOTE Some smaller machines cannot accommodate proximity-type probes due to space limitations.

6.9.4.14 [●] If specified, bearing housings shall be prepared for permanently mounting seismic vibration transducers in accordance with API 670. When metric fasteners are supplied, the threads shall be M8.

6.9.4.15 [●] If specified, a flat surface of an agreed size and location shall be provided for mounting of magnetic-based seismic vibration measuring equipment.

6.10 Lubrication

6.10.1 The vendor shall specify the preferred oil and required properties. Refer Parts 2, 3, and 4 for lubrication requirements.

6.10.2 The vendor with unit responsibility shall provide a lubrication system that supplies lubrication for the equipment train. See Parts 2, 3, and 4 for the system requirements for applicable type of machine.

6.11 Materials

6.11.1 General

6.11.1.1 Materials of construction shall be selected for the operating and site environmental conditions specified and shall be compatible with the process fluid (see 6.11.1.8).

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

6.11.1.2.1 Materials shall be identified by reference to applicable international standards, including the material grade. (see Table C.1).

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

6.11.1.3 [●] If specified, copper or copper alloys shall not be used for parts of machines or auxiliaries in contact with process fluids. Nickel-copper alloy (UNS N04400), bearing babbitt and precipitation-hardened stainless steels are excluded from this requirement.

NOTE Certain corrosive fluids in contact with copper alloys have been known to form explosive compounds.

6.11.1.4 The vendor may recommend optional ASTM and inspection procedures to ensure materials are satisfactory for service (see 6.11.1.2). Such tests and inspections shall be listed in the proposal.

6.11.1.5 The material specification of all gaskets and O-rings exposed to the process fluid shall be identified in the proposal.

NOTE Annex B.3 of API 682 includes information on elastomer selection.

6.11.1.6 External parts that are subject to rotary or sliding motions (such as control-linkage joints and adjusting mechanisms) shall be of corrosion-resistant materials suitable for the site environment.

6.11.1.7 Minor parts, such as nuts, springs, washers, gaskets, and keys, shall have corrosion resistance suitable for its environment.

6.11.1.8 [●] The purchaser shall specify any corrosive agents (including trace quantities) present in the process and injected fluids and in the site environment, including constituents that may cause corrosion.

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

NOTE 2 Stress Corrosion Cracking (SCC) is the most dangerous of the various types of corrosion failure of metals. SCC occurs unexpectedly and is extremely localized. As a rule, SCC is accompanied by little change in the equipment wall thickness. During SCC, the metal or alloy is virtually un-attacked over most of its surface, while fine cracks progress through it. There is no obvious correlation between the amount of corrosion and cracking due to stress corrosion cracking. SCC can cause through fracture in very short periods of time (in the most severe cases in a day or even several hours). SCC is minimized by minimizing residual stresses, proper material selection and by limiting the hardness of the material.

NOTE 3 Typical agents of concern for environmental cracking are hydrogen sulfide, amines. Halides (bromides, iodides, chlorides, fluoride), chlorine, cyanide, mercury, naphthenic acid, polythionic acid, hydrofluoric acid, mercury, carbon dioxide, ammonia, ammonia bisulfide, phenols, caustics (sodium, potassium, and lithium hydroxide), sea water, brine.

6.11.1.9 If it is necessary to fabricate hard-faced, overlay or repaired by welding austenitic stainless steel parts that are exposed to conditions that can promote intergranular corrosion, they shall be made of low-carbon or stabilized grades.

NOTE Overlays or hard surfaces that contain more than 0.10 % carbon can sensitize both low-carbon and stabilized grades of austenitic stainless steel unless a buffer layer that is not sensitive to intergranular corrosion is applied.

6.11.1.10 Where mating parts, such as studs and nuts, of austenitic stainless steel or materials with similar galling tendencies are used, they shall be lubricated with an anti-seizure compound of the proper temperature specification and compatible with the specified process fluid(s).

NOTE With and without the use of anti-seizure compounds, the torque loading values required to achieve the necessary preload can vary considerably.

6.11.1.11 [●] The purchaser shall specify any agents (including trace quantities) present in the motive and process fluids and in the site environment, including constituents that may cause corrosion.

6.11.1.12 If hydrogen sulfide or chlorides have been identified in the gas composition, materials exposed to that gas shall be selected in accordance with the requirements of NACE MR0103/ISO 17945 and where applicable, the referenced NACE SP0472.

NOTE 1 NACE MR0103/ISO 17945 requires restrictive hardness limits, more restrictive weld qualification procedures, and limits to the carbon equivalent levels of materials versus NACE MR0175/ISO 15156 (see 6.11.1.12.3).

NOTE 2 It is the responsibility of the purchaser to determine the amount of H_2S that may be present, considering normal operation, start-up, shutdown, idle standby, upsets, or unusual operating conditions such as catalyst regeneration.

NOTE 3 Carbon or low alloy steels are not susceptible to cracking in chloride solutions, but some localized corrosion may occur. It is generally recognized that alloys with greater than approximately 30- 40% nickel are immune to chloride stress corrosion cracking (SCC). All austenitic (300 Series) SS are susceptible to chloride cracking. The severity of this stress corrosion cracking depends on the chloride concentration, temperature, fabrication, and operational stresses.

6.11.1.12.1 For process gas conditions known to cause Sulfide Stress Cracking as identified by NACE MR0103/ISO 17945 or NACE MR0175/ISO 15156, ferrous materials not covered by these standards shall have a maximum yield strength of 620 N/mm2 (90 000 psi) and a maximum Rockwell hardness of HRC 22 (240 HRB).

6.11.1.12.2 Components fabricated by welding shall meet the hardness requirements in both the welds and the heat-affected zones per NACE SP0472.

6.11.1.12.3 [●] If specified, NACE MR0175/ISO 15156 shall be used in place of NACE MR0103/ISO 17945.

NOTE 1 NACE MR0175/ISO 15156 applies to material potentially subject to sulfide and chloride stress-corrosion cracking in oil and gas production facilities. These are upstream facilities; however, NACE MR0175/ISO 15156 earlier editions have been applied to compressors in downstream facilities since the Fifth Edition of API 617 (1988) prior to the introduction of NACE MR0103/ISO 17945.

NOTE 2 A survey conducted of units built in accordance with NACE MR0175/ISO 15156 in previous API 617 editions has indicated no failures. The more restrictive requirements of NACE MR0103/ISO 17945 may therefore not be required to provide sufficient protection against corrosion.

6.11.1.13 The vendor shall select materials to avoid conditions that can result in electrolytic corrosion. If such conditions cannot be avoided, the purchaser and the vendor shall agree on the material selection and any other precautions necessary.

NOTE If dissimilar materials with significantly different electrical potentials are placed in contact in the presence of an electrolytic solution, galvanic couples that can result in serious corrosion of the less noble material can be created. The NACE Corrosion Engineer's Reference Book is one resource for selection of suitable materials in these situations.

6.11.1.14 If austenitic stainless steel parts exposed to conditions that may promote intergranular corrosion are to be fabricated, hard faced, overlaid or repaired by welding, they shall be made of low-carbon or stabilized grades.

NOTE Overlays or hard surfaces that contain more than 0.10% carbon can sensitize both low-carbon and stabilized grades of austenitic stainless steel unless a buffer layer that is not sensitive to intergranular corrosion is applied.

6.11.1.15 Where mating parts such as studs and nuts of austenitic stainless steel or materials with similar galling tendencies are used, they shall be lubricated with an anti-seize compound suitable for the process temperatures and compatible with the material(s) and specified process fluid(s).

NOTE The required torque values to achieve the necessary bolt preload will vary considerably depending if anti-seize compounds are used on the threads.

6.11.1.16 The vendor shall select materials to avoid conditions that may result in electrolytic corrosion. Where such conditions cannot be avoided, the purchaser and the vendor shall agree on the material selection and any other precautions necessary.

NOTE When dissimilar materials with significantly different electrical potentials are placed in contact in the presence of an electrolytic solution, galvanic couples that can result in serious corrosion of the less noble material can be created. The NACE Corrosion Engineer's Reference Book is one resource for selection of suitable materials in these situations.

6.11.1.17 Materials, casting factors and quality of any welding shall be equal to those required by the specified pressure design code. The manufacturer's data report forms, as specified in the code, are not required.

NOTE For impact requirements, refer to 6.11.5.

6.11.1.18 Low-carbon steels can be notch-sensitive and susceptible to brittle fracture at ambient or low temperatures.

6.11.1.18.1 Steel pressure-containing parts made to a coarse austenitic grain-size practice (such as ASTM A515) shall not be used.

6.11.1.18.2 Only fully killed or normalized steels made to fine-grain practice shall be used for pressure-containing parts.

6.11.1.19 O-ring materials shall be compatible with all specified services. Special consideration shall be given to the selection of O-rings for high-pressure services to ensure that they are not damaged on rapid depressurization (explosive decompression).

NOTE 1 Susceptibility to explosive decompression depends on the gas to which the O-ring is exposed, the compounding of the elastomer, temperature of exposure, the rate of decompression and the number of cycles.

NOTE 2 Agents affecting elastomer selection include ketones, ethylene oxide, sodium hydroxide, methanol, benzene and solvents.

6.11.1.20 The bolting for pressure joints shall be carbon steel in accordance with ASTM A307 Grade B for cast iron casings.

6.11.1.21 High temperature alloy steel bolting in accordance with ASTM A193 Grade B7 shall be used for steel casings.

6.11.1.22 Carbon steel ASTM A194 Grade 2H nuts shall be used.

6.11.1.23 Where space is limited, case hardened carbon steel nuts in accordance with ASTM A563 Grade A may be used.

6.11.1.24 For temperatures below – 30 °C (– 20 °F), bolting and nuts in accordance with ASTM A320 shall be used. The grade of ASTM A320 will depend on design, service conditions, mechanical properties, and low-temperature characteristics.

6.11.1.25 For NACE applications, bolting in accordance with ASTM A193 Grade B7M and nuts in accordance with ASTM A194 Grade 2HM shall be provided.

6.11.2 Castings

6.11.2.1 Castings shall comply with material specification requirements regarding porosity, hot tears, shrink holes, blow holes, cracks, scale, blisters, and similar injurious defects.

6.11.2.2 Surfaces of castings shall be cleaned by sandblasting, shotblasting, chemical cleaning or any other standard method.

6.11.2.3 Mold-parting fins and remains of gates and risers shall be chipped, filed, or ground flush.

6.11.2.4 The use of chaplets in pressure castings shall be held to a minimum. Where chaplets are necessary, they shall be clean and corrosion-free (plating of chaplets is permitted) and of a composition compatible with the casting.

6.11.2.5 All repairs that are not covered by the agreed material specifications shall be subject to the purchaser's approval.

6.11.2.6 Pressure-containing ferrous castings shall only be repaired as specified in a) through f).

a) Weldable grades of steel castings shall be repaired using a qualified welding procedure based on the requirements of the Section VIII, Division 1, and Section IX of the ASME BPVC or other internationally recognized standard as approved by the purchaser.

b) After major weld repairs, and before hydrotest, the complete repaired casting shall be given a post-weld heat treatment to ensure stress relief and continuity of mechanical properties of both weld and parent metal and dimensional stability during subsequent machining operations.

c) Post weld heat treatment on individual minor weld repairs after final machining may be performed by local heat treatments with purchaser approval.

d) If defects in ductile iron castings exist and are within allowed repair limits of ASTM A395, plugging is an acceptable repair method. The holes drilled for plugs shall be carefully examined, using liquid penetrant, to ensure that all defective material has been removed.

e) All repairs that are not covered by the agreed material specification shall be subject to the purchaser's approval.

f) If either NACE MR0103/ISO 17945 (per 6.11.1.12) or NACE MR0175/ISO 15156 (per 6.11.1.12.3) has been specified, the completed weld repairs shall meet the requirements of the applicable standard.

6.11.2.7 Cored voids that can become fully enclosed by methods such as plugging, welding or assembly shall not be used.

6.11.2.8 All ductile (nodular) iron castings shall be produced in accordance with ASTM A395, or other internationally recognized standard as approved by the purchaser.

NOTE Ductile iron is also commonly referred to as nodular iron or spheroidal graphite (SG) iron.

6.11.2.9 Production of the castings shall conform to the conditions specified in 6.11.2.9.1 through 6.11.2.9.4.

6.11.2.9.1 The keel or Y-block cast at the end of the pour shall have a thickness not less than the thickness of critical sections of the main casting.

NOTE Critical sections are typically heavy sections, section changes, high-stress points such as drilled lubrication points, the cylinder bore, valve ports, and flanges. Normally, bosses and similar sections are not considered critical sections of a casting. If critical sections of a casting have different thicknesses, average size keel or Y blocks can be selected in accordance with ASTM A395 or other internationally recognized standard.

6.11.2.9.2 The test block shall be tested for tensile strength and hardness and shall be microscopically examined.

6.11.2.9.3 Graphite nodules shall be classified under microscopic examination and shall be in accordance with ASTM A247.

6.11.2.9.4 There shall be no intercellular flake graphite.

6.11.2.10 A minimum of one set (three samples) of Charpy V-notch impact specimens at one-third the thickness of the test block shall be made from the material adjacent to the tensile specimen on each keel or Y-block.

6.11.2.10.1 All three specimens shall have an impact value not less than 12 J (9 ft-lbf)

6.11.2.10.2 The mean of the three specimens shall not be less than 14 J (10 ft-lbf) at room temperature.

6.11.2.11 An “as-cast” sample from each ladle shall be chemically analyzed.

6.11.2.12 Brinell hardness tests per ASTM E10 shall be made on the actual casting at feasible critical sections, such as section changes, flanges, casing bores and other accessible locations.

a) Sufficient surface material shall be removed before hardness tests are made to eliminate any skin effect.

b) Tests shall also be made at the extremities of the casting at locations that represent the sections poured first and last.

c) These shall be made in addition to the hardness test on keel or Y-blocks in accordance with 6.11.2.9.

6.11.3 Forgings

6.11.3.1 The forging material shall be selected from those listed in Annex C.

6.11.3.2 All forging repairs shall be subject to the purchaser's approval.

6.11.4 Welding

6.11.4.1 Welding of piping, pressure-containing parts, rotating parts and other highly stressed parts, weld repairs and any dissimilar-metal welds shall be performed and inspected by operators and procedures qualified in accordance with ASME BPVC Section VIII, Division I, and Section IX of the ASME BPVC or another purchaser approved standard such as ISO 9606-1 & ISO 15607 for welding procedures and welder qualification.

6.11.4.2 Non-pressurized component welding, such as welding on baseplates, non-pressure ducting, lagging, and control panels, shall be performed by welders qualified in accordance with AWS D1.1/D1.1M, or Section IX of the ASME BPVC or ISO 15614-1 or other purchaser approved welding standard.

6.11.4.3 **[●]** Table 5 gives specifications for the following:

a) procedures by which the welding and weld repairs shall be performed;

b) procedures by which the inspection of welding and weld repairs shall be carried out;

c) requirements for the qualification of the operators who carry out the welding, weld repairs and their inspection.

If specified or agreed by the purchaser, alternate codes or standards may be used.

Table 5 — Welding Requirements

Requirement	Applicable code or standard
Welder/operator qualification	ASME Code, Section IX
Welding procedure qualification	Applicable material specification or, where weld procedures are not covered by the material specification, ASME Code, Section IX
Non-pressure-retaining structural welding, such as baseplates or supports	AWS D1.1/D1.1M
Magnetic-particle or liquid-penetrant examination of the plate edges	Pressure design code [e.g. ASME Code, Section VIII, Division 1, UG-93(d)(3)]
Post-weld heat treatment	Applicable material specification or pressure design code (e.g. ASME Code, Section VIII, Division 1, UW 40)
Post-weld heat treatment of casing fabrication welds	Applicable material specification or pressure design code (e.g. ASME Code, Section VIII, Division I)

6.11.4.4 The vendor shall be responsible for the review of all repairs and repair welds to ensure that they are properly heat treated and non-destructively examined for soundness and compliance with the applicable qualified procedures.

6.11.4.5 Repair welds shall be non-destructively tested by the same method used to detect the original flaw and conform to the following requirements:

a) The minimum level of inspection after the repair shall be by the magnetic-particle method in accordance with 8.2.2.4 for magnetic material and by the liquid-penetrant method in accordance with 8.2.2.5 for non-magnetic material.

b) Procedures for major repairs shall be subject to review by the purchaser before any repair is made.

6.11.4.6 The purchaser shall be notified before making a major repair. Major repair, for the purpose of purchaser notification, is any defect that equals or exceeds any of the following criteria:

a) repair of any moving part;

b) repair of a pressure-containing part in which the depth of the cavity prepared for repair welding exceeds 50 % of the component wall thickness or is longer than 150 mm (6 in) in any direction;

c) if the total area of all repairs to the part under repair exceeds 10 % of the surface area of the part.

6.11.4.7 Connections welded to pressure casings shall be installed as specified in 6.11.4.9 to 6.11.4.12.

6.11.4.8 [●] In addition to the requirements in 6.11.4.3, specific welds shall be subjected to 100% radiography, magnetic-particle inspection, ultrasonic inspection, or liquid-penetrant inspection, if specified.

6.11.4.9 [●] If specified, proposed connection designs shall be submitted for approval before fabrication. The drawings shall show weld designs, size, materials, and pre- and post-weld heat treatments.

6.11.4.10 All welds shall be heat-treated in accordance with 6.11.4.3 and Table 5.

6.11.4.11 Post-weld heat treatment, if required, shall be carried out after all welds, including piping welds, have been completed.

6.11.4.12 Auxiliary piping welded to steel casings shall be of a material with the same nominal properties as the casing material or shall be of low-carbon austenitic stainless steel. Other materials compatible with the casing material and intended service may be used with the purchaser's approval.

6.11.5 Low-temperature service

6.11.5.1 Pressure casings and rotating elements shall be designed for the prevention of brittle fracture.

6.11.5.2 [●] The purchaser shall specify the minimum design metal temperature and concurrent pressure including any transient operation.

NOTE Normally, this will be the lower of the minimum surrounding ambient temperature or minimum process-fluid temperature; however, the purchaser can specify a minimum metal temperature based on properties of the process fluids, such as auto-refrigeration at reduced pressures.

6.11.5.3 The purchaser and the vendor shall agree on any special precautions necessary regarding conditions that can occur during operation, maintenance, transportation, erection, commissioning, and testing.

6.11.5.4 The selection of fabrication methods, welding procedures and materials for vendor-furnished steel pressure-retaining parts that can be subject to temperatures below the ductile-brittle transition point shall be identified by the vendor.

NOTE 1 Ferritic steels (such as carbon steel and low alloy steel containing chrome and moly) and martensitic steels (such as 12% chrome) can have ductile-to-brittle transition temperatures as high as 40 °C (100 °F).

NOTE 2 Some standards do not differentiate between rimmed, semi-killed, fully-killed, hot-rolled and normalized material, nor do they take into account whether materials were produced under fine- or coarse-grain practices.

6.11.5.5 Impact testing shall be performed in accordance with 6.11.5.5.1 through 6.11.5.5.4.

6.11.5.5.1 All carbon and low-alloy steel, pressure-containing components, including nozzles, flanges, and weldments, shall be impact-tested in accordance with the requirements of the Section VIII, Division 1, Section UCS-65 through 68 of the ASME BPVC or purchasers approved equivalent standard.

6.11.5.5.2 High-alloy steels shall be tested in accordance with Section VIII, Division l, Section UHA-51, of the ASME BPVC or purchasers approved equivalent standard.

6.11.5.5.3 For materials and thicknesses not covered by the Section VIII, Division I of the ASME BPVC or equivalent standards, the purchaser shall specify requirements.

6.11.5.5.4 Impact testing of a material may not be required depending on the minimum design metal temperature, thermal, mechanical, and cyclic loading, and the governing thickness.

NOTE Refer to requirements of the Section VIII, Division l, Section UG-20F of the ASME BPVC, for example.

6.11.5.6 Governing thickness used to determine impact testing requirements shall be the greater of the following:

a) nominal thickness of the largest butt-welded joint;

b) largest nominal section for pressure containment, excluding

   1) structural support sections, such as feet or lugs,

   2) sections with increased thickness required for rigidity to mitigate shaft deflection,

   3) structural sections required for attachment or inclusion of mechanical features such as jackets or seal chambers;

c) one-fourth of the nominal flange thickness, including parting flange thickness for axially split casings (in recognition that the predominant flange stress is not a membrane stress).

6.11.5.7 The results of the impact testing shall meet the minimum impact energy requirements of Section VIII, Division l, Section UG-84, of the ASME BPVC or equivalent standard.

6.11.6 Additive Manufacturing

6.11.6.1 Any part that is manufactured by Additive Manufacturing ("3D Printing") shall be identified by the manufacturer.

6.11.6.2 [●] If specified, the vendor shall provide a listing of the technical information in accordance with Section 4.2 of API 20S, 1st edition.

6.11.6.3 Feedstock shall meet the requirements of Additive Manufacturing Specification Level (AMSL) 3, per API 20S.

6.12 Nameplates and rotation arrows

6.12.1 A nameplate shall be securely attached at a readily visible location on the equipment and on any major piece of auxiliary equipment.

6.12.2 Rotation arrows shall be cast in or attached to each major item of rotating equipment at a readily visible location.

6.12.3 Nameplates, rotation arrows (if attached), and attachment pins shall be austenitic stainless steel or nickel-copper (UNS N04400) alloy. Welding is not permitted.

6.12.4 The following data shall be clearly stamped or engraved on the nameplate:

a) vendor’s name;

b) serial number;

c) size, type and model;

d) rated capacity;

e) purchaser’s item number or other reference;

f) maximum continuous speed;

g) maximum allowable casing working pressure;

h) hydrostatic test pressure;

i) maximum allowable temperature.

7 Accessories

7.1 Drivers

7.1.1 General

7.1.1.1 The driver shall be:

a) the type specified;

b) sized to meet the maximum specified operating conditions, including external gear and coupling losses;

c) in accordance with applicable specifications, as stated in the inquiry and order;

d) and shall operate under the utility and site conditions specified in the inquiry.

7.1.1.2 The driver shall be sized to accept any specified process variations, such as changes in the pressure, temperature or properties of the fluids handled and plant start-up conditions.

7.1.1.3 The driver shall be capable of starting under the conditions specified, and the starting method shall be agreed by the purchaser and the vendor.

7.1.1.4 The driver's starting-torque capabilities shall exceed the speed-torque requirements of the driven equipment.

7.1.1.5 The supporting feet of drivers with a mass greater than 225 kg (500 lb) shall be provided with vertical jackscrews.

7.1.2 Motors

7.1.2.1 [●] The purchaser shall specify the type of motor and its characteristics and accessories, including but not limited to the following:

a) electrical characteristics;

b) starting conditions, including the expected voltage drop on starting;

c) type of enclosure;

d) sound pressure level;

e) area classification, based on API RP 500 or equivalent International Standard;

f) type of insulation;

g) required service factor;

h) ambient temperature and elevation above sea level;

i) transmission losses;

j) temperature detectors, vibration sensors, and heaters specified;

k) auxiliaries (e.g. motor-generator sets, ventilation blowers and instrumentation);

l) vibration acceptance criteria;

m) use in adjustable frequency drive (AFD) applications.

7.1.2.2 [●] Electric motor drives shall conform to guidelines of 7.1.2.2.1 through 7.1.2.2.3, or other standard as approved by the purchaser.

7.1.2.2.1 Low voltage induction motors shall be in accordance with IEEE 841 (up to 370 kW [500 HP]).

NOTE IEEE 841 at this time is ANSI/NEMA. There is no current equivalent IEC or ISO standard to IEEE 841.

7.1.2.2.2 General purpose medium voltage induction motors shall be in accordance with API 547 (186 kW [250 HP] and larger).

7.1.2.2.3 Special purpose medium and high voltage induction motors shall be in accordance with API 541. (373 kW [500 HP] and larger)

NOTE API 541, 546 and 547 are applicable to either ANSI/NEMA or IEC.

7.1.2.3 The motor rating shall be at least 110 % of the maximum power required (including gear and coupling losses) for any of the specified operating conditions. Consideration shall be given to the starting conditions of both the driver and driven equipment and the possibility that these conditions can be different from the normal operating conditions.

NOTE The 110 % applies to the design phase of a project. After testing, this margin might not be available due to performance tolerances of the driven equipment.

7.1.2.4 The motor torque shall exceed the required torque for any operating case by at least 10%.

NOTE Positive displacement machines are constant-torque machines and therefore, the highest required torque can occur during lower operating speeds and power.

7.1.2.5 The motor's starting torque shall meet the requirements of the driven equipment at a reduced voltage of 80 % of the normal voltage, or such other value as may be specified, and the motor shall accelerate to full speed within 15 s or such other period of time agreed upon by the purchaser and the vendor.

7.1.3 Steam Turbines

7.1.3.1 Steam turbines may be used for dry screw compressors when approved by the purchaser. Refer to Part 2 for requirements.

NOTE Steam turbines are not typically used for oil-flooded screw compressors or rotary blowers.

7.1.4 Gear units

External gear units shall conform to API 677.

7.2 Adjustable Frequency Drives (AFD) and Devices

The manufacturer of the variable speed drive shall confirm that the drive speed range is suitable for startup and all specified operating conditions.

7.2.1 Electric AC Motor driven adjustable frequency drive (AFD)

Note: This device varies the input frequency of the supplied electrical power to result in varied motor speed.

7.2.1.1 The output torque to the connected machinery shall be at least 110% of the greatest torque required (including any gear and coupling losses) for any of the specified operating conditions.

Note: The machinery manufacturer with overall responsibility is not always the purchaser of a variable speed motor or AFD controls.

7.2.1.2 The zero-speed torque to the connected machinery shall exceed the static breakaway torque of the entire machinery train.

7.2.2 Hydraulic adjustable speed drives (Variable Speed Fluid Coupling)

Note: This device is located between the driver and driven equipment and varies the driven speed by introducing variable hydraulic slip in a fluid coupling.

7.2.2.1 The manufacturer of the hydraulic variable speed drive shall provide mass elastic data for the drive to the purchaser.

7.2.2.2 The manufacturer of the hydraulic variable speed drive shall identify any variation of the torsional stiffness as a function of torque and/or speed.

7.3 Couplings

7.3.1 Couplings shall be supplied by the manufacturer of the driven equipment with unit responsibility.

7.3.2 The manufacturer, type, and mounting arrangement of couplings shall be agreed upon by the purchaser and the vendors of the driver and driven equipment.

7.3.3 Coupling hubs shall be mounted at the compressor manufacturer's facility before equipment is shipped.

NOTE Coupling spacer assemblies are typically installed in the field.

7.3.4 Couplings shall be non-lubricated, flexible element, spacer-type couplings manufactured to meet AGMA 9000 Class 9 and shall comply with the following:

a) Flexible elements shall be of corrosion-resistant material.

b) Couplings shall be designed to retain the spacer if a flexible element ruptures.

c) Coupling hubs shall be steel.

d) The distance between the driven and driver shaft ends (distance between shaft ends, or DBSE) shall be at least 125 mm (5 in) and shall permit removal of the coupling, bearings, seal and rotor, as applicable, without disturbing the driver, driver coupling hub or the suction and discharge piping. This dimension, DBSE, shall always be greater than the minimum total seal length.

NOTE - DBSE dimension usually corresponds to the nominal coupling spacer length.

e) Provision shall be made for the attachment of alignment equipment without the need to remove the spacer or dismantle the coupling in any way.

NOTE One way of achieving this is to provide at least 25 mm (1 in.) of bare shaft between the coupling hub and the bearing housing where alignment brackets may be located.

7.3.5 Information on shafts, keyway dimensions (if any) and shaft-end movements due to end play and thermal effects shall be furnished to the vendor supplying the coupling.

NOTE This information is normally furnished by the vendor of the driven equipment or the driver vendor.

7.3.6 The coupling-to-shaft juncture shall be designed and manufactured to be capable of transmitting power at least equal to the power rating of the coupling.

7.3.7 The purchaser of the coupling shall provide or include a moment simulator, if required for the mechanical running test (see 8.3.3).

7.3.8 Test-bed coupling mass should simulate the contract coupling moment.

7.3.9 Couplings shall be mounted in accordance with the requirements of 7.3.9.1 through 7.3.9.6.

7.3.9.1 For a tapered-hub coupling, the vendor shall provide a plug gauge from a matched plug and ring set, for the purpose of checking the bore of the hub, unless an alternative method of ensuring a correct fit has been agreed.

7.3.9.2 Keys and keyways and their tolerances shall conform to AGMA 9002, Commercial Class.

7.3.9.3 Flexible couplings with cylindrical bores shall be mounted with an interference fit. Cylindrical shafts shall comply with AGMA 9002, and the coupling hubs shall be bored to the following tolerances as detailed in ISO 286-2:

a) For shafts of 50 mm (2 in.) diameter and smaller—Grade N7

b) For shafts larger than 50 mm (2 in.) diameter—Grade N8

7.3.9.4 Where maintenance (such as for mechanical seal) requires removal of the coupling hub from the shaft, and the shaft diameter is greater than 60 mm (2.5 in.), the coupling hub shall be a taper fit. Taper for keyed couplings shall be 1/16 slope (0.75 in. /ft diametrical).

7.3.9.5 Hub bore surface finish shall be 32 µin or better.

7.3.9.6 Non hydraulic fit coupling hubs shall be furnished with tapped puller holes at least 10 mm (0.375 in.) diameter to facilitate removal.

7.3.10 [●] If specified, a coupling data sheet shall be provided listing torsional stiffness tolerance range (+/-), and inertia of major components.

7.4 Guards

7.4.1 Guards over couplings between drivers and driven equipment, and shaft guards between bearing housings and seal glands, shall be supplied and mounted by the vendor with unit responsibility.

NOTE Soleplate mounted equipment or large equipment shipped in components may need to have guards mounted at site.

7.4.2 [●] Guards shall enclose the coupling(s) and other rotating components to prevent personnel from contacting moving parts during operation of the equipment train. Allowable access dimensions shall comply with specified standards, such as ANSI B11.19, ISO 14120, or other applicable nationally recognized standard.

7.4.3 Guards shall be constructed with sufficient rigidity to withstand a 900 N (200 lbf) concentrated static load in any direction without the guard contacting moving parts.

7.4.4 Guards shall be fabricated from solid sheet or plate. Woven wire shall not be used for coupling guards.

7.4.5 [●] With purchaser approval guards fabricated from expanded metal or perforated sheets may be used if the size of the openings does not exceed 10 mm (0.375 in.).

7.4.6 Guards shall be constructed of steel, brass, aluminum or nonmetallic (polymer) materials as agreed.

7.4.7 [●] If specified, guards shall be constructed of an agreed spark resistant material.

NOTE 1 Many users consider pure aluminum and aluminum alloys with a maximum content of 2% magnesium or 0.2% copper, all copper, and copper-based alloys (e.g., brass, bronze) to be spark-resistant. However, some local standards, such as ISO 80079-36, might restrict the usage of aluminum or nonmetallic materials within potentially explosive atmospheres.

NOTE 2 Nickel-copper alloys (UNSN0440X or UNSN0550X) and copper-based alloys (e.g., brass, bronze, aluminum bronze, beryllium bronze) are generally considered to be spark resistant. Nickel based alloys including alloy 600 (UNSN06600) and alloy 625 (UNSN06625) are considered spark resistant.

NOTE 3 Materials that are not considered “spark resistant” include stainless steels, iron, steel (all alloys), magnesium, and titanium.

NOTE 4 See ISO 80079-36 (IEC 60079-0) for guidance on materials for non-electrical equipment in explosive atmospheres.

7.4.8 [●] If specified for guards used in potentially explosive atmospheres, an ignition hazard assessment (risk analysis) in accordance with ISO 80079-36 shall be conducted and documented.

Note: This is a requirement for ATEX and may be required in other jurisdictions.

7.4.9 For an ignition hazard assessment (risk analysis) in accordance with ISO 80079-36, the equipment category shall be Group II with Category 1.

NOTE Group II equipment is defined for places with a potentially explosive atmosphere, other than mines susceptible to firedamp. Category 1 equipment requires the assessment to list the potential ignitions sources from expected and rare malfunctions.

7.4.10 Guards shall be removable without disturbing the coupled elements.

7.5 Belt Drives

Belt drives are not permitted.

7.6 Baseplates and Soleplates

7.6.1 General

7.6.1.1 [●] The equipment shall be furnished with soleplates or a baseplate, as specified.

NOTE Refer to Annex D for typical baseplate and soleplate drawings.

7.6.1.2 Baseplates and soleplates shall comply with the requirements of 7.6.1.3 through 7.6.1.17.

7.6.1.3 The upper and lower surfaces of baseplates and soleplates and any separate pedestals mounted thereon shall be machined parallel. The surface finish shall be 125 µm (0.005 in.) Ra (arithmetic average roughness) or better.

7.6.1.4 The baseplates and soleplates shall be furnished in accordance with 7.6.1.4.1 to 7.6.1.4.7.

7.6.1.4.1 Baseplates and soleplates shall be furnished with horizontal (axial and lateral) jackscrews, the same size or larger than the vertical jackscrews in the equipment feet.

7.6.1.4.2 The lugs holding these jackscrews shall be removable or as a minimum attached to the baseplates and soleplates in such a manner that they do not interfere with the installation of the equipment, jackscrews, or shims.

7.6.1.4.3 Precautions shall be taken to prevent vertical jackscrews in the equipment feet from marring the shimming surfaces.

7.6.1.4.4 Supports and alignment bolts shall be rigid enough to permit the machine to be moved using its lateral and axial jackscrews.

7.6.1.4.5 Alternative methods of lifting equipment for the removal or insertion of shims or for moving equipment horizontally, such as provision for the use of hydraulic jacks, may be proposed.

7.6.1.4.6 Such arrangements should be proposed for equipment that is too heavy to be lifted or moved horizontally using jackscrews.

7.6.1.4.7 Alignment jackscrews shall be plated for rust resistance.

7.6.1.5 Machinery supports shall be designed to limit the relative displacement of the shaft end caused by the worst combination of pressure, torque, and allowable piping stress to 50 µm (0.002 in.). See Parts 2, 3 and 4 for allowable piping loads for the different types of machines.

7.6.1.6 If pedestals or similar structures are provided for centerline-supported equipment, the pedestals shall be designed and fabricated to permit the machine to be moved using horizontal jackscrews.

7.6.1.7 Epoxy grout shall be used for machines mounted on concrete foundations.

7.6.1.8 Grouting preparation and installation shall be in accordance with API 686.

7.6.1.8.1 The vendor shall blast-clean in accordance with SSPC SP6 or ISO 8501 Grade Sa2 all grout contact surfaces of the baseplates and soleplates.

7.6.1.8.2 Coat those surfaces with a primer compatible with specified epoxy grout.

7.6.1.8.3 The manufacturer shall advise the purchaser the actual primer used.

7.6.1.8.4 The grout manufacturer should be consulted to ensure proper field preparation of the baseplates and soleplates for satisfactory bonding of the grout to the grout primer.

7.6.1.9 The anchor bolts shall not be used to fasten equipment to the baseplates and soleplates.

7.6.1.10 Baseplates and soleplates shall conform to the following.

a) Baseplates and soleplates shall not be drilled for equipment to be mounted by others.

b) Baseplates and soleplates shall be supplied with leveling screws. A leveling screw shall be provided near each anchor bolt. If the equipment and baseplates and soleplates are too heavy to be lifted using leveling screws, alternate methods shall be provided by the equipment vendor. The design of the alternate method shall be included in the proposal.

c) Outside corners of baseplates and soleplates that are in contact with the grout shall have 50 mm (2 in.) minimum radiused outside corners (in the plan view).

d) All machinery mounting surfaces shall be treated with a rust preventive immediately after machining.

e) Baseplates and soleplates shall extend at least 25 mm (1 in.) beyond the outer three sides of equipment feet.

NOTE This requirement allows handling of shims and mounting level or laser type instruments to check alignment.

f) Baseplates and soleplates shall be machined to a finish of 6 µm (250 µin) *Ra* (arithmetic average roughness) or better.

7.6.1.11 The alignment shims shall be in accordance with API 686 and shall straddle the hold-down bolts and vertical jackscrews and be at least 6 mm (0.25 in.) larger on all sides than the equipment feet.

7.6.1.12 Anchor bolts shall be furnished by the purchaser.

7.6.1.13 Hold-down bolts used to attach the equipment to the baseplates and soleplates and all jackscrews shall be supplied by the vendor.

7.6.1.14 Equipment shall be designed for installation in accordance with API RP 686.

7.6.1.15 Grouted baseplates or soleplates shall be sized to limit the static loading to 690 kN/m^2 (100 psi) on the grout.

7.6.1.16 Diametrical clearance between anchor bolts and the anchor bolt holes in the baseplate and soleplate shall be a minimum of 6 mm (1/4 in.).

7.6.1.17 Working clearance shall be provided at the hold-down bolt and jack bolt locations to allow the use of standard socket or box wrenches, to achieve the specified torque.

7.6.2 Baseplates

7.6.2.1 If a baseplate is specified, the purchaser shall indicate the major equipment to be mounted on it.

7.6.2.2 A baseplate shall be a single, fabricated steel unit, unless the purchaser and the vendor mutually agree that it may be fabricated in multiple sections.

7.6.2.3 Multiple-section baseplates shall have machined and doweled mating surfaces, which shall be bolted together to ensure accurate field reassembly.

NOTE A baseplate with a nominal length of more than 12 m (40 ft) or a nominal width of more than 4 m (12 ft) can require fabrication in multiple sections because of shipping restrictions.

7.6.2.4 Single-piece baseplates shall be furnished with a gutter type drain of at least 76 mm (3 in.) wide and 51 mm (2 in.) deep around the circumference of the base deck.

a) gutter shall be sloped at least 1 in 120 toward the driven equipment end,

b) a tapped drain opening of at least DN 38 (NPS 1½) shall be located to effect complete drainage.

7.6.2.5 All joints, including deck plate to structural members, shall be continuously seal-welded on both sides to prevent crevice corrosion. Stitch welding, top or bottom, is unacceptable.

7.6.2.6 If a baseplate(s) is provided, it shall extend under the drive-train components so that any leakage from these components is contained within the baseplate.

7.6.2.7 [●] If specified, the baseplate shall be designed to facilitate the use of optical, laser-based, or other instruments for accurate leveling in the field.

7.6.2.7.1 The details of such facilities shall be agreed by the purchaser and vendor.

7.6.2.7.2 If the requirement is satisfied by the provisions of leveling pads and/or targets, they shall be accessible with the baseplate on the foundation and the equipment mounted.

7.6.2.7.3 Removable protective covers shall be provided.

7.6.2.7.4 Pads or targets shall be located close to the machinery support points.

7.6.2.7.5 For baseplates longer than 6 m (20 ft), additional pads shall be located at intermediate points.

7.6.2.8 [●] If specified, the baseplate shall be designed for column mounting (that is, of sufficient rigidity to be supported at specified points) without continuous grouting under structural members.

a) The baseplate design shall be mutually agreed upon by the purchaser and the vendor.

b) Design suitability shall be verified by FEA or similar suitable design tool.

7.6.2.9 The baseplate shall be provided with lifting attachments meeting the requirements of 7.6.2.9.1 through 7.6.2.9.7.

7.6.2.9.1 **T**he baseplate shall be provided with lifting lugs for at least a four-point lift.

7.6.2.9.2 Lifting attachments on the baseplate or equipment shall be designed using a maximum allowable dynamic stress of one - third of the specified minimum yield strength of the material.

NOTE Design of lifting attachments can be in accordance with standards such as ASME BTH-1 "Design of Below-the-Hook Lifting Devices".

7.6.2.9.3 Baseplates shall be designed for lifting with all equipment mounted.

NOTE In some cases it can be more practical to design the baseplate to remove heavy equipment prior to lifting.

7.6.2.9.4 Lifting the baseplate complete with all equipment mounted shall not permanently distort or otherwise damage the baseplate or the equipment mounted on it.

7.6.2.9.5 Lugs or trunnions that are attached by welding shall have continuous welds and shall be 100% NDE tested in accordance with the applicable code.

7.6.2.9.6 Removable lugs or commercially available specialty products such as pivot type hoisting rings can be provided with purchaser approval.

7.6.2.9.7 [●] If specified, commercially available lifting attachments shall be furnished with material and load test certifications traceable to an internationally recognized standard and attested by an independently accredited third-party agency or organization.

7.6.2.10 For accessibility and grouting, the baseplate shall be designed per 7.6.2.10.1 to 7.6.2.10.7.

7.6.2.10.1 The bottom of the baseplate between structural members shall be open unless an oil reservoir integral with the base plate is supplied.

7.6.2.10.2 If the baseplate is designed for grouting, it shall be provided with at least one grout hole having a clear area of at least 130 cm^2 (20 in^2) and no dimension less than 75 mm (3 in.) in each bulkhead section.

7.6.2.10.3 The grout holes shall be located to permit grouting under all load-carrying structural members. Where practical, the holes shall be accessible for grouting with the equipment installed.

7.6.2.10.4 The holes shall have 13 mm (0.5 in.) raised-lip edges, and if located in an area where liquids can impinge on the exposed grout, metallic covers with a minimum thickness of 1.5 mm (0.060 in.) shall be provided.

7.6.2.10.5 Grout hole covers shall be convex and extend to the deck surface per Figure 7.

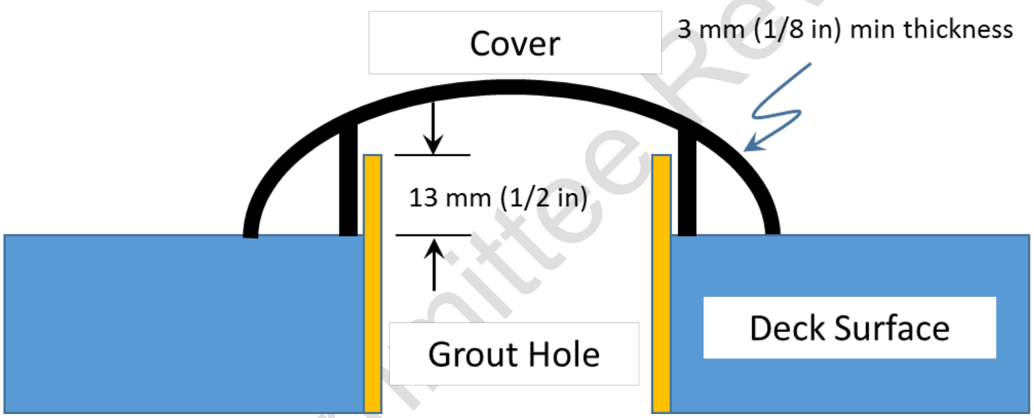


Figure 7 - Cross-section of Grout Hole Cover

7.6.2.10.6 Vent holes at least 13 mm (0.5 in.) in diameter shall be provided at the highest point and located to vent the entire cavity in each bulkhead section of the baseplate.

7.6.2.10.7 Non-skid metal decking covering all walk and work areas shall be provided on the top of the baseplate.

NOTE Nonskid surfaces can be obtained by non-skid coatings or grating over the metal decking.

7.6.2.11 Two ground clips or pads shall be welded to the baseplate at diagonally opposed corners. These clips or pads shall be of the same material as the baseplate and accommodate a 13 mm (1/2 in. UNC) bolt.

7.6.2.12 The underside mounting surfaces of the baseplate shall be in one plane within 0.1 mm (0.004 in.).

NOTE Mounting surfaces in one plane permit the use of a single-level foundation.

7.6.2.13 All baseplate machinery mounting surfaces shall meet the following criteria (see Figure 8):

a) They shall be machined after the baseplate is fabricated,

b) They shall be machined to a finish of 6 µm (250 µin) Ra or better.

c) They shall have each mounting surface machined within a flatness of 75 µm per linear meter (0.001 in. per linear foot) of mounting surface.

d) To prevent a soft foot, if the machine is installed on the baseplate, the difference between all mounting surfaces in the same horizontal plane shall be within 125 µm (0.005 in.).

e) Mounting surfaces for different equipment shall be machined parallel to each other within 125 µm (0.005 in.).

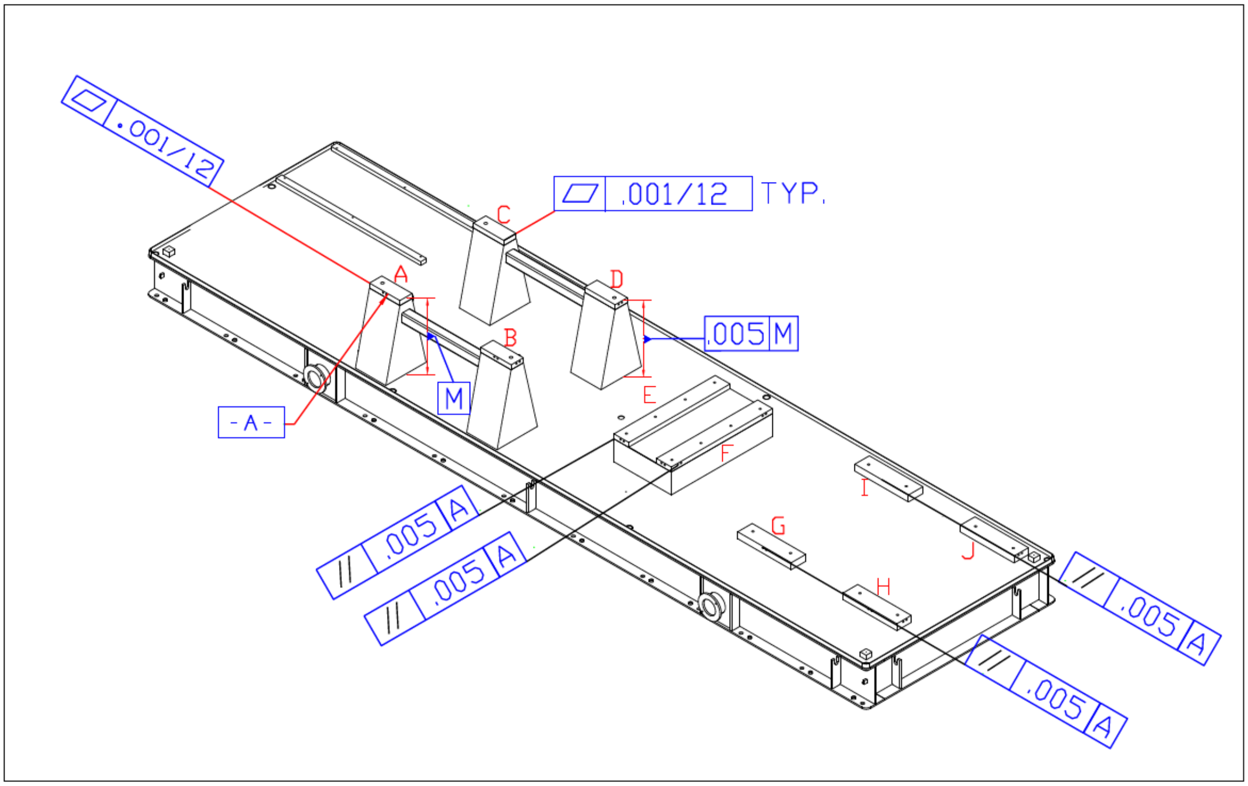


Figure 8 - Mounting Surface Criteria

7.6.2.14 The tolerances in 7.6.2.13 shall be recorded and verified by placing the baseplate in unrestrained condition on a flat machined surface at the place of manufacturer.

7.6.2.15 [●] If specified, sub-soleplates shall be provided by the vendor.

7.6.2.16 Support for the major equipment shall be located directly beneath the equipment feet and shall extend in-line vertically to the bottom of the baseplate.

7.6.2.17 [●] If specified, the bottom of the baseplate shall have machined mounting pads. These pads shall be machined in a single plane after the baseplate is fabricated.

7.6.3 Soleplates and sub-soleplates

7.6.3.1 [●] If soleplates are specified, they shall meet the requirements of 7.6.3.2 and 7.6.3.3 in addition to those of 7.6.1.

7.6.3.2 Adequate working clearance shall be provided at the bolting locations to allow the use of standard socket or box wrenches and to allow the equipment to be moved using the horizontal and vertical jackscrews.

7.6.3.3 Soleplates shall be steel plates that are thick enough to transmit the expected loads from the equipment feet to the foundation, but in no case shall the plates be less than 40 mm (1-1/2 in.) thick.

7.6.3.4 [●] If specified, sub-soleplates shall be provided by the vendor.

7.6.3.5 If sub-soleplates are specified, they shall be steel plates at least 25 mm (1 in.) thick. The finish of the sub-soleplates' mating surfaces shall match that of the soleplates (see 7.6.1.3).

7.6.3.6 Soleplates shall be large enough to extend beyond the feet of the equipment in all directions and shall be designed such that the anchor bolts are not covered by machine feet.

7.6.3.7 Soleplates in excess of 30 kg (75 lb) shall have provision for a minimum of two bolted lifting attachments. Each lifting attachment shall be designed to lift the total weight of the soleplate.

7.7 Controls and Instrumentation

7.7.1 General

7.7.1.1 [●] The vendor shall provide machine performance data and all other information as agreed to design a control system for start-up, for all specified operating conditions and for shutdown.

7.7.1.2 [●] If specified, the vendor shall review the purchaser's overall compressor control system for compatibility with vendor-furnished control equipment.

7.7.1.3 Instrumentation and installation shall conform to the requirements of API 670 and API 614.

7.7.1.4 [●] The purchaser shall specify required construction and installation standards for controls.

7.7.1.5 [●] The purchaser shall specify whether controls and instruments are designed for outdoor or indoor installation.

7.7.1.6 Controls and instrumentation that are designed for outdoor installation shall have a minimum ingress protection level of IP65 as detailed in IEC 60529 or a NEMA 4 minimum rating per NEMA Standard Publication 250.

7.7.1.7 If IEC 60529 ingress protection for outdoor installation is specified, the controls and instrumentation, equipment and wiring shall comply with the construction requirements of IEC 60079 "Explosive Atmosphere Standards".

NOTE Special consideration can be required for instrumentation working below -20 ºC (-4 ºF) or above 55 ºC (130 ºF).

7.7.1.8 [●] Terminal boxes shall have a minimum ingress protection level of IP 66 as detailed in IEC 60529 or a NEMA 4X minimum rating per NEMA Standard Publication 250, as specified.

a) If IP 66 protection level is specified, the terminal boxes shall comply with the construction requirements of IEC 60079 "Electrical apparatus for explosive atmospheres".

b) Terminal boxes shall be 316 SS.

NOTE 1 IEC addresses Environment protection and electrical protection separately. Ingress protection is covered by the IP designation in IEC 60529. Electrical protection is covered by IEC 60079.

NOTE 2 The IP Code only addresses requirements for protection of people, ingress of solid objects, and ingress of water. There are numerous other requirements covered by the NEMA Type designations that are not addressed by the IEC 60529/IP Codes. IEC 60529 does not specify the following:

a) construction requirements;

b) door and cover securement;

c) corrosion resistance;

d) effects of icing;

e) gasket aging and oil resistance;

f) coolant effects.

The Type designation of NEMA specifies requirements for these additional performance protections. For this reason, the IEC enclosure IP Code designations cannot be converted to enclosure NEMA Type numbers. (NEMA Publication “A brief comparison of NEMA 250 and IEC 60529”)

NOTE 3 NEMA addresses both environmental and electrical protection (Construction features) in one standard NEMA Publication 250.

7.7.1.9 Instrumentation and controls shall be designed and manufactured for use in the area classification (class, group and division or zone) specified in 6.1.3.3.

7.7.1.10 All conduit, armored cable and supports shall be designed and installed so that it can be easily removed without damage and shall be located so that it does not hamper removal of bearings, seals, or equipment internals.

7.7.1.11 Where applicable, controls and instrumentation shall conform to API RP 551 Part 1.

7.7.2 Control systems

7.7.2.1 [●] The compressor may be controlled based on inlet pressure, discharge pressure, flow, or some combination of these parameters. This may be accomplished by suction throttling, speed variation, a slide valve volume-control device or a cooled bypass from discharge to suction.

7.7.2.2 The control system may be mechanical, pneumatic, hydraulic, electric or any combination thereof. The system may be manual, or it may be automatic with a manual override.

7.7.2.3 The purchaser shall specify the method of control, the source of the control signal, its sensitivity and range, and the equipment to be furnished by the vendor.

NOTE For flooded screw compressors, there is the possibility of the bypass not requiring cooling.

7.7.2.4 For a variable-speed drive, the control signal shall act to adjust the set point of the driver’s speed-control system.

7.7.2.4.1 The speed of the machine shall vary linearly and directly with the control signal.

7.7.2.4.2 The control range shall be from maximum continuous speed to 95 % of the minimum speed required for any specified operating condition or 70 % of the maximum continuous speed, whichever is lower.

7.7.2.5 [●] If specified, a combination of control modes shall be provided.

NOTE Typically, this is necessary on machines with a limited speed range, for multi-service or multi-stream applications.

7.7.2.6 [●] If constant-speed drive is specified, the control signal shall actuate the slide valve volume-control device if furnished, or the control valve in the compressor piping.

7.7.2.7 The full range of the specified control signal shall correspond to the required operating range of the driven equipment. The maximum control signal shall correspond to the maximum continuous speed or the maximum flow.

7.7.3 Control panels

7.7.3.1 [●] If specified, a control panel shall be provided.

7.7.3.2 Control panels shall conform to the requirements of API 614.

7.7.4 Instrumentation

7.7.4.1 General

Instrumentation shall comply with API 614, API 670, and API 692 where applicable.

7.7.4.2 Tachometers

7.7.4.2.1 [●] If specified, a tachometer shall be provided for variable-speed units.

7.7.4.2.2 The type, range and indicator provisions shall be as specified.

7.7.4.2.3 The tachometer shall be supplied by the driver vendor and shall be furnished with a minimum range of 0 % to 125 % of maximum continuous speed.

7.7.4.3 Vibration and position detectors

7.7.4.3.1 [●] If specified, non-contacting vibration and axial-position transducers shall be supplied, installed, and calibrated in accordance with API 670.

7.7.4.3.2 [●] If specified, seismic-vibration transducers shall be supplied, installed, and calibrated in accordance with API 670.

7.7.4.4 [●] If specified, vibration, axial position and seismic monitors shall be supplied and calibrated in accordance with API 670.

7.7.4.5 Bearing temperature detector

7.7.4.5.1 [●] If specified, for compressors utilizing hydrodynamic thrust or radial bearings, bearings shall be fitted with bearing-metal temperature sensors installed in accordance with API 670.

NOTE Smaller compressors sometimes do not have sufficient clearance to utilize bearing-metal temperature sensors.

7.7.4.5.2 [●] If specified, a bearing-temperature monitor shall be supplied and calibrated in accordance with API 670.

7.7.4.6 Relief valves

7.7.4.6.1 The vendor shall furnish the relief valves for installation on equipment or piping that the vendor is supplying.

7.7.4.6.2 Other relief valves related to equipment or piping outside the system that the vendor is supplying should be furnished by the purchaser.

7.7.4.6.3 The vendor's quotation shall list all relief valves and shall clearly state that these valves shall be furnished by the vendor.

7.7.4.6.4 The sizing, selection and installation of relief valves shall meet the requirements of API 520, Parts I and II. Relief valves shall be in accordance with API 526.

7.7.4.6.5 The vendor shall determine the size and set pressure of all relief valves within his scope of supply.

7.7.4.6.6 Relief valve sizes and settings shall consider all possible modes of equipment failure.

7.7.4.6.7 Relief valves shall not have an accumulation exceeding 10% of set pressure.

7.7.4.6.8 Relief valves shall have steel bodies.

7.7.4.6.9 [●] If specified, thermal relief valves shall be provided for accessories or cooling jackets that can be blocked in by isolation valves.

7.7.4.7 Compressor depressurization valve

[●] If specified, the vendor shall supply a depressurization valve installed in the piping system.

7.7.4.8 Shutdown isolation valves

[●] If specified, the vendor shall supply shutdown isolation valves at both suction and discharge-gas termination points.

NOTE Start-up with closed isolation valves might not be possible due to small, enclosed volume or high settle-out pressure.

7.7.5 Alarms and shutdowns

7.7.5.1 General

7.7.5.1.1 An alarm/shutdown system shall be provided which initiates an alarm if any one of the specified parameters reaches an alarm point and initiates shutdown of the equipment if any one of the specified parameters reaches the shutdown point.

7.7.5.1.2 [●] The purchaser shall specify the alarms and shutdowns required, which, as a minimum, should include those listed in Table 6.

NOTE 1 When dry gas seals are specified, the corresponding alarms and trips are described in API 692.

NOTE 2 Automatic shutdown of some equipment may pose a greater impact on the facility than allowing the equipment to be damaged.

Table 6 — Recommended alarms only or alarms and shutdowns

Condition
Axial position movement
Overspeed
Unit shutdown
Operation of spare lube-oil pump
Operation of spare seal-oil pump
High radial shaft vibration
High casing or bearing housing vibration
High winding temperature
High bearing temperature
High compressor-discharge temperature
High gas differential pressure
High inlet-air-filter differential pressure
High level on separators
High lube-oil-filter differential pressure
High seal-oil-filter differential pressure
High thrust-bearing drain temperature
High or low lube-oil temperature
High or low lube-oil reservoir level
High or low seal-oil pressure
High or low seal-oil temperature
High or low seal-oil reservoir level
Low coolant flow to compressor jacket
Low buffer-gas pressure
Low lube-oil pressure

7.7.5.1.3 The vendor shall advise the purchaser of any additional alarms and/or shutdowns considered essential to safeguard the equipment.

7.7.5.1.4 [●] The purchaser shall specify the extent to which this alarm/shutdown system is to be supplied by the equipment vendor.

7.7.5.1.5 Alarm/shutdown systems shall comply with the requirements of API 614.

7.7.5.1.6 The necessary valving and switches or bridging links (jumpers) shall be provided to enable all instruments and other components, except shutdown-sensing devices, to be replaced with the equipment in operation.

7.7.5.1.7 [●] If specified, shutdown sensing devices shall be provided with valving, bridging links or other approved protocol to allow replacement with the equipment in operation.

7.7.5.1.8 If isolation valves are specified for shutdown-sensing devices, the vendor shall provide a means of locking the valves in the open position.

7.7.6 Electrical systems

7.7.6.1.1 Electrical systems shall be in accordance with API 614.

7.8 Piping

7.8.1 Auxiliary piping

7.8.1.1 Auxiliary piping shall be in accordance with API 614 and API 692.

7.8.1.2 Oil-supply piping and tubing, including fittings (excluding slip-on flanges), shall be stainless steel.

7.8.1.3 Auxiliary piping to the machine shall have breakout spools to allow for maintenance and for removal of the entire machine.

7.8.1.4 Provision shall be made for bypassing the bearings (and seals if applicable) of all equipment in the train during oil system flushing operations.

NOTE Generally, this is accomplished by short spool pieces at the equipment.

7.8.1.5 Provision shall be made for flushing dry gas seal system interconnecting piping prior to operation.

NOTE Refer to API 692 Part 4 Annex B for cleaning/flushing of field installed piping.

7.8.2 Instrument piping

Instrument piping and tubing, if furnished, shall be in accordance with API 614 or API 692, whichever applies.

7.8.3 Process piping

7.8.3.1 For the protection of rotating equipment during the initial operation, the vendor shall provide a temporary removable strainer meeting the following:

a) Be made from austenitic stainless steel.

b) Shall have a mesh size adequate to stop all objects that can be damaging to the equipment with a maximum strainer hole size shall be 3 mm (1/ 8 in.).

c) Having an open flow area equal to 150 % of the cross-sectional area of the suction pipe.

d) The removable strainer shall be identified by a protruding tab.

e) The piping arrangement shall permit the removal of the strainer without disturbing alignment.

f) Strainers shall be installed in spool pieces to minimize piping removed.

NOTE Strainer can be cone, basket, or T-type**.**

7.8.3.2 [●] If specified, a permanent strainer shall be furnished. Requirements for a permanent strainer shall be mutually agreed.

7.8.3.3 [●] The extent of, and requirements for, process piping to be supplied by the vendor shall be specified.

7.8.3.4 Process piping, if furnished, shall conform to the requirements of API 614.

7.8.3.5 [●] If specified, the vendor shall review the design of all piping, appurtenances, and vessels (e.g. pulsation suppression devices, intercoolers, aftercoolers, separators, knockout drums, air-intake filters, and expansion joints) and supports immediately upstream and downstream of the equipment. The purchaser and the vendor shall agree on the scope of this review.

7.8.4 Intercoolers and aftercoolers

7.8.4.1 [●] If specified, the vendor shall furnish intercoolers between each compression stage.

7.8.4.2 [●] If specified, the vendors shall furnish aftercoolers.

7.8.4.3 Intercoolers and aftercoolers shall be furnished in accordance with Section VIII, Division 1, of the ASME BPVC or other purchaser specified pressure design code.

7.8.4.4 Intercoolers and aftercoolers shall conform to the requirements of API 614.

7.8.5 Inlet separators

7.8.5.1 [●] The purchaser shall advise the manufacturer of the quantity and type of any entrained liquid(s) or solid particles in the process gas stream.

NOTE 1 Oil-flooded screw compressors have lower allowable limits of entrained liquids and solid particles.

NOTE 2 Solids and liquids not removed by the inlet separator pass through the oil-flooded screw compressor, collect in the discharge gas/oil separator, and have the possibility of damaging the compressor's oil pump, rotor housing, bearings, shaft seals and rotors.

NOTE 3 Some contaminants, especially catalytic metal particles like iron, increase the rate of oil oxidation and have the possibility of stripping the oil in an oil-flooded screw compressor of its polar additives (i.e. anti-wear and extreme-pressure additives, plus rust and oxidation inhibitors and dispersants).

7.8.5.2 [●] If specified, the vendor shall furnish an inlet separator for installation upstream of the compressor, to remove liquids and solid particles from the process gas stream.

NOTE 1 Liquids can excessively dilute the recirculated oil stream in an oil-flooded screw compressor, particularly at start-up or upset conditions.

NOTE 2 Liquids can carry dissolved solids that plate out on dry screw compressor and rotary lobe blowers due to evaporation from inlet pressure drop and compression heat.

NOTE 3 Many solid particles are best removed in the inlet separator with the separated liquids.

7.8.5.3 If an inlet filter/separator is specified, the vendor shall supply differential pressure measurement.

7.8.5.4 [●] If specified, means for liquid level monitoring and draining shall be provided.

7.8.5.5 [●] It should be recognized that many configurations and arrangements are available. If specific features are desired, these shall be specified by the purchaser.

7.8.5.6 If vane- or mesh-type demisters are furnished, they shall be constructed of AISI 300 series stainless steel or high alloy steel types UNS N04400, N04401, N04404, N05500 or N04405 and supported upstream and downstream of the mesh material.

7.8.6 Pulsation suppressors/silencers

7.8.6.1 Pulsation suppressors and silencers shall be provided in conformance with API 688.

7.8.6.2 The requirement for, and the scope of, an analysis of pulsation and noise suppression shall be per the requirements of API 688.

7.8.6.3 Inlet and exhaust pulsation suppressors/silencers for each casing shall be supplied by the compressor manufacturer. Their primary function shall be to provide the maximum practical reduction of pulsations in the frequency range of audible sound.

7.8.6.4 Diffusers or devices that split the gas flow through small orifices shall not be used in applications where contaminants present in the gas stream can build up to ultimately obstruct the flow. However, if used, such devices should be easily accessible for cleaning.

7.8.6.5 The minimum corrosion allowance for carbon steel shells shall be 3 mm (1/8 in.).

7.8.6.6 If corrosive gases require the use of materials other than carbon steel, the material and any required corrosion allowance shall be specified by the purchaser.

7.8.6.7 [●] The purchaser shall specify on the datasheet the corrosion allowance for carbon-steel or non-carbon-steel material for the specific gas that is being compressed.

7.8.6.8 The thickness for non-carbon-steel shell material shall be equal to or greater than the thickness required for carbon steel, including the carbon-steel corrosion allowance.

7.8.6.9 Internals shall have a minimum thickness of 6 mm (0.25 in.).

7.8.6.10 [●] Pulsation suppressors/silencers shall be in accordance with the specified pressure design code and shall be suitable for not less than the specified relief valve setting.

7.8.6.11 In addition to being designed for static conditions, the pulsation suppressors/silencers shall be designed for dynamic loads, considering the service cycles over the expected life of the vessel and the pulsing load characteristic.

7.8.6.12 All welds shall be continuous full penetration.

7.8.6.13 A DN 20 (NPS 3/4) pressure-test connection shall be provided at each pulsation suppressor/silencer inlet and outlet nozzle.

7.8.6.14 A DN 25 (NPS 1) minimum external-drain connection shall be provided for each compartment where liquids can collect while the compressor is in service.

7.8.6.15 Where individual compartment drains are impractical and bulkheads extend to the vessel wall, circular-notched openings in the bulkheads may be used with the purchaser's approval.

7.8.6.16 The arrangement of internals shall ensure that liquids flow to drain connections under all operating conditions. The effect of drain openings on silencer performance shall be considered.

7.8.6.17 The inlet nozzle of the inlet pulsation suppressor/silencer and the discharge nozzle of the discharge pulsation suppressor/silencer shall be provided with two flanged DN 25 (NPS 1) connections located to permit, without interference, the purchaser's installation of dial thermometers and thermowells for high-temperature alarm or shutdown elements.

7.8.6.18 All main connections to pulsation suppressors/silencers shall be flanged.

7.8.6.19 [●] If specified, inspection openings of size DN 150 (NPS 6), complete with blind flanges and gaskets, shall be provided for access to each compartment. DN 100 (NPS 4) inspection openings may be provided on vessels less than 500 mm (20 in.) in diameter.

NOTE Inspection openings might not be practical on some silencer designs.

7.8.6.20 [●] If specified, insulation mounting clips on pulsation suppressors/silencers shall be provided.

7.8.6.21 All connections and nameplates shall be unobstructed by the insulation.

7.9 Special tools

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

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

7.9.3 These or similar special tools shall be used, and their use demonstrated during shop assembly and post-test disassembly of the equipment.

7.9.4 If special tools are provided, each tool shall be labeled using metal stamps or have a permanently attached stainless steel tag to indicate its intended use.

7.9.5 Tools which do not exceed 1 m (3 ft) in length, width, or height and that weigh less than 40 kg (90 lb) shall be packaged in one or more rugged metal boxes and shall be marked "special tools for (tag/item number), box x of x".

7.9.6 Larger tools do not need to be boxed but shall have a stainless steel tag permanently attached to indicate both the intended use and the tag/item number of the equipment for which they are intended.

7.10 Coatings, Insulation, and Jacketing

7.10.1 [●] If specified, insulation for personnel protection, thermal conservation or sound attenuation shall be provided by the vendor. The extent of insulation shall be mutually agreed.

7.10.2 [●] If specified, surfaces shall be treated to prevent corrosion under insulation.

7.11 Enclosures

7.11.1 [●] If specified, enclosure(s) shall be provided.

NOTE This section does not apply to sound walls or barriers.

7.11.2 Enclosures shall meet purchaser's acoustical, weatherproofing, safety, and/or fire protection requirements.

7.11.3 Enclosure(s) shall be designed to ensure the package can meet the maintenance, operation, service life requirements, and electrical area classification.

7.11.4 An enclosure system shall consist of the following:

a) an enclosure surrounding the driver and/or driven equipment;

b) an enclosure ventilation system;

c) if specified, a fire protection system (see 7.10.2), including enclosure isolation devices.

7.11.5 Outdoor enclosures shall be weatherproof for the site conditions specified.

7.11.6 Enclosures shall be designed to permit on-site maintenance. The degree of disassembly for maintenance shall be stated in the proposal.

7.11.7 Enclosure floor compartment shall have drain connections and piping to facilitate removal of liquids.

7.11.8 Removable roof sections, side panels, or hinged bulkhead walls shall be provided for heavy maintenance.

7.11.9 Walls shall be internally insulated with non-toxic, non-flammable, mold-resistant mineral wool, or equivalent material. Insulating foam shall not be used.

7.11.10 Access openings, such as doors or manways shall be provided for routine maintenance and inspection. The sealing devices (weatherstripping or gaskets) utilized around the perimeter of these access ways shall be designed to withstand normal use without loss of sealing function.

7.11.11 Conduits, fire prevention systems, gas detection, etc., shall not be attached to the underside of the roof or any other panels that must be removed for maintenance.

7.11.12 The enclosure shall be provided with a fan driven forced ventilation system designed to provide 100% of the ventilation load in the most severe climatic/load conditions.

7.11.13 Fans shall be redundant and negative pressure design.

7.11.14 Ventilation system will include air filtration, and/or silencing equipment, or both if required by the vendor.

7.11.15 The ventilation system shall be designed to handle all specified site climatic or operational conditions.

7.11.16 Ventilation system shall have been proved to ensure that no dead spaces exist within the enclosure either by physical type test, computational fluid dynamics (CFD) analysis or other means to avoid the chance of dangerous accumulations of vapor occurring.

7.11.17 All equipment and instrumentation shall be suitable for the environmental conditions inside the enclosure.

8 Inspection, testing, and preparation for shipment

8.1 General

8.1.1 The purchaser shall specify the minimum inspection and testing requirements.

8.1.2 The vendor shall submit an inspection and test plan for purchaser's approval.

8.1.3 [●] The purchaser shall specify the extent of participation in the inspection and testing.

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

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

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

8.1.7 [●] The expected dates of testing shall be communicated at least 30 days in advance of testing and the actual dates confirmed as agreed. The vendor shall give at least five working days advanced notification of a witnessed or observed inspection or test.

NOTE Hydrostatic and running test notification is covered in 8.3.1.

8.1.8 A witnessed mechanical running or performance tests, requires written confirmation of the successful completion of a preliminary test. Results of the preliminary test shall be provided if requested.

8.1.9 [●] Purchaser shall specify if the vendor may perform an unwitnessed mechanical or performance preliminary test prior to a witnessed test.

NOTE Some purchasers prefer not to have preliminary tests prior to witnessed tests to understand any difficulties encountered during testing.

8.1.10 Equipment, materials and utilities for the specified inspections and tests shall be provided by the vendor.

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

8.2 Inspection

8.2.1 General

8.2.1.1 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 that the requirements of the specification have been met;

c) fully identified records of all heat treatment, 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) other data specified by the purchaser or required by applicable codes and regulations (see 5.1 and Annex D).

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

NOTE Some materials can require painting with primer to prevent corrosion.

8.2.1.3 In addition to the requirements of 6.11.4.3, the purchaser may specify the following:

a) parts that shall be subjected to surface and subsurface examination;

b) type of examination required, such as magnetic-particle, liquid-penetrant, radiographic or ultrasonic examination (see Table 7).

NOTE 1 Inspection of pressure containing components is covered in 8.2.2.6.

NOTE 2 ASTM material specifications contain mandated and supplemental inspections.

NOTE 3 Review of quality assurance and testing are items on the coordination meeting agenda in Annex E.

Table 7 — ASME Materials Inspection Standards

Type of Inspection	Methods	Acceptance Criteria	
		For Fabrications	For Castings
Radiography	Section V, Articles 2 and 22 of the ASME BPVC	Section VIII, Division 1, UW-51 (for 100% radiography) and UW-52 (for spot radiography) of the ASME BPVC	Section VIII, Division 1, Appendix 7 of the ASME BPVC
Ultrasonic inspection	Section V, Articles 4, 5, and 23 of the ASME BPVC	Section VIII, Division 1, UW-53 and Appendix 12 of the ASME BPVC	Section VIII, Division 1, Appendix 7 of the ASME BPVC
Magnetic particle inspection	Section V, Articles 7 and 25 of the ASME BPVC	Section VIII, Division 1, Appendix 6 of the ASME BPVC	See acceptance criteria in 8.2.2.4 and Table 8
Liquid penetrant inspection	Section V, Articles 6 and 24 of the ASME BPVC	Section VIII, Division 1, Appendix 8 of the ASME BPVC	Section VIII, Division 1, Appendix 7 of the ASME BPVC

8.2.2 Material inspection

8.2.2.1 Material Inspection of Non-Pressure Containing Parts

8.2.2.1.1 If radiographic, ultrasonic, magnetic-particle or liquid-penetrant inspection of welds or materials is required or specified, the criteria in 8.2.2.2 to 8.2.2.5 shall apply unless other corresponding procedures and acceptance criteria have been specified.

8.2.2.1.2 Cast iron may be inspected only in accordance with 8.2.2.4 and/or 8.2.2.5.

NOTE Radiographic and ultrasonic inspection are not appropriate for cast iron.

8.2.2.1.3 Welds, cast steel and wrought material shall be inspected in accordance with 8.2.2.2 to 8.2.2.5.

NOTE The material inspection of pressure-containing parts is covered in 8.2.2.6.

8.2.2.1.4 The vendor shall review the design of the equipment and shall impose more stringent criteria than the generalized limits required in the other subclauses of 8.2.2, if necessary.

8.2.2.1.5 Defects that exceed the limits imposed in the other subclauses of 8.2.2 shall be removed to meet the quality standards cited, as determined by the inspection method specified.

8.2.2.2 Radiography

Radiography shall be in accordance with ASTM E94 and ASME B31.3.

8.2.2.3 Ultrasonic inspection

Ultrasonic inspection shall be based upon the procedures ASTM A609 (castings), ASTM A388 (forgings), or ASTM A578 (plate).

8.2.2.4 Magnetic-particle inspection

Both wet and dry methods of magnetic-particle inspection shall be in accordance with ASTM E709. To prevent buildup of potential voltage in the equipment, all components shall be demagnetized to the free air gauss levels in Table 8 if measured with a calibrated Hall Effect probe.

Table 8 — Maximum Allowable Free Air Gauss Levels

+/- 2 Gauss	Bearing and seal assemblies including all components
+/- 4 Gauss	Casing and all stationary components except bearing and seal assemblies
+/- 2 Gauss	Shaft and all rotating Components

NOTE The free air gauss level is measured while suspending the component from a non-conductive strap with no influence from stray magnetic fields.

8.2.2.5 Liquid-penetrant inspection

Liquid-penetrant inspection shall be in accordance with ASTM E165 and ASTM E1417.

8.2.2.6 Material Inspection of Pressure Casing

NOTE 1 - Refer to 8.2.2.1 for inspection of non-pressure containing parts.

NOTE 2 - Refer to 3.1.46 for the definition of pressure casing.

8.2.2.6.1 Regardless of the generalized limits presented in this section, it shall be the vendor's responsibility to review the design limits of all materials and welds if more stringent requirements are specified.

8.2.2.6.2 Defects that exceed the limits imposed in 8.2.2 shall be removed to meet the quality standards cited, as determined by additional magnetic particle or liquid penetrant inspection as applicable before repair welding.

8.2.2.6.3 If radiographic, ultrasonic, magnetic particle, or liquid penetrant inspection of welds or materials is required by the ASME BPVC or specified, the procedures and acceptance criteria in Table 9 shall apply, except as required by 8.2.2.6.1. Alternative standards may be proposed by the vendor for approval by the purchaser.

NOTE Other national or local standards may be more stringent than ASME BPVC.

Table 9 — Materials Inspection Standards for Pressure Casings

Type of inspection	**Methods**	**Acceptance criteria**	
		For fabrications	**For castings**
Radiography	Section V, Articles 2 and 22 of the ASME BPVC	Section VIII, Division 1, UW-51 (for 100% radiography) and UW-52 (for spot radiography) of the ASME BPVC	Section VIII, Division 1, Appendix 7 of the ASME BPVC
Ultrasonic inspection	Section V, Articles 4, 5 and 23 of the ASME BPVC	Section VIII, Division 1, UW53 and Appendix 12, of the ASME BPVC	Section VIII, Division 1, Appendix 7, of the ASME BPVC
Magnetic particle inspection	Section V, Articles 7 and 25 of the ASME BPVC	Section VIII, Division 1, Appendix 6 of the ASME BPVC	For Compressible Fluids: See acceptance criteria in 8.2.2.6.10 and Table 10 For Incompressible Fluids: Section VIII, Division 1, Appendix 7 of the ASME BPVC
Liquid penetrant inspection	Section V, Articles 6 and 24 of the ASME BPVC	Section VIII, Division 1, Appendix 8 of the ASME BPVC	Section VIII, Division 1, Appendix 7, of the ASME BPVC

8.2.2.6.4 The purchaser shall be notified before making a major repair to a pressure containing part. Major repairs, for the purpose of purchaser notification only, is any defect that equals or exceeds any of the three criteria defined below.

a) The depth of the cavity prepared for repair welding exceeds 50% of the component wall thickness.

b) The length of the cavity prepared for repair welding is longer than 150 mm (6 in) in any direction.

c) The total area of all repairs to the part under repair exceeds 10% of the surface area of the part.

8.2.2.6.5 All repairs to pressure containing parts shall be made as required by the following documents:

a) The repair of plates, prior to fabrication, shall be performed in accordance with the ASTM standard to which the plate was purchased.

b) The repair of castings or forgings shall be performed prior to final machining in accordance with the ASTM standard to which the casting or forging was purchased.

c) The repair of a fabricated casing or the defect in either a weld or the base metal of a cast or fabricated casing, uncovered during preliminary or final machining, shall be performed in accordance with Table 10.

8.2.2.6.6 Plate used in fabrications shall be 100% Ultrasonic inspected prior to starting fabrication in accordance with the ASTM standard to which the plate was purchased.

8.2.2.6.7 Cast and Nodular iron shall be inspected only in accordance with magnetic particle and liquid penetrant methods.

8.2.2.6.8 Spot radiography shall consist of a minimum of one 150-millimeter (6-inch) spot radiograph for each 7.6 meters (25 feet) of weld on each casing. If spot radiograph is required, as a minimum, one spot radiograph shall be performed for each welding procedure and welder used for pressure-containing welds.

8.2.2.6.9 For magnetic particle inspections, linear indications shall be considered relevant only if the major dimension exceeds 1.6 millimeters (1/16 inch). Individual indications that are separated by less than 1.6 millimeters (1/16 inch) shall be considered continuous.

8.2.2.6.10 For cast steel casing parts examined by magnetic particle methods, acceptability of defects shall be based on a comparison with the photographs in ASTM E125. For each type of defect, the degree of severity shall not exceed the limits specified in Table 10.

Table 10 — Maximum severity of defects in castings

Type	Defect	Maximum severity level
I	Linear discontinuities	1
II	Shrinkage	2
III	Inclusions	2
IV	Chills and chaplets	1
V	Porosity	1
VI	Welds	1

8.2.2.7 Positive Material Identification (PMI)

PMI testing shall be in accordance with 8.2.2.7.1 through 8.2.2.7.7.

8.2.2.7.1 [●] If specified, alloy steel items shall be subject to PMI testing per the datasheet.

8.2.2.7.2 [●] In addition to the components outlined in 8.2.2.6.1 other materials, welds, fabrications, and piping shall be PMI tested as specified.

8.2.2.7.3 If PMI testing has been specified for a fabrication, the components comprising the fabrication, including welds, shall be checked after the fabrication is complete except as permitted in 8.2.2.7.5. Testing may be performed prior to any heat treatment.

8.2.2.7.4 Unique (non-stock) components such as impellers, turbine blading, and shafts may be tested after manufacturing and prior to rotor assembly.

8.2.2.7.5 If PMI is specified, techniques providing quantitative results shall be used.

NOTE 1 PMI test methods are intended to identify alloy materials and are not intended to establish the exact conformance of a material to an alloy specification.

NOTE 2 Additional information on PMI testing can be found in API RP 578.

NOTE 3 PMI is used to verify that the specified materials are used in the manufacturing, fabrication, and assembly of components.

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

8.2.2.7.7 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.

8.2.3 Mechanical inspection

8.2.3.1 During assembly of the equipment, each component (including integrally cast-in passages) and all piping and appurtenances shall be inspected to ensure they have been cleaned and are free of foreign materials, corrosion products and mill scale.

8.2.3.2 All oil-system components furnished shall meet the cleanliness requirements of API 614.

8.2.3.3 [●] If specified, the purchaser may inspect the equipment and all piping and appurtenances for cleanliness before heads are welded onto vessels, openings in vessels or exchangers are closed or piping is finally assembled.

8.2.3.4 [●] If specified, the hardness of parts, welds and heat-affected zones shall be verified as being within the allowable values by testing. The method, extent, documentation and witnessing of the testing shall be mutually agreed upon by the purchaser and the vendor.

8.3 Testing

8.3.1 General

8.3.1.1 Equipment shall be tested in accordance with 8.3.2 through 8.3.4. Other tests that may be specified by the purchaser are described in 8.3.5.

8.3.1.2 At least six weeks before the first scheduled running test, the vendor shall submit to the purchaser, for his review and comment, detailed procedures for the mechanical running test and all specified optional running tests (see 7.3.4), including acceptance criteria for all monitored parameters.

8.3.1.3 Testing notification requirements are covered in 8.1.6. If the testing is rescheduled, the vendor shall notify the purchaser. A new date shall be agreed with 5 working days advance notice.

8.3.2 Hydrostatic tests

8.3.2.1 The pressure-containing parts of the compressor casing shall be tested hydrostatically in accordance with ASTM E1003, with liquid at a minimum of 1-1/2 times the maximum allowable working pressure but not less than a gauge pressure of 150 kPa (1,5 bar; 20 psi).

NOTE For gas-pressure-containing parts, the hydrostatic test is a test of the mechanical integrity of the component and is not a valid leakage test.

8.3.2.2 The test liquid shall be at a higher temperature than the nil-ductility transition temperature of the material being tested.

NOTE The nil-ductility temperature is the highest temperature at which a material experiences complete brittle fracture without appreciable plastic deformation.

8.3.2.3 Auxiliary systems shall be hydrostatically tested according to ASME BPVC Sec VIII Div 1 or other purchaser approved design code. The minimum hydrostatic test pressure shall not be less than 150 kPa (20 psi).

NOTE Some auxiliary systems are tested to 1.3 times the MAWP (ASME BPVC) and some are tested to 1.43 times the MAWP (ISO).

8.3.2.4 If the part tested is to operate at a temperature at which the strength of a material is below the strength of that material at the testing temperature, the hydrostatic test pressure shall be multiplied by a factor obtained by dividing the allowable working stress for the material at the testing temperature by that at the rated operating temperature.

8.3.2.4.1 The stress values used shall conform to those given in ANSI/ASME B31.3 for piping or in section 6.2.1 for casings.

8.3.2.4.2 The pressure thus obtained shall then be the minimum pressure at which the hydrostatic test shall be performed. The datasheets shall list actual hydrostatic test pressures.

8.3.2.4.3 Applicability of this requirement to the material being tested should be verified before hydrotest, as the properties of many grades of steel do not change appreciably at temperatures up to 200 °C (400 °F).

8.3.2.5 The chloride content of liquids used to test austenitic stainless steel materials shall not exceed 100 mg/kg (100 parts per million by mass).

8.3.2.6 To prevent deposition of chlorides on austenitic stainless steel as a result of evaporative drying, all residual liquid shall be removed from tested parts at the conclusion of the test.

NOTE 1 Chloride content and its concentration is limited to prevent stress corrosion cracking.

NOTE 2 NACE SCC resistance of 304 and 316 at temperatures below 50 C show that SCC can be avoided at much higher concentrations than allowed above. The above limit is set based on use of potable water and the requirement to wipe dry which prevents much higher concentrations of chlorides from forming.

8.3.2.7 Tests durations shall be sufficient to permit complete examination of parts under pressure.

8.3.2.8 The hydrostatic test shall be considered satisfactory when neither leaks nor seepage through the pressure-containing parts or joints are observed for a minimum of 30 minutes. Large, heavy, pressure-containing parts or complex systems can require a longer testing period as agreed upon by the purchaser and the vendor.

8.3.2.9 Gaskets used during hydrotest of an assembled casing shall be of the same design as supplied with the casing.

8.3.3 Mechanical running test

8.3.3.1 Requirements prior to the mechanical running test

8.3.3.1.1 The contract shaft seals and bearings shall be used in the machine for the mechanical running test.

8.3.3.1.2 All oil pressures, viscosities and temperatures shall be within the range of operating values recommended in the vendor’s operating instructions for the specific unit being tested.

8.3.3.1.3 For external pressure-lubrication systems, oil flow rates for each oil feed connection shall be measured.

NOTE Measurement of oil flow rates for integral pressure-lubrication systems can be impractical.

8.3.3.1.4 Test-stand oil filtration shall not exceed 10 µm nominal.

8.3.3.1.5 Oil-system components downstream of the filters shall meet the cleanliness requirements of API 614 before any test is started.

8.3.3.1.6 All joints and connections shall be checked for tightness and any leaks shall be corrected.

8.3.3.1.7 All warning, protective and control devices used during the test shall be checked and adjusted as required.

8.3.3.1.8 The vibration characteristics determined using the instrumentation specified in 8.3.3.1.9 to 8.3.3.1.15 shall serve as the basis for acceptance or rejection of the machine (see 6.8.4).

8.3.3.1.9 Shop test facilities shall include the capability of seismic monitoring of casing vibration.

8.3.3.1.10 Seismic vibration data shall be recorded in horizontal and vertical directions, at radial planes transverse to each bearing centerline and in the axial direction, using shop instrumentation during the test.

NOTE Compressor-equipment configuration can limit measuring device location.

8.3.3.1.11 All instrumentation used for the tests shall have valid calibration at the time of the test.

8.3.3.1.12 [●] If specified, all purchased vibration proximity probes, cables, oscillator-demodulators and seismic probes shall be used during the test.

8.3.3.1.13 If vibration probes are not furnished by the equipment vendor, or if the purchased probes are not used during the test or compatible with shop readout facilities, then shop devices and readouts that meet the accuracy requirements of API 670 shall be used.

8.3.3.1.14 If vibration proximity probes are specified, shop test facilities shall include instrumentation with the capability of continuously monitoring, displaying, recording, and printing vibration displacement and phase angle (x-y-y′), vibration spectra, Bode plots, and shaft orbits.

8.3.3.1.15 If shaft vibration probes or provisions for probes are supplied, phase-related electrical and mechanical runout shall be determined by rotating the rotor through the full 360° supported in V-blocks at the journal centers.

a) The combined runout, measured with a non-contacting vibration probe, and the mechanical runout, measured with dial indicators at the centerline of each probe location shall be continuously recorded during the rotation.

b) Teflon shall not be used in the V blocks.

NOTE The rotor runout determined above generally cannot be reproduced if the rotor is installed in a machine with hydrodynamic bearings. This is due to pad orientation on tilt pad bearings and effect of lubrication in all journal bearings.

8.3.3.1.16 Records of electrical and mechanical runout for the full 360° at each probe location shall be reported.

8.3.3.2 Speed requirements for the mechanical running test

8.3.3.2.1 The mechanical running test shall be run at maximum continuous speed for a minimum of 4 h. Figure 9 illustrates the mechanical running test including requirements of 8.3.3.2.2 through 8.3.3.2.4.

8.3.3.2.2 Variable-speed equipment shall be operated at speed increments of approximately 10 % from minimum allowable speed to the maximum continuous speed and run at the maximum continuous speed until bearings, lube-oil temperatures and shaft vibrations have stabilized.

NOTE Operating below minimum allowable speed damages the equipment.

8.3.3.2.3 The speed for variable-speed equipment shall be increased to trip speed (see Table 1) and the equipment shall be run for a minimum of 15 min.

8.3.3.2.4 The speed for variable-speed equipment shall be reduced to the maximum continuous speed and the equipment shall be run continuously for 4 h.

Note: Blade Frequency, Exclusion Zone and Critical Speeds are not applicable to rotary-type positive-displacement compressors.

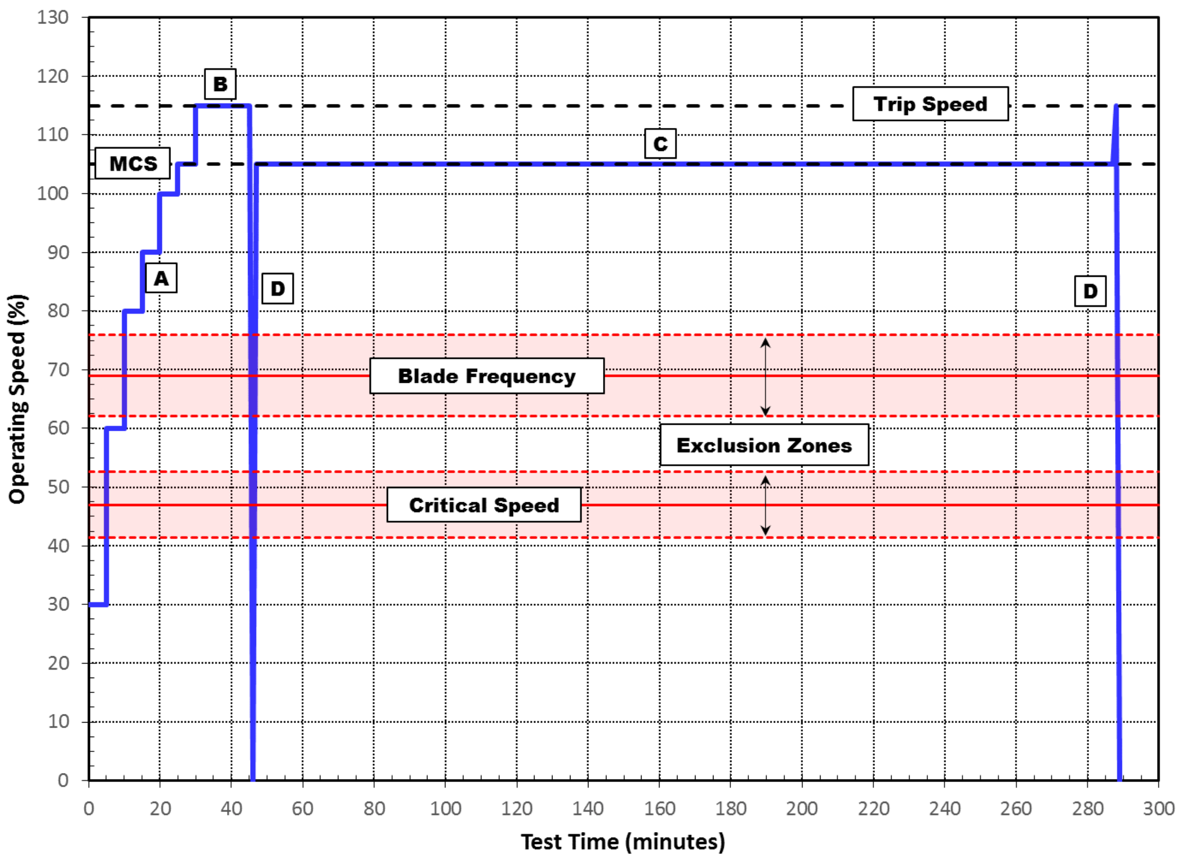


Figure 9 – Mechanical Test

Key:

A Warm Up Phase

- Speed increased multiple increments

B Trip Speed Operation (see Table 1 for applicable trip speeds)

- 15 minutes

C Maximum Continuous Speed Four Hour Test

- Oil supply variations performed
- Operating conditions recorded

D Ramp Down/Ramp Up (Not applicable for rotary-type positive-displacement compressors)

- Trip speed to shutdown

8.3.3.3 Requirements during the mechanical running test

8.3.3.3.1 During the mechanical running test, the mechanical operation of all equipment being tested, and the operation of the test instrumentation shall be satisfactory.

8.3.3.3.2 The measured vibration shall not exceed the limits specified in Parts 2, 3 or 4, as applicable, and shall be recorded throughout the operating speed range.

8.3.3.3.3 While the equipment is operating at maximum continuous speed and at other speeds that have been specified in the test agenda, a spectrum analysis shall be made for vibration amplitudes at frequencies other than synchronous. As a minimum, this spectrum analysis shall cover a frequency range from 0.25 to 8 times the maximum continuous speed but not more than 90,000 cycles per minute (1500 Hz).

8.3.3.3.3.1 If the amplitude of any discrete, non-synchronous vibration, excluding the frequency of the other rotor and its harmonics, exceeds 20 % of the allowable overall vibration as defined in Parts 2, 3, or 4 (as applicable) or 75 % of the allowable overall vibration in the case of the pocket-passing frequency (PPF) and its harmonics, the purchaser and the vendor shall agree on requirements for any further investigation, which may include additional testing.

NOTE 1 For screw compressors, vibration at pocket-passing frequency and its harmonics, or at the frequency of the other rotor and its harmonics, are common and can constitute a major part of the total vibration level as limited in 6.8.4.

NOTE 2 For high vibration at the PPF or its harmonics, this additional testing can require closed-loop testing simulating the contract relative molecular mass.

8.3.3.3.3.2 If the vendor can demonstrate that electrical or mechanical runout is present, a maximum of 25 % of the test level calculated from Parts 2, 3, and 4 vibration limits (as applicable) or 6.5 µm (0.25 mil), whichever is greater, may be vectorially subtracted from the vibration signal measured during the factory test.

8.3.3.3.4 [●] If specified, all real-time vibration data as agreed by the purchaser and vendor shall be recorded and a copy provided to the purchaser.

8.3.3.3.5 [●] If specified, lube-oil and seal-oil inlet pressures and temperatures shall be varied through the range permitted in the operating manual.

a) This shall be done during the 4 h test.

b) This option does not constitute a waiver of the other specified test requirements.

c) The combination of pressure and temperature variations during the test will be agreed.

d) Lube-oil and seal-oil operating conditions should be held until bearing temperatures have stabilized within 1 °C (2 °F) over 10 minutes.

8.3.3.3.6 The purchaser shall advise additional testing requirements for spare parts.

8.3.3.4 Requirements after the mechanical running test is completed

8.3.3.4.1 If replacement or modification of bearings or seals or dismantling of the case to replace or modify other parts is required to correct mechanical or performance deficiencies, the initial test is not acceptable and the final shop tests shall be run after these deficiencies are corrected.

8.3.3.4.2 If spare rotors are ordered to permit concurrent manufacture, each spare rotor set shall also be given a mechanical running test in accordance with the requirements of this part of API 619.

8.3.4 Leak Test

8.3.4.1 After the mechanical running test is completed, each completely assembled compressor casing intended for toxic, hazardous, flammable, or hydrogen-rich service, or when specified for other gases, shall be tested as specified in 8.3.4.2 to 8.3.4.4.

8.3.4.2 The casing (including end seals) shall be:

a) pressurized with an inert gas to the maximum sealing pressure or the maximum seal design pressure (as agreed by the purchaser and the vendor);

b) held at this pressure for a minimum of 30 min and subjected to a soap-bubble test or another approved test to check for gas leaks.

The test shall be considered satisfactory if no casing or casing joint leaks are observed.

NOTE EN 1779 describes various methods of leak testing.

8.3.4.3 Test-gas relative molecular mass should approximate contract-gas relative molecular mass. Helium for low relative-molecular-mass contract gas and nitrogen for high relative molecular mass should be considered.

8.3.4.4 The casing (with or without end seals installed) shall be pressurized to the rated discharge pressure, held at this pressure for a minimum of 30 min and subjected to a soap-bubble test or another approved method to check for gas leaks. The test shall be considered satisfactory if no casing or casing joint leaks are observed.

NOTE The requirements of 8.3.4.2 to 8.3.4.4 can necessitate two separate tests.

8.3.4.5 In cases where instrumentation sensors are in contact with process gas the sensor sealing assembly or housing shall be leak tested during the compressor's leak test of 8.3.4.4.

8.3.4.6 Heat run

8.3.4.6.1 A Heat run shall be performed at maximum continuous speed, with the discharge temperature stabilized at the maximum operating discharge temperature, plus 11 °C (20 °F) for a minimum of 30 minutes.

NOTE Test pressure in a heat run can vary due to dissimilarities between test gas and service gas.

8.3.4.6.2 For dry screw compressors, a heat run shall be performed prior to the 4 h mechanical test run.

8.3.4.6.3 [●] If specified, for rotary lobe blowers, a heat run shall be performed prior to the 4 h mechanical test run.

8.3.4.6.4 The compressor shall be run at the maximum continuous speed, with the discharge temperature stabilized at the maximum operating temperature at any of the specified operating conditions plus 11 K [20 R[9]] for a minimum of 30 minutes.

NOTE 1 Excessive internal clearances required for higher-temperature operation result in decreased volumetric efficiency under normal operating conditions.

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9) Rankin is a deprecated unit.

NOTE 2 On machines with water-flush seals and high leakage rate, there is the possibility of not achieving the heat-run temperature.

8.3.4.6.5 A high-discharge-temperature shutdown point should be set below the heat-run temperature.

8.3.4.6.6 For compressors using oil-buffered seal units, when any test run with air involves a discharge temperature above 120 °C (250 °F), the test shall be conducted using a modified procedure to eliminate the oil-air high-temperature hazard. The modified test procedure shall be agreed upon by the purchaser and the vendor.

8.3.5 Optional tests

8.3.5.1 General

[●] If specified, the shop tests described in 8.3.5.2 to 8.3.5.12 shall be performed. Test details shall be mutually agreed upon by the purchaser and the vendor.

8.3.5.2 Performance test

8.3.5.2.1 [●] If specified, the machine shall be tested in accordance with ISO 1217. See 6.1.2.10 b).

8.3.5.2.2 Vibration levels shall be measured and recorded during this test as specified in 8.3.3.1.9 to 8.3.3.1.15.

8.3.5.3 Complete-unit test

8.3.5.3.1 Components such as compressors, gears, drivers, and auxiliaries that make up a complete unit shall be tested together. Scope and acceptance criteria of this test shall be mutually agreed.

8.3.5.3.2 [●] If specified, torsional vibration measurements shall be made to verify the vendor’s analysis.

8.3.5.3.3 The complete-unit test may be performed in place of, or in addition to, separate tests of individual components specified.

8.3.5.4 Tandem test

[●] If specified, machines arranged for tandem drive shall be tested as a unit during the mechanical running test, using the shop driver and oil systems.

8.3.5.5 Gear test

[●] If specified, if an external gearbox is provided in the drive train, it shall be tested with the machine unit during the mechanical running test.

8.3.5.6 Helium test

8.3.5.6.1 [●] If specified, Pressure-containing parts, such as compressor casings, shall be tested for gas leakage with helium at the maximum allowable working pressure. Test methods and acceptance criteria shall be mutually agreed. See EN 1779 for more information.

8.3.5.6.2 A helium test should be specified if the molar mass of the gas handled is less than 12, if the gas contains more than 0.1 mole % hydrogen sulfide, or vacuum service between 0 and 10 mbar absolute (0 - 0.15 psia).

8.3.5.6.3 The helium test shall be performed after a successful hydrostatic test.

8.3.5.7 Sound-level test

[●] If specified, the sound-level test shall be performed in accordance with ISO 2151, 3746 and 3744 or another agreed standard.

NOTE A sound-level test on the test stand is not representative of the sound level in the field due to differences in operating conditions and piping system.

8.3.5.8 Auxiliary-equipment test

[●] If specified, auxiliary equipment, such as oil systems, gears, and control systems, shall be tested in the vendor's shop. Details of the auxiliary-equipment tests shall be developed jointly by the purchaser and the vendor.

8.3.5.9 Post-test inspection

8.3.5.9.1 [●] If specified, the compressor shall be dismantled, inspected, and reassembled after satisfactory completion of the mechanical running test.

8.3.5.9.2 [●] The purchaser should specify whether the gas test required by 8.3.4. shall be performed before or after the post-test inspection.

8.3.5.10 Inspection of hub/shaft fit for hydraulically mounted couplings

[●] If specified, after the running tests, the shrink fit of hydraulically mounted couplings shall be inspected by comparing hub/shaft match marks to ensure that the coupling hub has not moved on the shaft during the tests.

8.3.5.11 Spare-parts test

[●] Spare parts such as couplings, gears and seals shall be tested as specified.

NOTE A mechanical test of the spare rotor set is mandated in 8.3.3.4.2.

8.3.5.12 [●] If specified, the vendor's representative shall witness:

a) a check of the piping alignment performed by unfastening the major flanged connections of the equipment,

b) the initial shaft alignment check (cold alignment),

c) shaft alignment at operating temperature (hot alignment).

NOTE Many factors can adversely affect site performance. These factors include such items as piping loads, alignment at operating conditions, supporting structure, handling during shipment and handling and assembly at the site. Refer to API RP 686 for basic guidelines for conduction piping alignments, shaft hold and cold alignments.

8.3.6 Test data

8.3.6.1 Immediately upon completion of each witnessed mechanical, performance and optional test, copies of the data logged shall be given to the witness.

8.3.6.2 The purchaser and the vendor shall mutually agree that the test data have met the acceptance criteria shown in the test specification.

8.3.7 Test report

[●] If specified, the vendor shall provide test reports within the timetable identified on the VDDR (see example form in Annex F).

8.4 Preparation for shipment

8.4.1 Equipment shall be prepared for the type of shipment specified, including blocking of the rotor when necessary.

8.4.2 Blocked rotors shall be identified by means of corrosion-resistant tags attached with stainless steel wire.

8.4.3 The preparation shall make the equipment suitable for six months of outdoor storage from the time of shipment, with no disassembly required before operation except for inspection of bearings and seals.

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

8.4.5 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 API RP 686-96, Chapter 3.

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

a) Except for machined surfaces, all exterior surfaces that can corrode during shipment, storage or in service shall be given at least one coat of the manufacturer’s standard paint. The paint shall not contain lead or chromates.

NOTE Austenitic stainless steels are typically not painted.

b) Exterior machined surfaces except for corrosion-resistant material shall be coated with a rust preventive.

c) The interior of the equipment shall be clean; free from scale, welding spatter and foreign objects; and sprayed or flushed with a rust preventive that can be removed with solvent. The rust preventive shall be applied through all openings while the rotor is rotated.

d) Internal surfaces of bearing housings and carbon-steel oil-systems components shall be coated with an oil-soluble rust preventive that is compatible with the lubricating oil.

e) Any paint exposed to lubricants shall be oil resistant. If synthetic lubricants are used, special precautions shall be taken to assure compatibility with the paint.

f) Permanent internal coating shall be compatible with process gases, cooling media and lubricants.

8.4.7 Flanged openings shall be designed per the following.

a) Flanged openings shall be provided with metal closures at least 5 mm (3/16 in) thick with elastomer gaskets and at least four bolts that match the ASME standard bolt for the flange size and pressure class.

b) Each elastomeric gasket shall be equal to the flange diameter.

c) For studded openings, all nuts needed for the intended service shall be used to secure closures.

d) Each opening shall be car-sealed so that the protective cover cannot be removed without the seal being broken.

8.4.8 Threaded openings shall be provided with steel caps or round-head steel plugs. In no case shall non-metallic (e.g. plastic) caps or plugs be used.

NOTE These are shipping plugs; permanent plugs are covered in 6.4.4.5.

8.4.9 Openings that have been beveled for welding shall be provided with closures designed to prevent entry of moisture and foreign materials and damage to the bevel.

8.4.10 Lifting points and lifting lugs shall be clearly identified on the equipment or equipment package. The recommended lifting arrangement shall be as described in the installation manual.

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

8.4.12 Material shipped separately shall be identified with securely affixed, corrosion-resistant metal tags indicating the item and serial number of the equipment for which it is intended.

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

8.4.14 A spare rotor set shall be prepared and packed according to a) through g).

a) A spare rotor set, when purchased, shall be prepared for unheated indoor storage for a period of at least ten years.

b) It shall be treated with a rust preventive and shall be housed in a vapor-barrier envelope with a slow-release, volatile corrosion inhibitor.

c) [●] The rotor shall be crated for domestic, or export shipment as specified.

d) A purchaser-approved resilient material 3 mm (1/8 in.) thick [not tetrafluoroethylene (TFE) or polytetrafluoroethylene (PTFE)] shall be used between the rotor and the cradle at the support areas.

NOTE TFE and PTFE are not recommended as cradle support liners since they cold flow and impregnate into the surface.

e) The rotor shall not be supported on the journals.

f) The probe-target area barriers shall be marked with the words “Probe area – do not cut”.

g) [●] If specified, the rotor shall be prepared for vertical storage.

   i) It shall be supported from its coupling end with a fixture designed to support 1.5 times the rotor’s weight without damaging the shaft.

   ii) Instructions on the use of the fixture shall be included in the installation, operation, and maintenance manuals.

8.4.15 [●] If specified, spare rotors shall be shipped in a container capable of nitrogen pressurization and suitable for long term vertical or horizontal storage. Rotors shall have rust preventative coatings.

8.4.16 Critical shaft areas such as journals, end-seal areas, probe-target areas, and coupling-fit areas shall be protected with a corrosion barrier followed by a separate barrier material to protect against incidental mechanical damage.

8.4.17 Loose components shall be dipped in wax or placed in plastic bags and contained by cardboard boxes. Loose boxes are to be securely blocked in the shipping container.

8.4.18 Spare parts shall be packaged separately from materials belonging to the main order.

8.4.19 All packing materials shall be biologically decomposable or recyclable.

8.4.20 Composition wood product such as Particleboard, Medium Density Fiberboard (MDF), and Oriented Strand Board (OSB) shall not be used.

8.4.21 Each item shall be marked with lifting and sling points that will distribute the load equally and keep them in a stable horizontal position.

8.4.22 Each item shall be provided with lashing points to secure the load horizontally and axially during transport.

8.4.23 Auxiliary piping connections furnished on the purchased equipment shall be impression stamped or permanently tagged to agree with the vendor's connection table or general arrangement drawing. Service and connection designations shall be indicated.

8.4.24 Bearing assemblies shall be fully protected from the entry of moisture and dirt.

8.4.24.1 If volatile corrosion-inhibitor crystals in bags are installed in large cavities to absorb moisture, the bags shall be attached in an accessible area for ease of removal.

8.4.24.2 Where applicable, corrosion-inhibitor bags shall be installed in wire cages attached to flanged covers with bag locations indicated by corrosion-resistant tags attached with stainless steel wire.

8.4.25 Connections on auxiliary piping, removed for shipment, shall be match-marked for ease of reassembly.

8.4.26 [●] If specified, the fit-up and assembly of machine-mounted piping, intercoolers, etc. shall be completed in the vendor's shop prior to shipment.

8.4.27 [●] If specified, the vendor shall provide lifting tools suitable for lifting the equipment or equipment package. Lifting tools can include spreader bars, shackles, and slings.

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

8.4.29 Package Markings and Shipping Documentation

8.4.29.1 [●] All markings shall be in English and other specified language.

8.4.29.2 Package markings shall be stenciled on two opposite sides of the shipping unit. A shipping unit may be a box, carton, bundle, crate, drum, loose self-supported piece of equipment etc.

8.4.29.3 Lettering shall be between 7.6 cm and 12.7 cm (3 in. to 5 in.) high in weatherproof black ink to ensure visibility.

8.4.29.4 Shipping packages that cannot be stenciled directly must have attached corrosion resistant metal tags with raised markings.

8.4.29.5 Shipping packages 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 "Standard Practice for Pictorial Markings for Handling of Goods".

8.4.29.6 Package markings shall include:

a) purchasers purchase order number and tag number;

b) shipping unit piece number;

c) gross weight;

d) dimensions;

e) purchasers project name.

8.4.29.7 Packaged equipment shall be shipped with duplicate packing lists – one inside and the other on the outside of the shipping container. Also, a paper copy of package markings shall be inside each container.

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

8.4.29.9 Equipment or materials that contain or are coated with chemical substances shall be prominently tagged at openings to indicate the nature of contents and precautions for shipping, storage, and handling.

NOTE Some examples include oils, corrosion inhibitors, antifreeze solutions, desiccants, hydrocarbon substances, and unused paint.

8.4.29.10 Substances that are supplied with the shipment shall have a Safety Data Sheet (SDS).

8.4.29.11 If a substance is exempt from regulation, a statement to that effect shall be included.

8.4.29.12 At least two weeks before shipment, SDSs shall be forwarded to the receiving facility, to allow planning for handling of any regulated substances.

8.4.29.13 SDSs in protective envelopes shall be affixed to the outside of the shipping package.

9 Vendor's data

9.1 General

9.1.1 The purchaser may specify the content of proposals, meeting frequency and vendor data content/format identified in Annex E. Annex E provides a general outline of information that potentially may be requested by the purchaser.

9.1.2 [●] If specified, the information in Annex E shall be provided.

Annex A
(informative)

Capacity Rating and Tolerance

A.1 The content of this informative annex refers to clause 6.1.2.10.

A.2 This annex discusses capacity sizing of rotary compressors and the intent of the term "no negative tolerance (NNT)" as used in this standard to apply to the "normal capacity" of rotary process compressors.

A.3 The "normal operating point" is defined by the purchaser and is normally the minimum capacity at the specified pressures and temperatures required to meet the process conditions with NNT permitted (this is typically the process flow sheet material balance capacity). The purchaser completes the data sheets with a capacity and identifies the operating conditions as "normal" or "alternate." The purchaser also provides information on the data sheets about any proposed alternate operating conditions. The sizing of the compressor takes into account all specified operating conditions, and the manufacturer's tolerances so that the resulting full-load capacity will never be less than the capacity at the certified operating point.

A.4 The compressor "manufacturer's rated capacity" is that capacity to which the compressor is sized by the manufacturer. Because of the tolerance on capacity, the manufacturer typically will increase the normal capacity prior to sizing the compressor. Since this standard establishes tolerances on normal capacity, and not the manufacturer's rated capacity, the purchaser and the manufacturer should ensure that they have a mutually understood tolerance on the manufacturer's rated capacity.

NOTE 1 Tolerances on smaller machines are inherently larger than on larger machines. The manufacturer should advise the manufacturer's tolerances for smaller machines and adjust the certified capacity accordingly. ISO 1217-1 table B.2 allows tolerances of +/-4% to +/- 7% of inlet volume flow rate depending on calculated volume flow rate at specified conditions.

NOTE 2 For some gases with very low MW, very high MW, very high temperature, 2-phase flow, or other complex process conditions, additional corrections and/or increased tolerances may be applied by the manufacturer. These vary by manufacturer and may not be covered by standard calculation methods.

A.5 "Total power at the compressor shaft," as used in the data sheets under the manufacturer's rated capacity, is intended to mean the power required at the compressor input shaft.

A.6 "Total power including power transmission losses" is the total power at the compressor shaft plus all losses in the drive system and is used for selecting the driver.

A.7 The tolerance on the manufacturer's certified shaft power is ±4 % and is calculated on the basis of manufacturer's rated capacity. Using the manufacturer's rated capacity and corresponding power, the proper relationship of power to unit capacity exists and will agree with calculations. (For example, kilowatts per hundred cubic meters per hour or brake horsepower per hundred cubic feet per minute.

A.8 Example 1 (See Figure A.1)

A.8.1 Here's an example where a manufacturer's standard tolerances are +/- 5% on inlet volume flow rate and +/- 5% on shaft power. Expected data are assumed to be 2000 hp shaft power and 10,000 cfm at 3600 rpm.

A.8.2 Given NNT on inlet volume flow rate, the compressor speed must be increased by approximately 5% and then the calculated flow rate is de-rated by 5% to achieve NNT. The final tolerance on inlet volume flow rate is then +10 / -0% at this speed and set of process conditions.

A.8.3 Because the speed has increased by ~5% to meet NNT on inlet volume flow rate, the shaft power is now also expected to be ~5% higher. Given +4% maximum shaft power and the compressor's standard +/-5% tolerance on shaft power, the power must be de-rated a further 1% (or the vendor must shrink their tolerance window). The final tolerance on shaft power is +4 / -6% at this speed and set of process conditions.

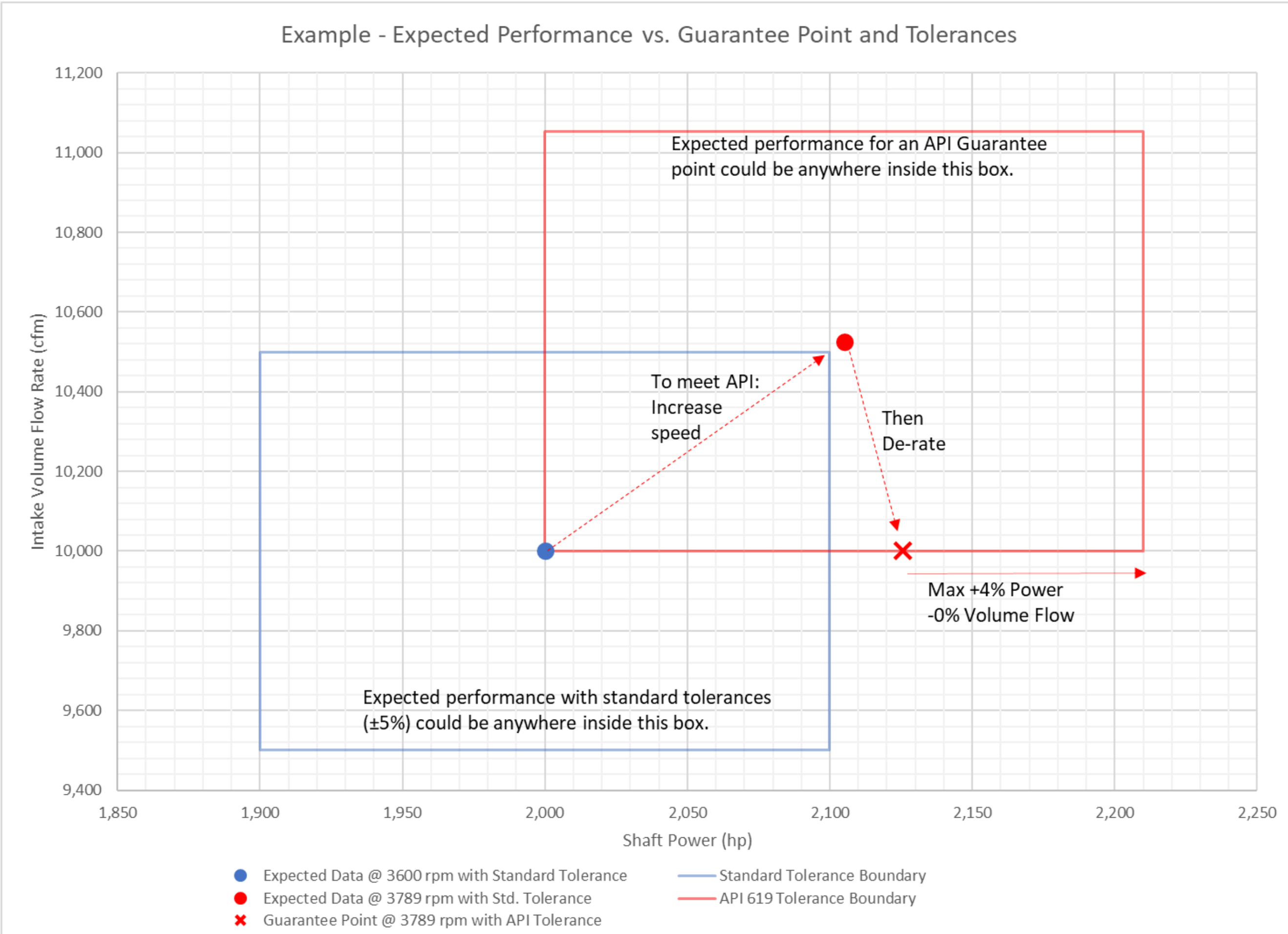


Figure A.1 Expected Performance Graph

Annex B

(Informative)

Internal and External Compression

B.1 Positive Displacement

Screw compressors are positive displacement compressors which include internal compression. Positive displacement means that a machine displaces a fixed volume of fluid per revolution. This displacement per revolution is normally defined as liters per revolution or cubic feet per revolution. In a screw compressor, this volume is based on the physical geometry of the machine, for example a compressor's rotors at its inlet condition.

B.2 Internal Compression

Internal compression means that by the time that same gas is at the discharge of the compressor, its volume has been reduced. This physical reduction in volume is a function of the vi or volume ratio of the screw compressor and causes a corresponding increase in pressure.

v_i = volume ratio = volume at suction / volume at discharge (B.1)

For example, a machine with a *vi* of 4 would have 1 liter of gas at its discharge port for every 4 liters of gas at its inlet port.

B.3 Screw compressors

Screw compressors are positive-displacement compressors which include internal compression. The physical reduction in volume is a function of v_i or volume ratio of screw compressor and causes a corresponding increase in pressure.

This reduction in volume can be related to the internal Pressure Ratio of the machine by the following formula:

$$\pi_i = v_i^{\,k} \qquad \text{(B.2)}$$

where:

π_i = internal pressure (compression) ratio

k = kappa = c_p/c_v for the gas mixture

$\pi_i = P_{2abs\_internal} / P_{1abs\_internal}$

Typical nominal π_i ratio for oil-free (dry) screw compressors ranges from 1.8 to 4.

Typical v_i for oil-flooded screw compressors ranges from 2 to 5.5.

Fig B.1 Graphics Pending

Figure B.1 - Compression Process

Table B.1
Ideal π_i as a function of v_i and k

π_i		k (c_p/c_v or adiabatic exponent)					
		1.1	1.2	1.3	1.4	1.5	1.6
	2	2.14	2.30	2.46	2.64	2.83	3.03
	2.5	2.74	3.00	3.29	3.61	3.95	4.33
	3	3.35	3.74	4.17	4.66	5.20	5.80
v_i	3.5	3.97	4.50	5.10	5.78	6.55	7.42
	4	4.59	5.28	6.06	6.96	8.00	9.19
	4.5	5.23	6.08	7.07	8.21	9.55	11.10
	5	5.87	6.90	8.10	9.52	11.18	13.13

B.4 Under-compression and Over-compression

In practice, the actual process conditions rarely match the internal physical design of the machine exactly. This leads to under-compression or over-compression. Under-compression is when the internal compression ratio is less than the external (process) pressure ratio. Over-compression is when the internal compression ratio is more than the external (process) pressure ratio.

The curved line in Figure B.2 represents an ideal adiabatic compression process. The deviations above or below the line, when $\pi \neq \pi_i$, are part of an isochoric (constant volume) compression process.

Fig B.2 Graphics Pending

Figure B.2 – Screw Compressor p-V Diagram under different working pressure conditions

This isochoric compression above and below the ideal adiabatic p-V curve is inherently less efficient. The shaded area represents lost work. The difference in internally generated pressure vs. discharge pressure can also lead to increased pulsation, vibration, and noise. Over-compression in particular can be quite damaging when it is extreme. See API 688 for reference.

B.5 Rotary Lobe Blowers

Rotary lobe blowers like the example in Figure B.3 are also positive displacement machines, but they don't have internal compression. The trapped volume of gas remains the same as it is moved from the suction side to the discharge side. One hundred percent (100%) of the compression done by a rotary lobe blower is considered external compression. It occurs by increasing the volume of the gas into the discharge line (isochoric compression) rather than by increasing its pressure (adiabatic compression).

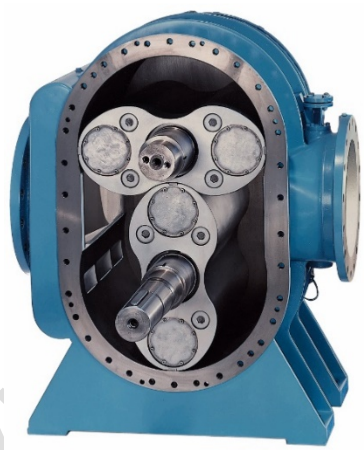


Figure B.3 – Rotary Lobe Blower

With no restriction on the discharge of a rotary lobe blower, no pressure is generated. The amount of pressure generated is dependent solely on the downstream pressure or flow restriction. Figure B.4 shows the working principle while Figure B.5 shows the p-V diagram and Figure B.6 shows the operation principle.

While it's called 'external' compression because it is dependent on external sources, the pressure increase occurs inside the rotary lobe blower's casing. Once the rotors are closed to the suction but open to the discharge, gas at discharge pressure comes rushing into the machine to fill the volume between the rotors and housing. As the blower rotates, that gas is then pushed out of the blower casing.

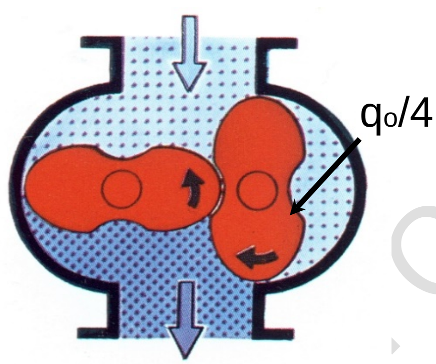


Figure B.4 – Rotary Lobe Blower Working Principle

Fig B.5 Graphics Pending

Figure B.5 – Rotary Lobe Blower p-V diagram

In Figures B.4 and B.5:

q_0 = displacement per revolution

Q_0 = theoretical volume flow rate ($Q_0 = q_0 * n$ = displacement/revolution * speed)

Q_v = internal slippage due to clearances

Q_1 = inlet volume flow rate = $Q_0 - Q_v$

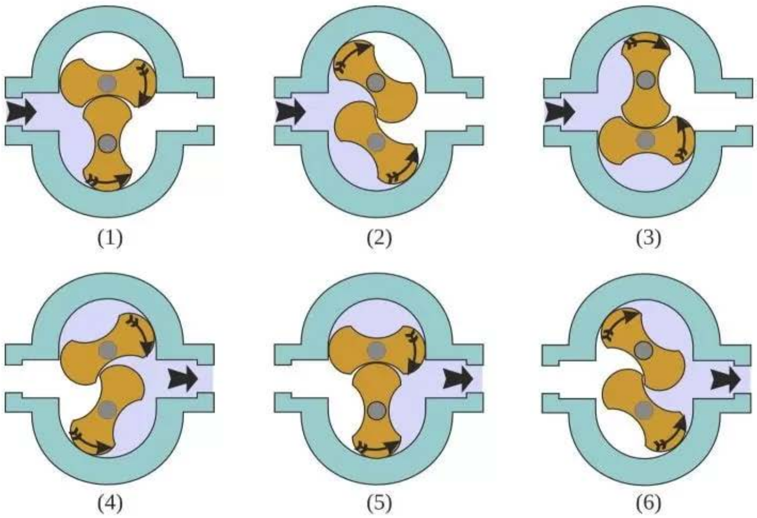


Figure B.6 – Principle of Operation for Rotary Lobe Machines

Internal and external compression notes:

Oil-free (dry) screw compressors are typically described/defined by a nominal PI (π_i). This is based on their actual v_i and assumes a kappa of 1.4. For other gases, the actual π_i will vary. To calculate actual internal pressure (compression) ratio for anything other than air or N2, you would first need to calculate their actual v_i using a c_p/c_v of 1.4. Then calculate their π_i from that v_i based on the actual gas composition.

Oil-flooded screw compressors are typically described/defined by their v_i volume ratio. Volume ratios are defined by a fixed ratio of volumes based on the design of the compressor casing and porting vs. rotors. When an oil-flooded screw compressor offers a variable vi, the location and/or shape of the discharge port can be varied to change the calculated volume ratio. This occurs independently of the operation of the slide valve. On a compressor with slide valve and a fixed v_i, the v_i varies as the slide valve moves. Figure B.7 shows a slide valve.

Fig B.7 Graphics Pending

Figure B.7 - Oil-flooded slide valve showing radial Vi cutout

Up to this point, everything has been purely theoretical. In real life, there are differences in rotor filling ability vs. speed (Volumetric Efficiency), pressure drops inside the machine and accessories, slippage past the lobes, gases that change their c_p/c_v as they're compressed, liquids being injected, variable vi, etc. These make the detailed modeling more complicated, but the basic concept remains the same. As a result, the optimum π_i or v_i for any given project may not match the theoretical 'ideal'.

The following topics are not discussed above in terms of their impact on internal compression. These can be quite complicated, vary by machine design, and vary by process.

- Impact of 2-phase flow (oil, water, or process condensates)
  - v_i is based on the starting and ending volume of gas. Incompressible fluid changes the calculation of gas volume at inlet and discharge.
  - Location of oil/water/liquid injection ports or liquid ingress into process
  - Phase changes (evaporation or condensation)
- Impact of non-ideal gases (compressibility)
- Polymerization or other reactions during compression process
- Economizer ports, SOC ports, pre-inlet ports, or other side-stream flows between the inlet and discharge of the compressor or blower.
  - These in-effect 'super-charge' the gas by adding a cool, higher pressure gas stream part-way through the compression process. This effect can be used to increase pressure ratio or to increase effective capacity.

- Port location varies depending on type of port, machine design, and process requirements.
- Pressure at this port varies by machine design (port location radially and axially, v_i), inlet pressure, and c_p/c_v. Some machines may use multiple ports at different locations (pressures).

Liquid refrigerant injection is also possible.

Annex C
(Informative)

Materials and their specifications for rotary compressors

CAUTION — Table C.1 is intended as a general guide. See 6.11.1.1 and 6.11.1.2. Table C.1 should not be used without a knowledgeable review of the specific services involved.

Table C.1 — Materials and their specifications for rotary compressors

Component	Material	US Specification	EN Specification	JIS Specification	Material application RB = rotary blowers DS = dry screw OF = oil-flooded	Form	Temperature limits of materials[a]			
							°C		°F	
							Min.	Max.	Min.	Max.
Casing (cast)	Gray iron [1]	ASTM A48 class 30 or ASTM A278 class 30	EN 1561, GJL-200 / 5.1300		OF & DS & RB	Cast	– 10	300	14	572
	Gray iron [1]	ASTM A48 class 35 or ASTM A278 class 40	EN 1561, GJL-250 / 5.1301	JIS G 5501 FC250	OF & DS & RB	Cast	– 10	300	14	572
	Gray iron [1]	ASTM A48 class 45	EN 1561, GJL-300 / 5.1302	JIS G 5501 FC300	OF & DS	Cast	– 10	232	14	450
	Gray iron [1]	ASTM A48 class 50	EN 1561, GJL-350 / 5.1303	JIS G 5501 FC350	OF	Cast	– 10	232	14	450
	Ductile iron [2]	ASTM A395 grade 60-40-15	EN 1563, GJS-400-15 / 5.3105	JIS G 5502 FCD400	OF & DS & RB	Cast	– 10	300	14	572
	Ductile iron [2]	ASTM A395 or A536 grade 60-40-18	EN 1563, GJS-400-18-RT / 5.3104	JIS G 5502 FCD400	OF & DS & RB	Cast	– 20	300	– 4	572
	Ductile iron [2]	A395/A536 grade 60-40-18 with LT impact test	EN 1563, GJS-400-18-LT / 5.3103		OF & DS & RB	Cast	– 60	300	– 76	572
	Ductile iron [2]	ASTM A536 grade 70-50-05	EN 1563, EN-GJS-500-7 / 5.3200	JIS G 5502 FCD500	RB	Cast	– 10	300	14	572
	Steel	ASTM A216 grade WCB	EN 10213-1, GP240 GH / 1.0619		OF & DS & RB	Cast	– 29	300	– 20	572
	Steel	ASTM A352 grade LCB	SEW 685, GS-21Mn5 / 1.1138	JIS G 5152 SCPL1	OF & DS & RB	Cast	– 60	343	– 76	649
	Steel	ASTM A352 grade LC1		JIS G 5152 SCPL11	OF & DS & RB	Cast	– 60	350	– 76	662
	Steel	ASTM A352 grade LC2		JIS G 5152 SCPL21	OF & RB	Cast	– 75	200	– 103	392

	Steel	ASTM A352 grade LC3		JIS G 5152 SCPL31	OF & RB	Cast	– 100	200	– 148	392
	Steel	ASTM A352 grade LCC		JIS G 5202 SCW480	OF & DS	Cast	– 29	399	– 20	750
	Stainless steel	SAE type 304L		JIS G 5121 SCS13	DS & RB	Cast	– 196	350	– 321	662
	Stainless steel	SAE type 316		JIS G 5121 SCS14	DS & RB	Cast	– 196	350	– 321	662
	Stainless steel	ASTM A743 or A744 grade CA6NM	EN 10283, GX4CrNi13-4 / 1.4317	JIS G 5121 SCS5/13Cr-4Ni	DS & RB	Cast	– 196	350	– 321	662
	Stainless steel	ASTM A351 grades CF3, CF3M, CF8, CF8M, CF8C	EN 10213, GX5CrNiNb19-11 / 1.4552		DS & RB	Cast	– 200	345	– 328	653
	Stainless steel	ASTM A351 grade CF8MC	EN 10213, GX5CrNiMoNb 19-11-2 / 1.4581		DS & RB	Cast	– 200	345	– 328	653
	Stainless steel	ASTM A995, Grade 4A			RB	Cast	—	—	—	—
	Stainless steel	ASTM A995, Grade 6A			RB	Cast	—	—	—	—
Shaft [3]	Ductile iron [2]			JIS G 5502 FCD700	OF	Cast	– 29	350	– 20	662
	Steel	SAE 1030	EN 10083-1, C30	JIS G 4051 S30C	OF & DS	Forged	– 29	450	– 20	842
	Steel	SAE 1045	EN ISO 68301, C45+N / 1.0503	JIS G 4051 S45C	OF & DS & RB	Forged	– 29	450	– 20	842
	Steel	SAE 1055	EN 10083-2, C55 / 1.0535	JIS G 4051 S55C	OF	Forged	– 10	450	14	842
	Steel	ASTM A350 LF2			OF & RB	Forged	– 45		– 49	
	Steel	ASTM A668 class D - 1030 carbon steel			DS	Forged	– 29	399	– 20	750
	Steel	SAE 4130	EN 10083, 25CrMo4	JIS G 4105 SCM430	DS & RB	Forged	– 30	400	– 22	752
	Steel	SAE 4140	EN 10083-1, 40CrMo4 / 1.7525		RB	Forged	—	—	—	—
	Steel	SAE 4140 / 4142	EN 10083, 42CrMo4 / 1.7225		DS & RB	Forged	—	—	—	—
	Steel	ASTM 829M / SAE 4340	BS970 / 1.6582		RB	Forged	—	—	—	—
	Steel	SAE 1137			OF	Forged	—	—	—	—
	Stainless steel	ASTM A473, SAE type 304L		JIS G 3214 SUS304	DS & RB	Forged	– 196	400	– 321	752
	Stainless steel	ASTM A473, SAE type 316L		JIS G 3214 SUS316	DS & RB	Forged	– 196	400	– 321	752
	Stainless steel	ASTM A479 class 1, SAE type 410			DS & RB	Bar	– 59	345	– 75	650
	Stainless steel	ASTM A182 grade F6NM, SAE type 415	EN 10088-1, X3CrNiMo 13-4 / 1.4313	JIS G 3214 SUS F6NM/13Cr-4Ni	DS & RB	Forged	– 105	300	– 157	572
	Stainless steel	ASTM A473, SAE type 431	EN 10283, X17CrNi16-2 / 1.4057		DS & RB	Forged	—	—	—	—
	Stainless steel	SAE 405		JIS G 3214 SUS405	DS	Forged	– 10	400	14	752
Rotor body / lobes (cast)	Gray iron [1]	ASTM A48 class 30	EN 1561, GJL-200 / 5.1300		RB	Cast	– 10	300	14	572
	Gray iron [1]	ASTM A278 class 40	EN 1561, GJL-250 / 5.1301	JIS G 5501 FC250	RB	Cast	– 10	300	14	572

	Ductile iron [2]	ASTM A395 grade 60-40-15	EN 1563, GJS-400-15 / 5.3105	JIS G 5502 FCD400	RB	Cast	– 10	300	14	572
	Ductile iron [2]	ASTM A395 or A536 grade 60-40-18	EN 1563, GJS-400-18-LT / 5.3103	JIS G 5502 FCD400	RB	Cast	– 20	300	– 4	572
	Ductile iron [2]	ASTM A536 grade 70-50-05	EN 1563, EN-GJS-500-7 / 5.3200	JIS G 5502 FCD500	RB	Cast	– 10	300	14	572
	Ductile iron [2]			JIS G 5502 FCD600	OF	Cast	– 29	260	– 20	500
	Ductile iron [2]			JIS G 5502 FCD700	OF	Cast	– 29	350	– 20	662
	Steel	ASTM A216 grade WCB	EN 10213-1, GP240 GH / 1.0619		RB	Cast	– 10	300	14	572
	Steel	ASTM A352 grade LCB	SEW 685, GS-21Mn5 / 1.1138		RB	Cast	– 60	343	– 76	649
	Stainless steel	ASTM A743 or A744 grade CA6NM	EN 10283, GX4CrNi13-4 / 1.4317		RB	Cast	– 60	345	– 76	653
	Stainless steel	ASTM A351 grade CF8C	EN 10213, GX5CrNiNb19-11 / 1.4552		RB	Cast	– 105	300	– 157	572
Rotor body / lobes (forged)	Steel	SAE 1030	EN 10083-1, C30	JIS G 4051 S30C	OF & DS	Forged	– 10	450	14	842
	Steel	SAE 1045	EN ISO 68301, C45+N / 1.0503	JIS G 4051 S45C	OF & DS & RB	Forged	– 60	450	– 76	842
	Steel	SAE 1055	EN 10083-2, C55 / 1.0535	JIS G 4051 S55C	OF	Forged	– 10	450	14	842
	Steel	ASTM A519/5120	EN 10084, 20MnCr5 / 1.7147		OF	Forged	—	—	—	—
	Steel	SAE 4130	EN 10083, 25CrMo4	JIS G 4105 SCM430	OF & DS	Forged	– 30	400	– 22	752
	Steel	SAE 4140 / 4142	EN 10083, 42CrMo4 / 1.7225		DS	Forged	—	—	—	—
	Steel	ASTM A350 LF2			OF & RB	Forged	– 45	149	– 49	300
	Steel	ASTM A668 class D - 1030 carbon steel			DS	Forged	– 29	399	– 20	750
	Steel			JIS G 3221 SFCM 930S	OF	Forged	– 29	399	– 20	750
	Steel	SAE 1137			OF	Forged	—	—	—	—
	Stainless steel	ASTM A473, SAE type 304L		JIS G 3214 SUS304	DS & RB	Forged	– 196	400	– 321	752
	Stainless steel	ASTM A473, SAE type 316L		JIS G 3214 SUS316	DS & RB	Forged	– 196	400	– 321	752
	Stainless steel	ASTM A479 class 1, SAE type 410			DS	Bar	– 59	345	– 75	650
	Stainless steel	SAE type 420	EN 10283, X20Cr13 / 1.4021			Forged	—	300	—	572
	Stainless steel	ASTM A473, SAE type 431	EN 10283, X17CrNi16-2 / 1.4057		DS & RB	Forged	—	300	—	572
	Stainless steel	ASTM A182 grade F6NM	EN 10088-1, X3CrNiMo 13-4 / 1.4313	JIS G 3214 SUS F6NM/13Cr-4Ni	DS & RB	Forged	– 105	300	– 157	572
	Stainless steel	ASTM A276	EN 10088-3, 1.4418		DS	Forged	—	—	—	—
	Stainless steel			JIS G 3214 SUS 405	DS	Forged	– 10	400	14	752
Pulsation devices	Ductile iron [2]	ASTM A395 or A536 grade 60-40-18	EN 1563, GGG 40.3 / GJS-400-18-LT	JIS G 5502 FCD400	DS	Cast	– 20	300	– 4	572

	Steel	ASTM A516-60			DS	Plate	—	—	—	—
	Steel	ASTM A516-70 made to A 593			OF & DS	Plate	– 46b	—	– 50b	—
	Steel	ASTM A105			OF & DS	Forged	– 29	—	– 20	—
	Steel	ASTM A106B			OF & DS	Pipe	– 29	—	– 20	—
	Steel	ASTM A516 grade 70			DS	Plate	– 46	—	0	—
				JIS G 3103 SB410	OF & DS	Plate	0	350	32	662
				JIS G 3103 SB480	OF & DS	Plate	0	350	32	662
	Steel		EN 10025 (all parts) S235JRG2-1	JIS G 3106 SM400B	OF & DS	Plate	– 10	400	14	752
	Steel	ASTM A216 grade WCB	EN 10213-1, GP240 GH / 1.0619		DS	Cast	– 10	300	14	572
	Steel		EN 10216 (all parts) P265 GH/HII		DS	Plate	– 10	400	14	752
	Steel			JIS G 3115 SPV235	OF & DS	Plate	– 10	350	14	662
	Steel			JIS G 3115 SPV315	OF & DS	Plate	– 10	350	14	662
	Steel			JIS G 3454 STPG370-S	OF & DS	Pipe	– 10	350	14	662
	Stainless steel	ASTM A213 TP316L			DS	Plate	—	—	—	—
	Stainless steel	ASTM A312 type 316			OF & DS	Pipe	– 195	—	– 320	—
	Stainless steel	ASTM A312 type 304		JIS G 4304 SUS304	OF & DS	Pipe	– 196	400	– 321	752
	Stainless steel	ASTM A240 - type 316			DS	Plate	– 195	—	– 320	—
	Stainless steel	ASTM A333 - grade 6			DS	Pipe	– 46	—	– 50	—
	Stainless steel		EN 10088 (all parts) X5CrNi18-10		DS	Plate	– 196	400	– 321	752
	Stainless steel		EN 10088 (all parts) X5CrNiMo17-12-2		DS	Plate	– 196	400	– 321	752
	Stainless steel		EN 10088 (all parts) X6CrNiMoTi17-12-2		DS	Plate	– 196	400	– 321	752
	Stainless steel		EN 10088 (all parts) X6CrNiTi18-10		DS	Plate	– 10	400	14	752
	Stainless steel		EN 10213 (all parts) GX3 CrNiMo13-4		DS	Cast	– 105	300	– 157	572
	Stainless steel			JIS G 4304 SUS316	OF & DS	Plate	– 196	400	– 321	752

a The operating temperature limits of the compressor may be different, but shall be within the temperature limits of the materials.

b Shall be impact tested for the operating temperature.

Notes:

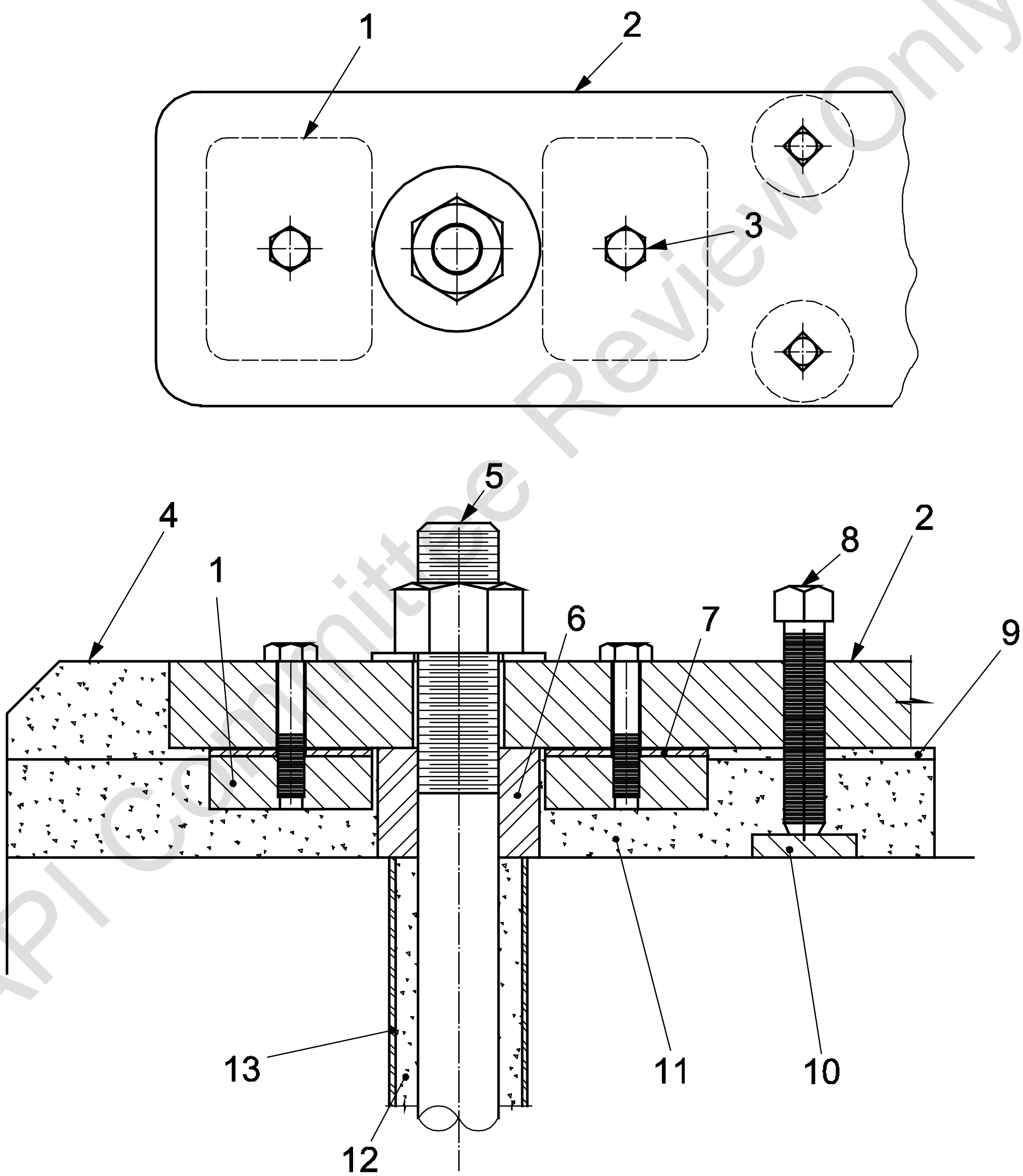
All These material grades may not be exact interchanges, but are intended to be equivalent. Slight variations will exist.

All	Opertaing limits and materials will vary by manufacturer.
1	Grey cast iron is used extensively in refrigeration compressors, upstream VRUs, and air blowers/compressors. Limited ductility at all temperatures. This is why it's not allowed by API 619 and EN 1012-3 for flammable or toxic gases.
2	Ductile iron is not the same as grey cast iron. It has material properties similar to cast steel, but often better casting quality. It is the minimum required by API 619 for flammable and toxic gas in our current markup of 5.2.8. It is also the minimum required to satisfy EN 1012-3.
3	For any single piece cast or forged rotors, the shafts are integral with the rotor body/lobes. The materials here are only shown for when the shafts are separate from the rotor bodies/lobes.
All	Consider removing all material temperature limits. List only allowable materials.

Annex D
(informative)

Typical mounting-plate arrangements

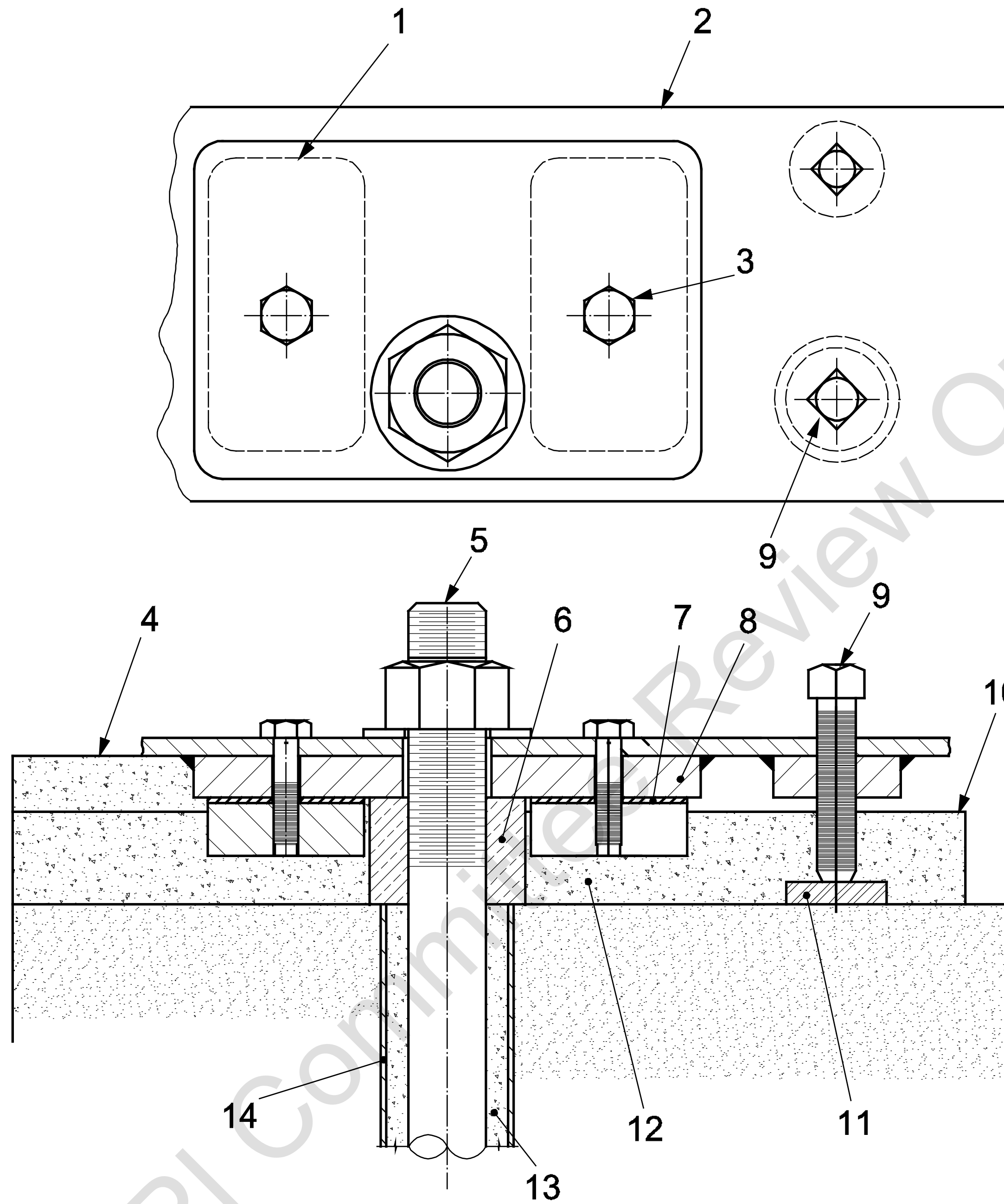
The figures in this annex show the arrangement for soleplates (Figure D.1) and baseplates (Figure D.2).



Key

1 subplate
2 mounting plate
3 capscrew
4 optional full-bed grout level
5 anchor bolt
6 anchor-bolt-sleeve grout seal
7 shims
8 levelling jackscrew
9 grout level for shim access
10 levelling plate
11 epoxy grout
12 non-bonding fill
13 anchor-bolt sleeve

Figure D.1 — Typical mounting-plate arrangement — Soleplate with subplate



Key

1 subplate
2 baseplate beam
3 capscrew
4 optional full-bed grout level
5 anchor bolt
6 anchor-bolt-sleeve grout seal
7 shims
8 baseplate mounting pad
9 levelling jackscrew
10 grout level for shim access
11 levelling plate
12 epoxy grout
13 non-bonding fill
14 anchor-bolt sleeve

Figure D.2 — Typical mounting-plate arrangement — Baseplate with subplate

Annex E
(Informative)

Contract Documents and Engineering Design Data

E.1 [●] If specified by the purchaser in 9.1.2, the contract documents and engineering design data shall be supplied by the vendor, as listed in this annex.

E.2 The information to be furnished by the vendor is specified in 8.1, 8.2 and 8.3.

E.3 The data shall be identified on transmittal (cover) letters, title pages and in title blocks or another prominent position on drawings, with the following information:

a) purchaser's/owner's corporate name;

b) job/project number;

c) equipment item number and service name;

d) inquiry or purchase order number;

e) any other identification specified in the inquiry or purchase order;

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

E.4 [●] If specified, a coordination meeting shall be held, preferably at the vendor's plant, 4 to 6 weeks after order commitment.

E.5 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, sub-vendor items and lines of communication;

b) datasheets;

c) applicable specifications and previously agreed exceptions;

d) schedules for the transmission of data, production and testing;

e) quality assurance programme and procedures;

f) inspection, expediting and testing;

g) schematics and bills of materials for auxiliary systems;

h) physical orientation of the equipment, piping and auxiliary systems, including access for operation and maintenance;

i) coupling selection and rating;

j) thrust- and journal-bearing sizing, estimated loadings and specific configurations;

k) seal operation and controls;

l) rotor dynamic analyses (lateral, torsional and transient torsional, as required);

m) equipment performance, alternative operating conditions, start-up, shutdown and any operating limitations;

n) scope and details of any pulsation or vibration analysis;

o) instrumentation and controls;

p) identification of items requiring design reviews;

q) inspection, related acceptance criteria and testing;

r) expediting;

s) other technical items.

E.6 Proposals

E.6.1 General

E.6.1.1 The vendor shall forward the original proposal, with the specified number of copies, to the addressee specified in the inquiry documents.

E.6.1.2 The proposal shall include, as a minimum, the data specified in E.6.2 to E.6.4, and a specific statement that the equipment and all its components and auxiliaries are in strict accordance with this part of API 619.

E.6.1.3 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.

E.6.1.4 The vendor shall provide sufficient detail to enable the purchaser to evaluate any proposed alternative designs. All correspondence shall be clearly identified in accordance with E.3.

E.6.2 Drawings

E.6.2.1 The drawings indicated on the vendor drawing and data requirements (VDDR) form (see example in Annex I) shall be included in the proposal. As a minimum, the following shall be included:

a) general arrangement or outline drawing for each machine train or skid-mounted package, showing overall dimensions, maintenance-clearance dimensions, overall masses, erection masses and the largest maintenance mass for each item; the direction of rotation and the size and location of major purchaser connections shall also be indicated;

b) cross-sectional drawings showing the details of the proposed equipment;

c) schematics of all auxiliary systems including fuel, lube-oil, control and electrical systems; bills of material shall be included;

d) sketches that show methods of lifting the assembled machine or machines, packages and major components and auxiliaries. [This information may be included on the drawings specified in item a) above.]

E.6.2.2 If “typical” drawings, schematics, and bills of material are used, they shall be marked up to show the mass and dimension data to reflect the actual equipment and scope proposed.

E.6.3 Technical data

The following data shall be included in the proposal:

a) purchaser’s datasheets with complete vendor’s information entered thereon and literature to fully describe details of the offering;

b) predicted noise data (see 6.1.3.7);

c) vendor drawing and data requirements form (see Annex F) indicating the schedule according to which the vendor agrees to transmit all the data specified;

d) schedule for shipment of the equipment, in weeks after receipt of an order;

e) list of major wearing components, showing any interchangeability with the owner's existing machines;

f) list of spare parts recommended for start-up and normal maintenance purposes;

g) list of the special tools furnished for maintenance, including a description of each tool and its function;

h) 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;

i) complete tabulation of utility requirements, e.g. steam, water, electricity, air, gas, lube oil (including the quantity and supply pressure of the oil required and the heat load to be removed by the oil) and the nameplate power rating and operating power requirements of auxiliary drivers; approximate data shall be clearly indicated as such;

j) description of any optional or additional tests and inspection procedures for materials as required by 6.11.1.4;

k) description of any special requirements, whether specified in the purchaser's inquiry or required by this part of API 619;

l) list of machines similar to the proposed machine(s) that have been installed and operating under conditions analogous to those specified in the inquiry;

m) any start-up, shutdown or operating restrictions required to protect the integrity of the equipment;

n) list of any components that can be construed as being of alternative design, hence requiring the purchaser's acceptance;

o) for constant-speed units, the vendor shall outline the procedure that can be followed to reduce power consumption in the event that excess pressure or flow is developed;

p) vendor list of all required relief valves, clearly indicating those furnished by the vendor;

q) for flooded screw compressors, the vendor shall state retention time, maximum and minimum liquid levels and capacity in the separator vessel.

E.6.4 Performance Data

The vendor shall provide complete performance data to encompass the range of operations, with any limitations indicated thereon. For constant-speed equipment, refer to the operating point on the data sheet.

E.6.5 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.

E.7 Contract data

E.7.1 General

E.7.1.1 Contract data shall be furnished by the vendor in accordance with the agreed VDDR form; see example in Annex F.

E.7.1.2 Each drawing shall have a title block in the lower right-hand corner with the date of certification, the identification data specified in 8.1.2, revision number and date and title. Similar information shall be provided on all other documents including sub-vendor items.

E.7.1.3 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.

E.7.1.4 After the data have been reviewed and accepted, the vendor shall furnish certified copies in the quantities specified.

E.7.1.5 A complete list of vendor data shall be included with the first issue of major drawings.

a) This list shall contain titles, drawing numbers, and a schedule for transmittal of each item listed.

b) This list shall cross-reference data with respect to the VDDR form in Annex I.

E.7.2 Drawings and technical data

E.7.2.1 The drawings and data furnished by the vendor shall contain sufficient information so that, together with the manuals specified in 8.3.5, the purchaser can properly install, operate and maintain the equipment covered by the purchase order.

E.7.2.2 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 (see example in Annex I), and shall satisfy the applicable detailed descriptions.

E.7.3 Progress reports

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

NOTE Refer to F.2 oo) for content of these reports.

E.7.4 Parts lists and recommended spares

E.7.4.1 The vendor shall submit complete parts lists for all equipment and accessories supplied.

E.7.4.2 These lists shall include part names, manufacturers' unique part numbers, materials of construction (identified by applicable International Standards).

E.7.4.3 Each part shall be completely identified and shown on appropriate cross-sectional, assembly-type cutaway or exploded-view isometric drawings.

E.7.4.4 Interchangeable parts shall be identified as such. Parts that have been modified from the standard dimensions or finish to satisfy specific performance requirements shall be uniquely identified by part number.

E.7.4.5 Standard purchased items shall be identified by the original manufacturer's name and part number.

E.7.4.6 The vendor shall indicate on each of these complete parts lists all those parts that are recommended as start-up or maintenance spares, and the recommended stocking quantities of each.

E.7.4.7 These should include spare parts recommendations of sub-suppliers that were not available for inclusion in the vendor's original proposal.

E.7.5 Installation, Operation, Maintenance and Technical-data Manuals

E.7.5.1 General

E.7.5.1.1 The vendor shall provide sufficient written instructions and all necessary drawings to enable the purchaser to install, operate, and maintain all the equipment covered by the purchase order.

E.7.5.1.2 This information shall be compiled in a manual or manuals with a cover sheet showing the information listed in 8.1.2, an index sheet and a complete list of the enclosed drawings by title and drawing number.

E.7.5.1.3 The manual or manuals shall be prepared specifically for the equipment covered by the purchase order. "Typical" manuals are unacceptable.

E.7.5.2 Installation manual

E.7.5.2.1 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 the final certified drawings. For this reason, it may be separate from the operating and maintenance instructions.

E.7.5.2.2 This manual shall contain information on alignment and grouting procedures, normal and maximum utility requirements, centres of mass, rigging provisions and procedures and all other installation data.

E.7.5.2.3 All drawings and data specified in 8.2.2 and 8.2.3 that are pertinent to proper installation shall be included as part of this manual; see also description in F.2 ll).

E.7.5.3 Operating and maintenance manual

E.7.5.3.1 A manual containing all required operating and maintenance instructions shall be supplied not later than 2 weeks after all specified tests have been successfully completed.

E.7.5.3.2 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; see also description in F.2 mm).

E.7.5.4 Technical-data manual

[●] If specified, the vendor shall provide the purchaser with a technical data manual within 30 days of completion of shop testing; see description in F.2 ss).

Annex F

(informative)

Typical vendor drawing and data requirements

F.1 General

This annex consists of a distribution record (schedule), followed by a representative description of the items that are presented alpha-numerically in the schedule.

Rotary-type positive-displacement compressor vendor drawing and data requirements	Job No.	Item No.
	Page _1_ of _2_	By
	Date	Rev No.

Proposal [a] Bidder shall furnish _______ copies of data for all items indicated by an X.

Review [b] Vendor shall furnish _______ copies and _______ transparencies of drawings and data as indicated.

Final [b] Vendor shall furnish _______ copies and _______ transparencies of drawings and data as indicated.
Vendor shall furnish _______ operating and maintenance manuals.

Distribution Record

Final – Received from vendor
Due from vendor [c]
Review – Returned to vendor
Review – Received from vendor
Review – Due from vendor [c]

Proposal [a]	Review [b]	Final [b]	**Document**	Review – Due from vendor [c]	Review – Received from vendor	Review – Returned to vendor	Due from vendor [c]	Final – Received from vendor
			a. Certified dimensional outline drawing and list of connections					
			b. Cross-sectional drawings and bill of materials					
			c. Rotor-assembly drawings and bill of materials					
			d. Thrust-bearing-assembly drawing and bill of materials					
			e. Journal-bearing-assembly drawings and bill of materials					
			f. Seal-assembly drawing and bill of materials					
			g. Coupling-assembly drawing and bill of materials					
			h. Seal-oil schematic and bill of materials					
			i. Seal-oil-assembly drawing and list of connections					
			j. Seal-oil-component drawing and data					
			k. Lube-oil/control-oil schematic and bill of materials					
			l. Lube-oil-system assembly and arrangement drawings					
			m. Lube-oil-component drawings and data					
			n. Oil-separator-vessel arrangement					
			o. Injection-system schematic					
			p. Electrical and instrumentation schematics and bill of materials					
			q. Electrical and instrumentation arrangement drawing and list of connections					
			r. Inlet capacity, power, and discharge temperature versus compression ratio and speed					
			s. Starting torque versus speed					
			t. Vibration-analysis data					
			u. Lateral critical-speed analysis report					
			v. Torsional critical-speed analysis report					
			w. Transient torsional critical-speed analysis report					
			x. Allowable flange loadings					
			y. Coupling alignment diagram					

[a] It is not necessary that proposal drawings and data be certified or as-built.

[b] Purchaser shall indicate in this column the time frame for submission of materials using the nomenclature given at the end of this form.

[c] Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

Rotary-type positive-displacement compressor vendor drawing and data requirements	Job No.	Item No.
	Page _2_ of _2_	By
	Date	Rev No.

Proposal [a] Bidder shall furnish _______ copies of data for all items indicated by an X.

Review [b] Vendor shall furnish _______ copies and _______ transparencies of drawings and data as indicated.

Final [b] Vendor shall furnish _______ copies and _______ transparencies of drawings and data as indicated.
Vendor shall furnish _______ operating and maintenance manuals.

Distribution Record

Final – Received from vendor
Due from vendor [c]
Review – Returned to vendor
Review – Received from vendor
Review – Due from vendor [c]

Proposal	Review	Final	**Document**	Review – Due from vendor	Review – Received from vendor	Review – Returned to vendor	Due from vendor	Final – Received from vendor
			z. Weld procedures					
			aa. Certified pressure test logs					
			bb. Mechanical running test logs					
			cc. Performance test logs					
			dd. Rotor balancing logs					
			ee. Rotor mechanical and electrical runout					
			ff. As-built datasheets					
			gg. As-built dimensions and/or data					
			hh. Silencer drawings and data					
			ii. Intercoolers/aftercoolers drawings and data					
			jj. Non-destructive test procedures and acceptance criteria					
			kk. Procedures for special and optional tests (see 7.3.4)					
			ll. Installation manual					
			mm. Operating and maintenance manuals					
			nn. Spare parts recommendation					
			oo. Engineering, fabrication and delivery schedule (progress reports)					
			pp. List of drawings					
			qq. Shipping list					
			rr. List of special tools furnished for maintenance					
			ss. Technical data manual					
			tt. Materials Safety Datasheets					
			uu. Preservation, packaging, and shipping procedures					
			vv. Bearing babbitt strength versus temperature curves					

[a] It is not necessary that proposal drawings and data be certified or as-built.
[b] Purchaser shall indicate in this column the time frame for submission of materials using the nomenclature given at the end of this form.
[c] Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

Permission to proceed with manufacture without purchaser's review of drawings (if granted) should be stated in the purchase order.

NOTE For a detailed explanation of drawing and data requirements, see Clause F.2.

Address for shipment of all drawings and data: ______________________________

____

____

Nomenclature:
_____ S – number of weeks prior to shipment
_____ F – number of weeks after firm order
_____ D – number of weeks after receipt of approved drawings

Vendor ______________________________
Date ______________ Vendor reference ______________
Signature ______________________________
(Signature acknowledges receipt of all instructions)

F.2 Documents

The following list describes the items that are presented alpha-numerically in F.1:

a) certified dimensional outline drawing, including

   1) size, rating, and location of all customer connections,

   2) approximate overall and handling masses,

   3) overall dimensions, maintenance clearances and dismantling clearances,

   4) shaft centerline height,

   5) dimensions of baseplates (if furnished), complete with diameter, number and locations of bolt holes and thickness of metal through which bolts must pass, and recommended clearance, centers of gravity and details for foundation design,

   6) location of silencers (if furnished),

   7) direction of rotation;

b) cross-sectional drawings and bill of materials, including

   1) journal-bearing clearances and tolerance,

   2) rotor float (axial),

   3) seal clearances (shaft and internal labyrinth) and tolerance,

   4) lobe clearances,

   5) timing gear clearances;

c) rotor-assembly drawing, including

   1) axial position from active thrust collar face to

      i) each lobe end,

      ii) each radial probe,

      iii) each journal-bearing centerline,

      iv) phase-angle notch,

      v) coupling face or end of shaft,

   2) thrust-collar assembly details, including

      i) collar-shaft fit with tolerance,

      ii) concentricity (or runout) tolerance,

      iii) required torque for locknut,

      iv) surface finish requirements for collar faces,

      v) preheat method and temperature requirements for “shrunk-on” collar installation,

   3) dimensioned shaft end(s) for coupling mounting(s),

   4) bill of materials;

d) thrust-bearing-assembly drawing and bill of materials;

e) journal-bearing-assembly drawing and bill of materials;

f) seal-assembly drawing and bill of materials;

g) coupling-assembly drawing and bill of materials, including allowable misalignment tolerances;

h) seal-oil schematic, including

   1) steady-state and transient oil flows and pressures,

   2) control, alarm and trip settings,

   3) heat loads,

   4) utility requirements, including electrical, water and air,

   5) pipe, valve and orifice sizes,

   6) instrumentation, safety devices and control schemes,

   7) control valve cv,

   8) bill of materials;

i) seal-oil-assembly drawing and list of connections; arrangement, including size, rating and location of all customer connections;

j) seal-oil component drawings and data, including

   1) for pumps and drivers:

      i) certified dimensional outline drawing,

      ii) cross-section and bill of materials,

      iii) mechanical-seal drawing and bill of materials,

      iv) completed data forms for pumps and drivers,

   2) for overhead tank, reservoir and drain tanks:

      i) fabrication drawings,

      ii) maximum, minimum and normal liquid levels,

      iii) design calculations,

   3) for coolers and filters:

      i) fabrication drawings,

      ii) completed data form for cooler(s),

   4) for instrumentation:

      i) controllers,

      ii) switches,

      iii) control valves,

      iv) gauges;

k) lube-oil/control-oil schematics and bills of materials, including

   1) steady-state and transient oil flows and pressures,

   2) control, alarm and trip settings,

   3) supply temperature and heat loads,

   4) utility requirements including electrical, water and air,

   5) pipe, valve and orifice sizes,

   6) instrumentation, safety devices and control schemes (including slide valve if applicable),

   7) control valve, cv;

l) lube-oil-assembly drawing, including size, rating, and location of all customer connections;

m) lube-oil component drawings and data, including

   1) for pumps and drivers:

      i) certified dimensional outline drawing,

      ii) cross-section and bill of materials,

      iii) mechanical seal drawing and bill of materials,

      iv) performance curves for centrifugal pumps,

      v) completed data forms for pumps and drivers,

   2) for coolers, filters, and reservoir:

      i) fabrication drawings,

      ii) maximum, minimum and normal liquid levels in reservoir,

      iii) completed data form for cooler(s),

   3) for instrumentation:

      i) controllers,

      ii) switches,

      iii) control valves,

      iv) gauges;

n) oil-separator-arrangement drawing, including

   1) outline drawing,

   2) details of internals,

   3) ASME code calculations,

o) injection-system schematic and bill of materials, including steady-state and transient flows and pressures at each use point;

p) electrical and instrumentation schematics, including

1) vibration warning and shutdown limits,

2) bearing-temperature warning and shutdown limits,

3) lube-oil-temperature warning and shutdown limits,

4) bill of materials;

q) electrical and instrumentation arrangement drawing and list of connections;

r) inlet capacity, brake horsepower and discharge temperature versus compression ratio and speed shall be shown for each casing; compressors with variable-speed drivers shall have curves for 80%, 90%, 100% and 105 % of rated speed;

s) speed-versus-torque curve, including load inertia where an electric motor driver is supplied. Both curves shall be shown on the same sheet;

t) vibration analysis data, including

1) number of lobes,

2) number of pockets,

3) number of teeth, for gears and gear-type couplings,

u) lateral critical speed analysis, including

1) method used,

2) graphic display of bearing and support stiffness and its effect on critical speeds,

3) graphic display of rotor response to unbalance,

4) graphic display of overhung moment and its effect on critical speed,

5) journal static loads,

6) stiffness and damping coefficients,

7) tilting-pad geometry and configuration, including

i) pad angle,

ii) pivot clearance,

iii) pad clearance,

iv) preload;

v) torsional critical-speed analysis, including, but not limited to, the following:

1) method used,

2) graphic display of mass-elastic system,

3) tabulation identifying the mass-moment torsional stiffness for each component in the mass-elastic system,

4) graphic display of exciting sources (revolutions per minute),

5) graphic display of torsional critical speeds and deflections (mode shape diagrams);

w) transient torsional analysis for all synchronous motor-driven units;

x) allowable flange loading(s) for all customer connections, including anticipated thermal movements referenced to a defined point;

y) alignment diagram, including cold and transient alignments and recommended misalignment limits during operation;

z) weld procedures for fabrication and repair;

aa) hydrostatic test logs and gas-leak test logs;

bb) mechanical run test logs, including, but not limited to, the following:

1) oil flows, pressures and temperatures,

2) vibration, including X-Y plot of amplitude and phase angle versus revolutions per minute during start-up and coast down,

3) bearing-metal temperatures,

4) observed critical speeds (if any),

5) if specified, tape recordings of real-time vibration data;

cc) performance test logs and report in accordance with ISO 1217;

dd) rotor-balance logs;

ee) rotor combined mechanical and electrical runout in accordance with 8.3.3.1.16;

ff) as-built datasheets;

gg) as-built dimensions and data, including

1) shaft or sleeve diameters at

i) thrust collar,

ii) each seal component,

iii) each rotor,

iv) each labyrinth,

v) each journal bearing,

2) each labyrinth bore,

3) each bushing seal component,

4) each journal-bearing inside diameter,

5) thrust-bearing axial runout,

6) thrust-bearing, journal-bearing and seal clearances,

7) metallurgy and heat treatment for

i) shafts,

ii) thrust collars,

iii) hardness readings (when H_2S is specified in process gas);

hh) silencer drawings and data, including

1) outline drawing,

2) datasheets, including dynamic-insertion losses for each octave band, pressure losses and materials of construction,

3) ASME design calculations;

ii) intercooler/aftercooler drawings and data including outline drawing;

jj) non-destructive test procedures and acceptance criteria as itemized on the purchase order datasheets or the vendor drawing and data requirements form;

kk) procedures for any special or optional tests (see 8.3.5);

ll) installation manual describing the following (see E.7.5.2):

1) storage procedures,

2) foundation plan,

3) grouting details,

4) setting equipment, rigging procedures, component masses and lifting diagrams,

5) coupling alignment diagram [per item y) above],

6) piping recommendations, including allowable flange loads,

7) composite outline drawings for the driver/driven-equipment train, including anchor-bolt locations,

8) dismantling clearances;

mm) operating and maintenance manuals describing the following:

1) start-up,

2) normal shutdown,

3) emergency shutdown,

4) operating limits, other operating restrictions and a list of undesirable speeds from zero to trip,

5) lube-oil recommendations and specifications,

6) routine operational procedures, including recommended inspection schedules and procedures,

7) instructions for

i) disassembly and reassembly of rotor in casing,

ii) rotor unstacking and restacking procedures,

iii) disassembly and reassembly of journal bearings (for tilting-pad bearings, the instructions shall include go/no-go dimensions with tolerances for three-step plug gauges),

iv) disassembly and reassembly of thrust bearing,

v) disassembly and reassembly of seals (including maximum and minimum clearances),

vi) disassembly and reassembly of thrust collar,

vii) wheel reblading procedures,

viii) boring procedures and torque values,

8) performance data, including

i) curve showing certified shaft speed versus site rated power,

ii) curve showing ambient temperature versus site rated power,

iii) curve showing output-power shaft speed versus torque,

iv) curve showing incremental power output versus water/steam-system injection rate (optional),

v) heat-rate correction factors (optional),

vi) thrust-bearing performance data,

9) vibration analysis data, per item t) to item w) above,

10) as-built data, including

i) as-built datasheets,

ii) as-built dimensions or data, including assembly clearances,

iii) hydrostatic test logs, per item aa) above,

iv) mechanical running test logs, per item bb) above,

v) rotor-balancing logs, per item dd) above,

vi) rotor mechanical and electrical runout at each journal, per item ee) above,

vii) physical and chemical mill certificates for critical components,

viii) test logs of all specified optional tests,

11) drawings and data, including

i) certified dimensional outline drawing and list of connections,

ii) cross-sectional drawing and bill of materials,

iii) rotor-assembly drawings and bills of materials,

iv) thrust-bearing-assembly drawing and bill of materials,

v) journal-bearing-assembly drawings and bills of materials,

vi) seal-component drawing and bill of materials,

vii) lube-oil schematics and bills of materials,

viii) lube-oil-assembly drawing and list of connections,

ix) lube-oil-component drawings and data,

x) electrical and instrumentation schematics and bills of materials,

xi) electrical and instrumentation assembly drawings and list of connections,

xii) governor and control- and trip-system data,

xiii) trip- and throttle-valve construction drawings;

nn) spare-parts list with stocking-level recommendations, in accordance with E.7.4;

oo) progress reports and delivery schedule, including vendor buy-outs and milestones. The reports shall include engineering, purchasing, manufacturing and testing schedules for all major components. Planned and actual dates and the percentage completed shall be indicated for each milestone in the schedule;

pp) list of drawings, including latest revision numbers and dates;

qq) shipping list, including all major components that will be shipped separately;

rr) list of special tools furnished for maintenance (see 7.9);

ss) technical-data manual, including the following:

1) as-built purchaser datasheets per item ff) above,

2) certified performance curves per item cc) above,

3) drawings in accordance with E.6.2,

4) as-built assembly clearances,

5) spare-parts list in accordance with E.7.4,

6) vibration data per item 1) above,

7) reports or diagram as per items u), v), w), y), bb), cc), dd) and ee) above,

8) API datasheets;

tt) material safety datasheets;

uu) preservation, packaging and shipping procedures;

vv) bearing babbitt strength-versus-temperature curves.

Bibliography

TBD

Petroleum, petrochemical and natural gas industries — Rotary-type positive-displacement compressors —

Part 2: Dry Screw Compressors

6th Edition Ballot Draft - March 2024

1 Scope

This part of API 619, in conjunction with requirements of API 619 Part 1, specifies minimum requirements for rotary-type positive displacement dry twin screw compressors (see Figure 1) used for vacuum or pressure or both, in special purpose applications that handle gas or process air in the petroleum, chemical, and gas industries.

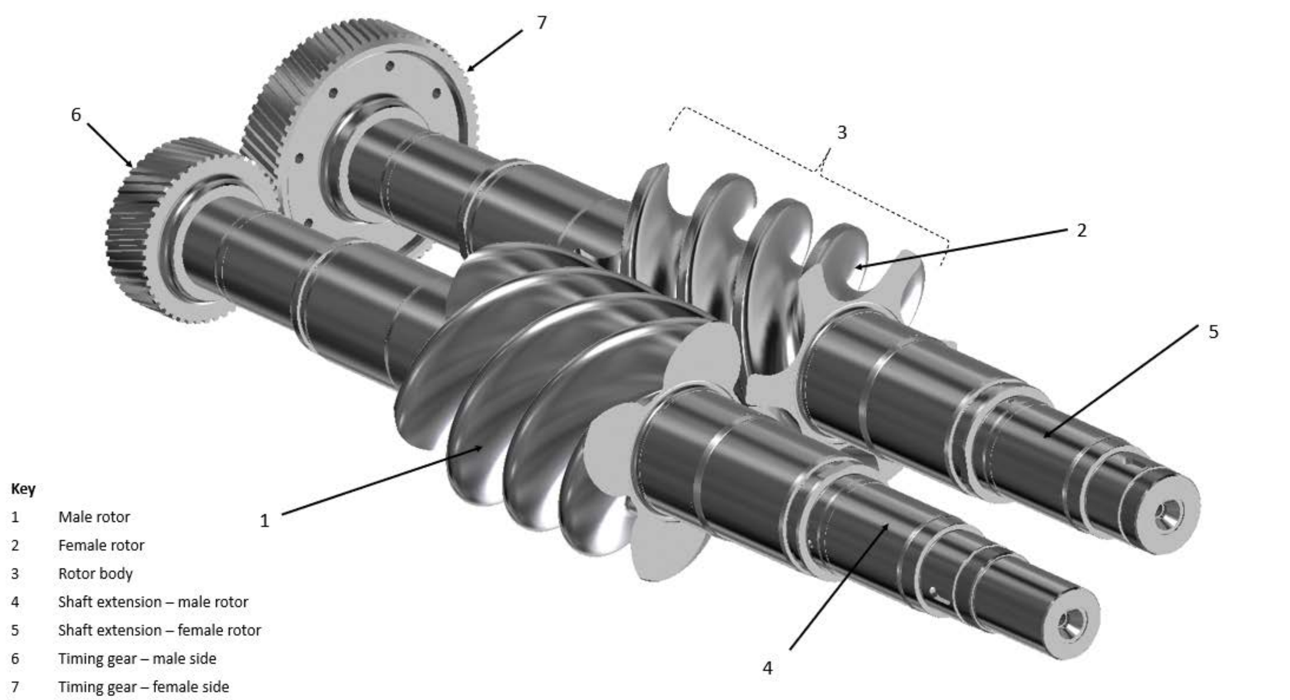


Figure 1 — Dry (Oil Free) Twin Screw compressor rotors

2 Normative references

Referenced documents indispensable for the application of this document are listed under Part 1, Section 2

3 Terms and definitions

For the purposes of this document, the terms, definitions, acronyms, abbreviations, and symbols given in Part 1, Section 3 apply.

4 Dimensions and Units

The dimensions and unit requirements of Part 1, Section 4 shall apply.

5 Requirements

5.1 Statutory Requirements

The statutory requirements in 5.1 of Part 1 shall apply.

5.2 Unit Responsibility

The unit responsibilities in 5.2 of Part 1 shall apply.

5.3 Documentation Requirements

The documentation requirements in 5.3 of Part 1 shall apply.

6 Basic Design

6.1 General

The general design requirements shall be in accordance with 6.1 of Part 1.

6.2 Pressure Casings

6.2.1 Casings shall be in accordance with 6.2 of Part 1 and the following paragraphs.

6.2.2 For dry screw compressors, system pressure protection shall be furnished at the compressor discharge.

6.2.3 [●] If specified, system pressure protection at the dry screw compressor discharge shall be furnished by supplier.

6.2.4 Pressure Casings designed for more than one maximum allowable working pressure shall not be used.

NOTE Cooling water jacket is not considered part of the pressure casing.

6.2.5 If a cooling jacket is utilized, this jacket shall have only external connections between the assembled components of the pressure casing.

6.3 Casing Appurtenances

Casing appurtenances shall be in accordance with 6.3 of Part 1.

6.4 Casing Connections

Pressure casing connections shall be in accordance with 6.4 of Part 1.

6.5 External Forces and Moments

6.5.1 As minimum, the compressor shall be designed to withstand external forces and moments on each nozzle as tabulated in Annex C.

NOTE Compressor casing allowable external nozzle loads lower than values of Annex C can be mutually agreed upon between purchaser and vendor. In such case, other measures can be utilized to reduce applied piping load to the compressor nozzles such as modified pipe support design, modified pipe route, use of expansion joint, etc.

6.5.2 The vendor shall furnish the allowable forces and moments for compressor nozzles and process tie-in points nozzles of the package in tabular form.

NOTE Silencers can require additional support.

6.5.3 Casing and supports shall be designed to have sufficient strength and rigidity to limit distortion of coupling alignment due to pressure, torque and allowable forces and moments to 50 µm (0.002 in.).

6.5.4 For applications with distortion in the supporting structure, such as offshore, the coupling distortion limit may not be limited to the above value. In that case, vendor and purchaser should mutually agree on acceptable values.

6.5.5 Expansion joints shall not be used in hazardous, flammable, or toxic service.

NOTE The use of expansion joints to limit piping forces and moments is not generally recommended. However, if used, care should be exercised in the selection and location of expansion joints to prevent possible early fatigue due to either pulsation or expansion strain or both. Expansion joints should not be used in flammable or toxic service.

6.6 Rotating Elements

6.6.1 Rotating Elements shall be in accordance with 6.6 of Part 1 and the following paragraphs.

6.6.2 Rotor bodies not integral with the shaft shall be welded to the shaft to prevent relative motion under any condition.

6.6.3 Structural welds on rotors shall be full-penetration continuous welds and shall be post-weld heat-treated, using qualified procedures and welders.

6.6.4 Rotors shall be forged steel.

6.6.5 Rotors with finished diameters less than 200 mm (8 in.) may be hot-rolled bar stock purchased to the same quality and heat treatment criteria as shaft forgings.

6.6.6 Dry screw compressor timing gears

6.6.6.1 Timing gears shall be made of forged steel.

6.6.6.2 Timing gears shall be a minimum of ISO 1328-1:1995 2013 accuracy grade 5.

NOTE For the purposes of this provision, AGMA 1328-1 is equivalent to ISO 1328-1.

6.6.6.3 Timing gears shall be of the helical type; see Figure B.1.

6.6.6.4 The timing gear ISO service factor shall be a minimum of 3.0.

6.6.6.5 The meshing relationship between gear-timed rotors shall be adjustable and the adjustment shall be arranged for positive locking.

6.6.6.6 The adjustment and locking provisions shall be accessible with the rotors in their bearings.

6.6.6.7 The gear enclosing chamber shall not be subject to contact with the gas.

6.6.6.8 Where timing gears must be removed for seal replacement, it shall be possible to retime the rotors without further disassembly of radially split casings.

6.6.6.9 Timing gears for helical lobe compressors shall have the same helix hand (right or left) as the rotors so that axial position has minimal effect on timing.

6.6.6.10 Inspection ports or other means shall be provided on the housing covers, such that timing gears may be inspected without disassembly of the unit.

6.7 Shaft Seals

6.7.1 Shaft Seals shall be in accordance with 6.7 of Part 1 and the following paragraphs.

6.7.2 Dry screw compressors with self-acting dry-gas seals and, other shaft seal types, shall have provisions for buffer gas injection to each seal.

6.7.3 Shaft seals for dry screw compressors shall be one or a combination of the following:

a) Labyrinth
b) Restrictive-ring
c) Mechanical contact seal
d) Dry-gas seal

6.8 Dynamics

6.8.1 Dynamics shall be in accordance with 6.8 of Part 1 and following paragraph.

6.8.2 Vibration limits of dry screw compressors shall be as specified in Table 1.

Table 1 — Vibration Limits for Dry Screw Compressors

	Hydrodynamic bearings[a,b,c,d]	**Rolling element bearings**[a,b]
Measurement on bearing housing		
Vibration at any speed within operating range		
— Overall	V_u < 5.0 mm/s RMS (0.2 in./s RMS)	V_u <8.0 mm/s RMS (0.3 in./s RMS)
— Increase in allowable vibrations at speeds beyond operating speed but less than trip speed	50 %	50 %
Measurement on shaft adjacent to bearing		
Overall vibration at any speed within the operating speed range	"A" shall be the lesser value of — $\sqrt{\left(1{,}03 \times 10^7/n\right)}$ µm $\left(\sqrt{\left(16\,000/n\right)}\text{ mils}\right)$ — or 50 % bearing clearance	
Increase in allowable vibration at speeds beyond operating speed but less than trip speed	50 %	

a V_u is the unfiltered velocity.

b RMS is the root mean square.

c A is the unfiltered peak-to-peak amplitude of vibration.

d n is the max. continuous speed in revolutions per minute (r/min).

6.9 Bearings and Bearing Housings

Bearings and bearing housings shall be in accordance with 6.9 of Part 1.

6.10 Lubrication

6.10.1 Bearings and bearing housings shall be designed for oil lubrication using a mineral oil in accordance with ASTM D4304 or ISO 8068 type TSA or TGA.

6.10.2 [●] If specified by the purchaser or required by the vendor, a synthetic lubrication oil shall be used.

6.10.3 If synthetic oil is required by the vendor, they shall provide a complete description of the proposed lubricant. Material compatibility with other components receiving the synthetic oil shall be confirmed.

NOTE Synthetic oils may act as solvents and dissolve coatings or attack seals.

6.10.4 [●] The purchaser may specify a preferred oil for vendor’s approval.

NOTE Users usually inventory only a limited number of oils.

6.10.5 If oil is supplied from a common system to two or more components of a machinery train (e.g. a compressor, a gear and a motor), the vendor having unit responsibility shall ensure compatibility of type, grade, pressure and temperature of oil for all equipment served by the common system.

NOTE The usual lubricant employed in a common oil system is a mineral oil that corresponds to ISO 3448:1992 Grade 32 or Grade 46

6.10.6 Lubrication system for dry screw compressors shall conform to API 614.

6.11 Materials

Materials shall be in accordance with 6.11 of Part 1.

6.12 Nameplates and rotation arrows

Nameplates and rotation arrows shall be in accordance with 6.12 of Part 1.

7 Accessories

7.1 Drivers

7.1.1 Drivers shall be in accordance with 7.1 of Part 1 and the following paragraphs.

7.1.2 Motors

Motor shall be in accordance with 7.1 of Part 1.

7.1.3 Steam Turbines

7.1.3.1 Steam turbine drivers may be furnished for dry screw compressors.

7.1.3.2 [●] Steam turbine drivers shall conform to API 611 or API 612 as specified by the purchaser.

7.1.3.3 Steam turbine drivers shall be sized (rated) to deliver continuously not less than 110 % of the maximum power requirement of the driven equipment (including any gear and coupling losses) when operating at any of the specified operating conditions and at the corresponding speed.

NOTE - The 110% applies to the design phase of the project. After testing, this margin might not be available due to performance tolerances of the driven equipment.

7.1.3.4 Steam turbine drivers shall deliver their rated power at the corresponding speed with coincident minimum inlet and maximum exhaust conditions as specified by the purchaser.

NOTE To prevent oversizing or to obtain higher operating efficiency or both, it can be desirable to limit maximum turbine capability by specifying normal power or a selected percentage of rated power instead of rated power at the minimum heat drop conditions specified.

7.1.4 Gear units

[●] External gear units shall conform to API 613 or API 677 as specified.

7.2 Adjustable Frequency Drives (AFD) and Devices

AFD’s shall be in accordance with 7.2 of Part 1.

7.3 Couplings

Couplings shall conform to API 671 and 7.2 of Part 1.

7.4 Guards

Guarding shall be in accordance with 7.3 of Part 1.

7.5 Belt Drives

Belt drives are not permitted for dry screw compressors.

7.6 Baseplates and Soleplates

Baseplate shall be in accordance with 7.6 of Part 1.

7.7 Controls and Instrumentation

Controls and instrumentation shall be in accordance with 7.7 of Part 1.

7.8 Piping

Piping shall be in accordance with 7.8 of Part 1.

7.9 Special Tools

Special tools shall be in accordance with 7.9 of Part 1.

7.10 Coatings, Insulation, and Jacketing

Insulation shall be in accordance with 7.10 of Part 1.

7.11 Enclosures

Enclosures shall be in accordance with 7.11 of Part 1.

8 Inspection, Testing and Preparation for Shipment

Inspection, testing and preparation for shipment shall be in accordance with Section 8 of Part 1.

9 Vendor's data

Vendor's data shall be in accordance with Section 9 of Part 1.

Annex A
(normative)
Dry Screw Compressor Datasheets

A representation of the datasheets is enclosed in this annex; however, MS Excel format datasheets have been developed and are available, for purchase from API publications distributors, with this standard. The MS Excel electronic datasheets can have additional functionality over printed hard copies.

ROTARY-TYPE POSITIVE DISPLACEMENT COMPRESSOR DRY SCREW DATA SHEET SI UNITS

JOB NO. ______ ITEM NO. ______ Rev

PURCHASE ORDER NO. ______ DATE ______

REQUISITION NO. ______

INQUIRY NO. ______

PAGE 1 OF 7 BY ______

APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ○ AS BUILT DATE ______ REVISION ______

FOR ______ UNIT ______

SITE ______ SERIAL NO. ______

SERVICE ______ NO. REQUIRED ______

MANUFACTURER ______ MODEL ______ DRIVER (7.1) ______

NOTE: ○ INDICATES INFORMATION TO BE COMPLETED BY PURCHASER ☐ BY MANUFACTURER

OPERATING CONDITIONS

ALL DATA ON PER UNIT BASIS	NORMAL (3.1.38) (6.1.2.1)	OTHER CONDITIONS (5.1.4) A	B	C	D	E
○ CERTIFIED POINT (6.1.1.4)						
○ GAS HANDLED (ALSO SEE PAGE 2) (6.1.2.2)						
○ REQUIRED STANDARD VOLUME FLOW Nm^3/h (1.013 bar & 0 °C) (DRY) (3.1.69)						
○ REQUIRED STANDARD VOLUME FLOW Nm^3/h (1.013 bar & 0 °C) (WET) (3.1.69)						
○ WEIGHT FLOW, kg/hr (DRY)						
○ WEIGHT FLOW, kg/hr (WET)						
INLET CONDITIONS: ○ COMPRESSOR INLET FLANGE ○ CUSTOMER CONNECTION						
○ PRESSURE - (bar a)						
○ TEMPERATURE (°C)						
○ RELATIVE HUMIDITY (%)						
○ MOLECULAR WEIGHT						
☐ Cp/Cv (K_1) (6.1.2.3)						
☐ COMPRESSIBILITY (Z_1) (6.1.2.3)						
☐ INLET VOLUME FLOW (m^3/h) (3.1.27)						
LIQUID INJECTION						
☐ LIQUID INJECTION COMPOSITION						
☐ LIQUID INJECTION WEIGHT FLOW, kg/hr						
☐ LIQUID PRESSURE						
☐ LIQUID TEMPERATURE						
DISCHARGE CONDITIONS: ○ COMPRESSOR DISCHARGE FLANGE ○ CUSTOMER CONNECTION						
○ PRESSURE - (bar a)						
☐ TEMPERATURE (°C)						
☐ Cp/Cv (K_2)						
☐ COMPRESSIBILITY (Z_2)						
☐ DEW POINT (°C)						
☐ GAS POWER (KW)						
☐ COMPRESSOR SHAFT POWER (KW)						
☐ POWER REQUIRED AT DRIVER (ALL LOSSES INCL) (KW)						
☐ COMPRESSOR INPUT ROTOR SPEED (RPM)						
☐ PRESSURE RATIO (R)						
☐ VOLUMETRIC EFFICIENCY (%)						
☐ SILENCER Δ P (bar) (7.8.6.4)						
○ SETTLE OUT PRESSURE - absolute (bar) (6.1.2.7)						

PROCESS CONTROL: (6.4.2.1)

CAPACITY CONTROL METHOD

○ COOLED BYPASS FROM ______ TO ______

○ SPEED VARIATION FROM ☐ RANGE OF SPEED VARIATION ______ % TO ______ %

○ OTHER ______

SIGNAL: ○ SOURCE ______

○ TYPE ○ ELECTRONIC ○ OTHER ______

○ RANGE: ______ TO ______ mA

○ OTHER ______

DISCHARGE TEMPERATURE CONTROL

METHOD: ☐ LQIUID INJECTION

SIGNAL: ☐ SOURCE ______

☐ TYPE ☐ ELECTRONIC ☐ OTHER ______

SERVICE:

○ CONTINUOUS ○ INTERMITTENT ○ STANDBY (3.53)

START-UP: (5.1.15.C) ○ NORM AL SUCTION PRESSURE ○ FROM SETTLE OUT CONDITION (6.1.2.8)

○ Compressor String Designed to Operate at normal suction pressure with Disch Pr Up to Relief Valve Set Pressure

ROTARY-TYPE POSITIVE DISPLACEMENT COMPRESSOR DATA SHEET SI UNITS

JOB NO. ______ ITEM NO. ______
PURCHASE ORDER NO. ______ DATE ______
REQUISITION NO. ______
INQUIRY NO. ______
PAGE 2 OF 7 BY ______

GAS ANALYSIS (6.1.2.2) ○ MOL % ○ ______	M.W.	NOR-MAL	MAX-IMUM	OTHER CONDITIONS A	B	C	D	○ REMARKS
AIR	28.966							
OXYGEN	32.000							
NITROGEN	28.016							
WATER VAPOR	18.016							
CARBON MONOXIDE	28.010							
CARBON DIOXIDE	44.010							
HYDROGEN SULFIDE	34.076							(6.11.1.8)
HYDROGEN	2.016							
METHANE	16.042							
ETHYLENE	28.052							
ETHANE	30.068							
PROPYLENE	42.078							
PROPANE	44.094							
I-BUTANE	58.120							
n-BUTANE	58.120							
I-PENTANE	72.146							
n-PENTANE	72.146							
HEXANE PLUS								
○ CORROSIVE AGENTS								(6.11.1.8)
○ SOLID PARTICLE								(7.8.5.1)
○ ENTRAINED LIQUID								(7.8.5.1)
○ NACE MATERIALS								(6.11.1.12)
TOTAL								

LOCATION:
○ INDOOR ○ OUTDOOR ○ GRADE
○ HEATED ○ UNDER ROOF ○ MEZZANINE
○ UNHEATED ○ PARTIAL SIDES ○
○ ELEC. AREA CLASSIFICATION

SITE DATA:
○ ELEVATION m BAROMETER Bara
○ RANGE OF AMBIENT TEMPERATURE:
Normal °C
Median Maximum °C
Median Minimum °C
Absolute Maximum °C
Absolute Minimum °C

UNUSUAL CONDITIONS: ○ DUST ○ FUMES
○ OTHER
○ COPPER AND COPPER ALLOYS PROHIBITED

PAINTING:
○ MANUFACTURER'S STD.
○ APPLICABLE SPECIFICATIONS:
○ ISO 12944 CATEGORY
○ OTHER

NOISE SPECIFICATIONS:
○ APPLICABLE TO MACHINE:
SEE SPECIFICATION
○ APPLICABLE TO NEIGHBORHOOD:
SEE SPECIFICATION
ACOUSTIC HOUSING: ○ YES ○ NO

APPLICABLE SPECIFICATIONS:
○ API 619-5th Chapter 2
○ VENDOR HAVING UNIT RESPONSIBILITY
○ GOVERNING SPECIFICATION (IF DIFFERENT)
○ API 691-1st
○ Supporting documents to demonstrate equipment is field proven
○ Duration of Uninterrupted Operation (6.1.1.6) hr

SHIPMENT: (8.4.1)
○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQ'D
○ OUTDOOR STORAGE MORE THAN 6 MONTH ______ MONTHS
○ LIFTING TOOLS (8.4.27)

SPARE ROTOR ASSEMBLY PACKAGE
○ METAL STORAGE CONTAINER
○ N2 PURGE ○ OTHER ______
○ VERTICAL STORAGE ○ HORIZONTAL STORAGE
○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQ'D

REMARKS:

ROTARY-TYPE POSITIVE DISPLACEMENT COMPRESSOR DATA SHEET SI UNITS

Rev

JOB NO. ______ ITEM NO. ______
REVISION NO. ______ DATE ______
PAGE 3 OF 7 BY ______

1 ☐ **SPEEDS:**
2 MAX. CONT. (3.1.33) ______ RPM TRIP (3.1.75) ______ RPM
3 MAX. TIP SPEEDS: ______ m/s @ MAX. OPER. SPEED
4 MIN. ALLOW (3.1.30) ______ RPM
5 ☐ LATERAL CRITICAL SPEEDS: (6.8.1.5)
6 FIRST CRITICAL ______ RPM
7 DAMPED ______ UNDAMPED ______
8 MODE SHAPE ______
9 LATERAL CRITICAL SPEED - BASIS:
10 ○ DAMPED UNBALANCE RESPONSE ANALYSIS
11 ☐ OTHER TYPE ANALYSIS: ______
12 ☐ **POCKET PASSING FREQUENCY AT RATED SPEED:** ______ Hz
13 ○ TORSIONAL ANALYSIS REQUIRED (6.8.2.1)
14 ☐ **TORSIONAL CRITICAL SPEEDS:** (6.8.2)
15 FIRST CRITICAL ______ RPM
16 SECOND CRITICAL ______ RPM
17 ☐ **VIBRATION:** (5.7.3.6) ______
18 HOUSING ______ mm/s RMS
19 SHAFT ______ µm
20 ☐ **ROTATION, LOOKING AT COMPRESSOR DRIVEN END:** ☐ CW ☐ CCW
21
22 ☐ **CASING:**
23 MODEL ______
24 CASING SPLIT ______
25 MATERIAL ______ ○ CLADDING (6.2.20) ______
26 OPERATION: ☐ PROVISIONS FOR LIQUID INJECTION
27 CORR. ALLOW (mm.) ______
MAX. ALLOWABLE WORK PRESS. (3.1.31) ______ (bar)
LEAK TEST GAS: ______
LEAK TEST PRESSURE (8.3.3.4.6)
30 ☐ WITH SEALS ______ (barg)
31 ☐ WITHOUT SEALS ______ (barg)
HYDROSTATIC TEST PRESSURE (8.3.2) ______ (barg)
MAX. ALLOW. TEMP. ______ °C MIN. OPER. TEMP. ______ °C
32 ○ MIN DESIGN METAL TEMP ______ °C @ ______ bar (G)
33 COOLING JACKET ☐ YES ☐ NO
28 ○ RELIEF VALVE SET PRESSURE ______ (bar)
29
34 ☐ **ROTORS:** (6.6)
35 TYPE ☐ SYMMETRIC ☐ ASYMMETRIC
36
37 DIAMETER (mm.): MALE: ______ FEMALE: ______
38 NO. LOBES: MALE ______ FEMALE ______
39 TYPE: ______
40 TYPE FABRICATION ☐ SINGLE PIECE FORGED ☐ FABRICATED
41 MATERIAL ______
42 MAX. YIELD STRENGTH (N/mm^2) ______
43 BRINELL HARDNESS. MAX. ______ MIN. ______
44 ROTOR LENGTH TO DIAMETER RATIO (L/D) ______
45 ROTOR CLEARANCE (mm) ______
46 ______
47 ______
48 INTERNALLY COOLED ☐ YES ☐ NO
49 ______
50 **REMARKS:** ______
51 ______
52 ______
53

☐ **SHAFT:** (6.6.1)
MATERIAL ______
DIA @ ROTORS (mm) ______ DIA @ COUPLING (mm) ______
SHAFT END. ☐ TAPERED ☐ CYLINDRICAL
SHAFT SLEEVES:
○ AT SHAFT SEALS ______ ☐ MATL. ______
☐ **TIMING GEARS:** (6.6.6)
PITCH LINE DIAMETER (mm) MALE: ______ FEMALE: ______
MATERIAL ______ TYPE ______
☐ **SHAFT SEALS:** (6.7.4)
○ SEAL SYSTEM TYPE (6.7.4.1) ______
○ SEE SEAL DATASHEET ______
○ SETTLE OUT PRESSURE (barG) ______
☐ OIL LEAKAGE (CC/MIN/SEAL) ______
○ TYPE OF SEAL GAS ______
☐ SEAL GAS FLOW (PER SEAL)
NORMAL: ______ kg/hr. @ ______ (bar)
MAX.: ______ kg/hr. @ ______ (bar)
○ TYPE BUFFER GAS (5.6.2.1) ______
☐ BUFFER GAS FLOW (PER SEAL)
NORMAL: ______ kg/hr. @ ______ (bar)
MAX.: ______ kg/hr. @ ______ (bar)
☐ **BEARING HOUSING:** (6.9.4)
MATERIAL ______

BEARINGS

Radial Bearing ○ Rolling Element ○ Hydrodynamic
Thrust Bearing ○ Rolling Element ○ Hydrodynamic
☐ **HYDRODYNAMIC RADIAL BEARING:** (IDENTIFY HIGHEST LOADED BEARING) (6.9.3)
TYPE ______ SPAN (mm) ______
AREA (mm^2) ______ LOADING (N/mm^2): ACT. ______ ALLOW. ______
NO. PADS ______ ROTOR ON ______ OR BETWEEN ______ PADS
BACKING MATERIAL ______
TYPE BABBITT ______ THICKNESS ______ (mm)
○ TEMP SENSORS (5.8.1.5) ______
○ TC ○ RTD TYPE ______
NO PER BRG ______
☐ **ROLLING ELEMENT RADIAL BEARING** (5.8.2)
(IDENTIFY HIGHEST LOADED BEARING) (5.8.3.1)
TYPE: ______ , Ndm: ______ mm/min
ENERGY DENSITY (kW-RPM):
☐ **HYDRODYNAMIC THRUST BEARING:** (IDENTIFY HIGHEST LOADED BEARING) (6.9.3)
TYPE ______
MFR. ______ AREA (mm^2) ______
LOADING (N/mm^2): ______ ACT. ______ ALLOW. ______
NUMBER OF PADS ______
BACKING MATERIAL ______
TYPE BABBITT ______ THICKNESS ______ (mm)
○ TEMP SENSORS (5.8.1.5) ______
○ TC ○ RTD TYPE ______
ACTIVE NO EA PAD ______ NO PER BEARING ______
OTHER ______
INACTIVE NO EA PAD ______ NO PER BEARING ______
OTHER
☐ **ROLLING ELEMENT THRUST BEARING** (5.8.2)
TYPE: ______ , Ndm: ______ mm/min
ENERGY DENSITY (kW-RPM):

54 **REMARKS:**
55
56

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PROCESS CONNECTIONS - COMPRESSOR CASING (6.4.2):

	SIZE	RATING	FACING	ORIENTATION
INLET				
DISCHARGE				

PROCESS CONNECTIONS - CUSTOMER INTERFACE:

	SIZE	RATING	FACING	ORIENTATION
INLET				
DISCHARGE				

CASING - ALLOWABLE PIPING FORCES AND MOMENTS: (6.5)

	INLET		DISCHARGE			
	FORCE N	MOMT N-m	FORCE N	MOMT N-m	FORCE N	MOMT N-m
AXIAL X						
VERTICAL Y						
HORIZ. 90° Z						
AXIAL X						
VERTICAL Y						
HORIZ. 90° Z						

OTHER CONNECTIONS: (6.4.3)

SERVICE:	NO	SIZE	TYPE/RATING
LUBE OIL INLET			
LUBE OIL OUTLET			
SEAL INLET			
SEAL OUTLET			
CASING DRAINS (5.3.4)			
VENTS			
COOLING WATER INLET			
COOLING WATER OUTLET			
LIQUID INJECTION			
OIL INJECTION			
PURGE FOR:			
BRG. HOUSING			
BETWEEN BRG. & SEAL			
BETWEEN SEAL & GAS			
OTHER			

VIBRATION DETECTORS: (6.9.4.12)

- IN ACCORDANCE WITH: API670 ______
- SEE ATTACHED API 670 DATASHEET
- TYPE: ☐ ☐ DISPLACEMENT
- ☐ MODEL ______
- MFR. ______
- NO. AT SHAFT/HOUSING ______ TOTAL NO. ______
- OSCILLATOR-DETECTORS SUPPLIED BY ______
  - MFR. ______ ☐ MODEL ______
- MONITOR SUPPLIED BY ______
  - LOCATION ______ ENCLOSURE ______
  - MFR. ______ ☐ MODEL ______
  - ☐ SCALE RANGE ______ ALARM. ☐ SET @ ______
  - SHUTDN: ☐ SET @ ______ TIME DLY. ______ SEC
- PHASE REFERENCE TRANSDUCER
- ACCELEROMETER ON EACH BEARINGHOUSING
- OTHER

AXIAL POSITION DETECTOR: (6.9.4.12)

- IN ACCORDANCE WITH: API 670 ______
- SEE ATTACHED API 670 DATASHEET
- TYPE ______ ☐ MODEL ______
- MFR. ______ NO. REQ'D per Shaft/Total ___ / ___
- OSCILLATOR-DETECTORS SUPPLIED BY ______
  - MFR. ______ ☐ MODEL ______
- MONITOR SUPPLIED BY ______
  - LOCATION ______ ENCLOSURE ______
  - MFR. ______ ☐ MODEL ______
  - ☐ SCALE RANGE ______ ALARM: ☐ SET @ ______
  - SHUTDOWN: ☐ SET @ ______ TIME DELAY ______

COUPLINGS: (7.2)

- IN ACCORDANCE WITH: API 671 ______
- SEE ATTACHED API 671 DATASHEET
- APPLICABLE SPECIFICATION ______
- COUPLING FURNISHED BY ______ MOUNTED BY ______
- COUPLING GUARD FURNISHED BY ______

	DRIVER-COMP OR	GEAR-COMP
MANUFACTURER		
MODEL		
COUPLING TYPE		
MOUNT CPLG. HALVES		
DBSE mm		
LIMITED END FLOAT REQ'D		
MOMENT SIMULATOR REQUIRED (7.2.7)		
CPLG. RATING (kW/100 RPM)		
KEYED (1) OR (2) OR HYDR. FIT		
COUPLING GUARD TYPE (7.3)		

BASEPLATE AND SOLEPLATES: (7.5)

SOLE PLATES FOR: ◯ COMPRESSOR ◯ GEAR ◯ DRIVER

BASEPLATE:

- COMMON (UNDER COMP. GEAR & DRIVER)
- UNDER COMP. ONLY ◯ OTHER ______
- DECKED WITH NON-SKID DECK PLATE ◯ OPEN CONSTR.
- DRIP RIM ◯ WITH OPEN DRAIN ◯ SUBPLATE
- HORIZONTAL ADJUSTING SCREWS FOR EQUIPMENT
- SUITABLE FOR COLUMN SUPPORT (6.3.2.4)
- SUITABLE FOR PERIMETER SUPPORT
- EPOXY GROUT/EPOXY PRIMER (6.3.1.6)

LUBE OIL SYSTEM (6.10)

- LUBRICANT MANUFACTURER ______
- LUBRICANT TYPE ______ GRADE (ISO 3448) ______
- API 614 LUBE OIL SYSTEM
- COMMON (5.10.2.1)
- OIL FILTER (5.10.3.6)
- OIL COOLER (5.10.3.3): TYPE ______ NO: ______
- OIL PUMP (5.10.3.4): TYPE ______ NO: ______

REMARKS:

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UTILITY CONDITIONS: (ALL UNITS ARE GAUGE)

STEAM		DRIVERS	HEATING
INLET	MIN.	___ kPa (bar) ___ °C	___ kPa (bar) ___ °C
	NORM	___ kPa (bar) ___ °C	___ kPa (bar) ___ °C
	MAX.	___ kPa (bar) ___ °C	___ kPa (bar) ___ °C
EXHAUST	MIN.	___ kPa (bar) ___ °C	___ kPa (bar) ___ °C
	NORM	___ kPa (bar) ___ °C	___ kPa (bar) ___ °C
	MAX.	___ kPa (bar) ___ °C	___ kPa (bar) ___ °C

ELECTRICITY:

	DRIVERS	HEATING	CONTROL	SHUT-DOWN
VOLTAGE				
HERTZ				
PHASE				

COOLING WATER
TEMP. INLET ______ °C MAX. RETURN ______ °C
PRESS. NORM ______ kPa (bar) DESIGN ______ kPa (bar)
MIN. RETURN ______ kPa (bar) MAX. ALLOW ∆ P ______ kPa (bar)
WATER SOURCE ______

INSTRUMENT AIR:
MAX PRESS ______ kPa (bar) MIN. ______ kPa (bar)

☐ **TOTAL UTILITY CONSUMPTION:**
COOLING WATER ______ m^3/h
STEAM, NORMAL ______ kg/h
STEAM, MAX ______ kg/h
INSTRUMENT AIR ______ Nm^3/h
NITROGEN ______ Nm^3/h
HP (DRIVER) ______ kW

☐ **MASSES (KG):**
COMPR. ______ GEAR ______ DRIVER ______ BASE ______
ROTORS: COMPR. ______ DRIVER ______ GEAR ______
COMPR. UPPER CASE ______
L.O. CONSOLE ______ S.O. CONSOLE ______
MAX. FOR MAINTENANCE (IDENTIFY) ______
TOTAL SHIPPING MASS ______

☐ **SPACE REQUIREMENTS (mm):**
COMPLETE UNIT L ______ W ______ H ______
L.O. CONSOLE L ______ W ______ H ______
S.O. CONSOLE: L ______ W ______ H ______

MISCELLANEOUS:
☐ RECOMMEND STRAIGHT RUN OF PIPE DIA. BEFORE SUCTION
○ VENDOR'S REVIEW & COMMENTS ON PURCHASER'S PIPING & FOUNDATION (5.1.16)
○ VENDOR REPRESENTATIVE OBSERVATION AT THE SITE (5.1.17)
○ OPTICAL ALIGNMENT FLATS REQUIRED ON COMPRESSOR, GEAR & DRIVER
○ LATERAL ANALYSIS REPORT REQUIRED (5.7.1.4)
○ TORSIONAL ANALYSIS REPORT REQUIRED (5.7.2.1)
○ CASING MOUNTED TORSIONAL SHAFT VIBRATION PICKUP
○ COORDINATION MEETING (8.1.3)

SHOP INSPECTION AND TESTS: (7.1)	REQ'D	OBS	WIT
SHOP INSPECTION (7.1.5)	○	○	○
HYDROSTATIC (7.3.2)	○	○	○
HELIUM LEAK (7.3.4.7)	○	○	○
HEAT RUN (7.3.3.5)	○	○	○
MECHANICAL RUN (7.3.3)	○	○	○
Real-time vibration data provided (7.3.3.3.3)	○		
Lube oil & seal oil pressure & temperature varied (7.3.3.3.4)	○		
USE SHOP LUBE & SEAL SYSTEM	○		
USE JOB LUBE & SEAL SYSTEM (7.3.4.9)	○		
USE SHOP VIBRATION PROBES, TRANSDUCERS, ETC.	○		
USE JOB VIBRATION PROBES, TRANSDUCERS, ETC.	○		
USE SHOP MONITORING EQUIPMENT	○		
USE JOB MONITORING EQUIPMENT	○		
MECHANICAL RUN SPARE ROTORS (7.3.3.4.2)	○	○	○
CASING LEAK TEST (7.3.3.4.3)	○	○	○
PERFORMANCE TEST (GAS) (AIR) (7.3.4.2)	○	○	○
COMPLETE UNIT TEST (7.3.4.2)	○	○	○
TORSIONAL VIBRATION MEASUREMENT (7.3.4.3)	○	○	
PRESSURE COMP. TO FULL OPER. PRESSURE	○	○	○
POST-TEST INSPECTION	○	○	
SOUND-LEVEL TEST (7.3.4.8)	○	○	○
TANDEM TEST (7.3.4.5)	○	○	○
AUX.-EQUIPMENT TEST (7.3.4.9)	○	○	○
FULL-LOAD TEST (7.3.4.11)	○	○	○
RESIDUAL UNBALANCE CHECK (5.7.3.5)	○	○	○

INLET & DISCHARGE DEVICES:
○ HIGH EFFICIENCY INLET SEPARATOR REQUIRED (6.8.2)
○ INLET AIR FILTER DP INDICATION TYPE (6.7.3) ______
○ PULSATION SUPPRESSORS FURNISHED BY ______

○ SPARE PARTS TO BE SUPPLIED (8.2.3F)
○ ROTOR ASSEMBLY
○ SEALS ○ GASKETS, O-RINGS
○ START-UP/COMMISSIONING
○ 2 YEARS SUPPLY
○ OTHER: ______

REMARKS:

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VENDOR MUST FURNISH ALL PERTINENT DATA FOR THIS SPECIFICATION SHEET BEFORE RETURNING.
ITEM NO. ______ SERVICE ______ JOB NO. ______
MANUFACTURER ______

APPLICABLE SPECIFICATIONS: ○ IEC ______ ○ NEMA
CONTROL PANEL: (6.4.3)
FURNISHED BY: ☐ VENDOR ☐ PURCHASER ☐ OTHERS ______
☐ LOCAL ______ ☐ REMOTE ______
☐ FREE STANDING ☐ WEATHERPROOF ☐ TOTALLY ENCLOSED
☐ VIBRATION ISOLATORS ☐ CABINET HEATERS ☐ PURGE CONNECTIONS
☐ ANNUNCIATOR: FURNISHED BY: ☐ VENDOR ☐ PURCHASER ☐ OTHERS ______
ANNUNCIATOR LOCATED ON ☐ CONTROL PANEL ☐ MAIN CONTROL BOARD

INSTRUMENT SUPPLIERS:

○ PRESSURE GAUGES:	MFR.	______	SIZE & TYPE:	______
○ TEMPERATURE GAUGES:	MFR.	______	SIZE & TYPE:	______
○ LEVEL GAUGES:	MFR.	______	SIZE & TYPE:	______
○ DIFF. PRESSURE GAUGES:	MFR.	______	SIZE & TYPE:	______
○ PRESSURE TRANSMITTERS	MFR.	______	SIZE & TYPE:	______
○ DIFF. PRESSURE TRANSMITTERS	MFR.	______	SIZE & TYPE:	______
○ TEMPERATURE TRANSMITTERS	MFR.	______	SIZE & TYPE:	______
○ LEVEL TRANSMITTERS	MFR.	______	SIZE & TYPE:	______
○ CONTROL VALVES:	MFR.	______	SIZE & TYPE:	______
○ PRESSURE RELIEF VALVES: (6.4.4.6)	MFR.	______	SIZE & TYPE:	______
○ THERMAL RELIEF VALVES: (6.4.4.6.4)	MFR.	______	SIZE & TYPE:	______
○ FLOW INDICATORS: (6.4.4.9)	MFR.	______	SIZE & TYPE:	______
○ GAS FLOW INDICATOR:	MFR.	______	SIZE & TYPE:	______
○ VIBRATION EQUIPMENT:	MFR.	______	SIZE & TYPE:	______
○ TACHOMETER: (6.4.4.2)	MFR.	______	RANGE & TYPE:	______
○ SOLENOID VALVES	MFR.	______	SIZE & TYPE:	______
○ ANNUNCIATOR: (6.4.5.4)	MFR.	______	MODEL & NO. POINTS	______
○ DEPRESSURIZATION VALVE (6.4.4.7)	MFR.	______	SIZE & TYPE:	______
○ THERMOCOUPLES	MFR.	______	SIZE & TYPE:	______
○ RESISTANCE TEMPERATURE DETECTOR (RTD)	MFR.	______	SIZE & TYPE:	______
○ THERMOWELLS	MFR.	______	SIZE & TYPE:	______
○ TACHOMETER: (6.4.4.2)	MFR.	______	SIZE & TYPE:	______
○ ______	MFR.	______	SIZE & TYPE:	______

☐ CUSTOMER CONNECTIONS BROUGHT OUT TO TERMINAL BOXES BY VENDOR

NOTE: ☐ SUPPLIED BY VENDOR ○ SUPPLIED BY PURCHASER

PRESSURE GAUGE REQUIREMENTS FUNCTION		LOCALLY MOUNTED	LOCAL PANEL	**TEMPERATURE GAUGE REQUIREMENTS:**		LOCALLY MOUNTED	LOCAL PANEL
COMPRESSOR SUCTION	______	☐ ○	☐ ○	COMPRESSOR SUCTION	______	☐ ○	☐ ○
COMPRESSOR DISCHARGE	______	☐ ○	☐ ○	COMPRESSOR DISCHARGE	______	☐ ○	☐ ○

CONTACTS:
ALARM CONTACTS SHALL: ☐ OPEN ☐ CLOSE TO SOUND ALARM AND BE NORMALLY ☐ ENERGIZED ☐ DE-ENERGIZED
SHUTDOWN CONTACTS SHALL: ☐ OPEN ☐ CLOSE TO TRIP AND BE NORMALLY ☐ ENERGIZED ☐ DE-ENERGIZED
NOTE: NORMAL CONDITION IS WHEN COMPRESSOR IS IN OPERATION.

MISCELLANEOUS:
○ INSTRUMENT TAGGING REQUIRED.
○ ALARM AND SHUTDOWN DEVICES SHALL BE SEPARATE.
PURCHASERS ELECTRICAL AND INSTRUMENT CONNECTIONS WITHIN THE CONFINES OF THE BASEPLATE AND CONSOLE SHALL BE: ☐ BROUGHT OUT TO TERMINAL BOXES. ☐ MADE DIRECTLY BY THE PURCHASER.
COMMENTS REGARDING INSTRUMENTATION: ______
COMMENTS REGARDING INSTRUMENTATION: ______

MISCELLANEOUS INSTRUMENTATION:
☐ ○ DRIVER START/STOP ☐ UNIT CONTROL PANEL ☐ SEPARATE PANEL ☐ MAIN BOARD ☐ ______
☐ ○ VIBRATION AND SHAFT POSITION PROBES & PROXIMITORS
☐ ○ VIBRATION AND SHAFT POSITION READOUT EQUIPMENT
☐ ○ VIBRATION READOUT LOCATED ON: ☐ UNIT CONTROL PANEL ☐ SEPARATE PANEL ☐ MAIN BOARD ☐ ______

REMARKS:

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VENDOR MUST FURNISH ALL PERTINENT DATA FOR THIS SPECIFICATION SHEET BEFORE RETURNING.
ITEM NO. ______ SERVICE ______ JOB NO. ______
MANUFACTURER ______

MISCELLANEOUS INSTRUMENTATION:

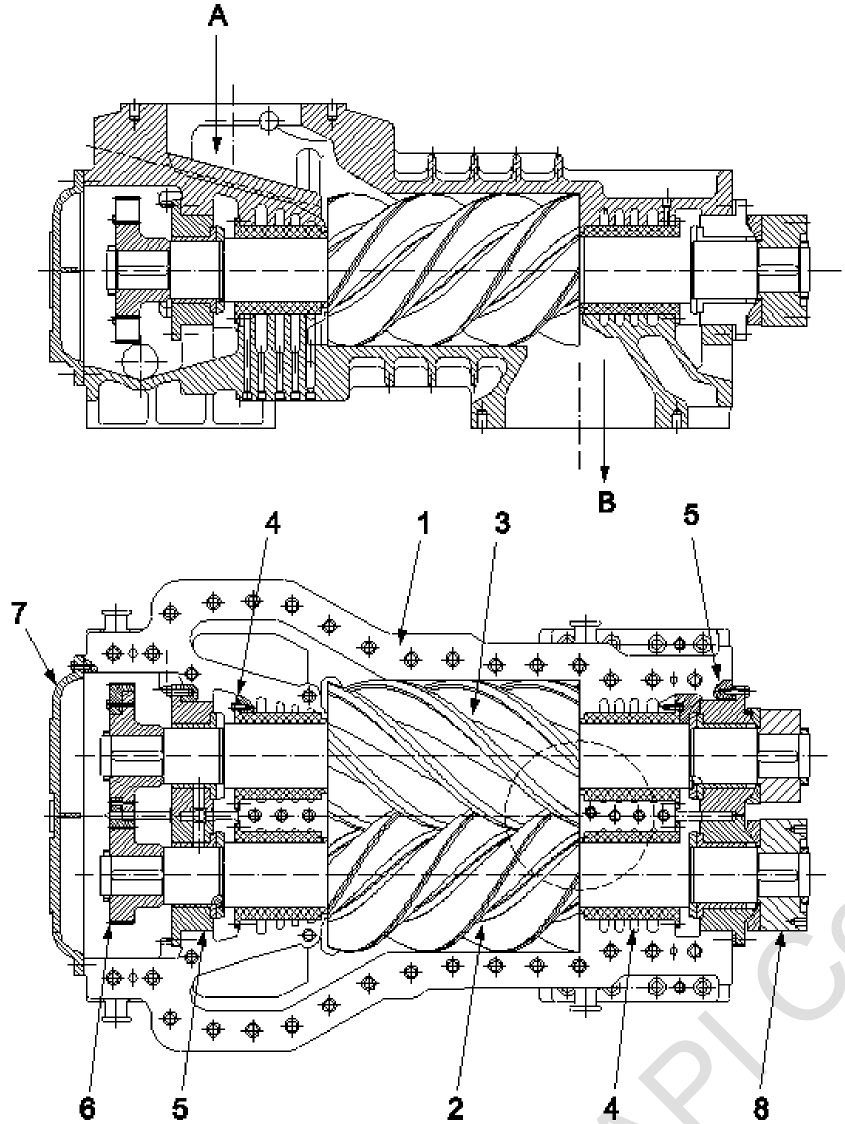
☐ ○ DRIVER START/STOP ☐ UNIT CONTROL PANEL ☐ SEPARATE PANEL ☐ MAIN BOARD ☐ ______
☐ ○ VIBRATION AND SHAFT POSITION PROBES & PROXIMITORS
☐ ○ VIBRATION AND SHAFT POSITION READOUT EQUIPMENT
☐ ○ VIBRATION READOUT LOCATED ON: ☐ UNIT CONTROL PANEL ☐ SEPARATE PANEL ☐ MAIN BOARD ☐ ______

ALARM & SHUTDOWN: (6.4.5.2)

FUNCTION	ALARM	TRIP	FUNCTION	ALARM	TRIP
☐ ○ HI LUBE OIL SUPPLY TEMPERATURE			☐ ○ DRIVER SHAFT RADIAL VIBRATION		
☐ ○ COMPRESSOR HI DISCH. TEMP.			☐ ○ DRIVER FRAME VIBRATION		
☐ ○ COMPRESSOR HI DISCH. PRESS.			☐ ○ DRIVER SHAFT AXIAL POSITION		
☐ ○ COMPRESSOR Δ P			☐ ○ GEARBOX SHAFT RADIAL VIBRATION		
☐ ○ LOW SUCTION PRESSURE			☐ ○ GEARBOX CASING VIBRATION		
☐ ○ SHAFT RADIAL VIBRATION			☐ ○ GEARBOX SHAFT AXIAL POSITION		
☐ ○ SHAFT AXIAL POSITION			☐ ○ HI COMPR. THRUST BRG. TEMP.		
☐ ○ CASING VIBRATION			☐ ○ HI COMPR. JOURNAL BRG. TEMP.		
☐ ○			☐ ○ HI DRIVER THRUST BRG. TEMP.		
☐ ○			☐ ○ HI DRIVER JOURNAL BRG. TEMP.		
☐ ○			☐ ○ HI GEARBOX THRUST BRG. TEMP.		
☐ ○			☐ ○ HI GEARBOX JOURNAL BRG. TEMP.		

REMARKS

Annex B
(Informative)
Typical Dry Screw Compressor Nomenclature



Key
A inlet
B outlet

1	casing	5	radial/thrust bearing
2	male rotor	6	timing gear
3	female rotor	7	end cover
4	shaft seal	8	drive shaft

Figure B.1 — Sections through dry screw compressor

Annex C
(normative)
External Forces and Moments

General

C.1 As a minimum, the compressor shall be designed to withstand external forces and moments on each nozzle as tabulated in Tables C.1 and C.2. The vendor shall furnish the allowable forces and moments for each nozzle in tabular form.

C.2 These values of allowable forces and moments pertain to the compressor structure only. They do not pertain to the forces and moments in the connecting pipes, flanges, and flange bolting, which shall not exceed the allowable stress specified by applicable codes and regulatory bodies.

C.3 Loads may be increased by mutual agreement between the purchaser and vendor; however, it is recommended that expected operating loads be minimized.

C.4 For nozzle sizes not given in Tables C.1 and C.2, the allowable forces and moments shall be agreed between the purchaser and vendor.

Table B.1 — Allowable forces

Force N	**Nozzle nominal size DN**								
	100	**150**	**200**	**250**	**300**	**350**	**400**	**450**	**500**
F_x	1 368	2 094	2 815	3 328	3 960	4 908	5 772	6 492	6 182
F_y	3 434	5 253	7 052	8 349	9 938	12 294	14 455	16 269	15 490
F_z	2 336	3 383	4 527	5 178	5 992	6 662	7 492	8 499	8 270
F_r	4 373	6 590	8 841	10 373	12 261	14 819	17 274	19 469	18 615
Force lb_f	**Nozzle nominal size NPS**								
	4	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**
F_x	308	471	633	748	890	1103	1297	1 460	1 390
F_y	772	1 181	1 585	1 877	2 234	2 764	3 250	3 657	3 482
F_z	525	761	1 018	1 164	1 347	1 498	1 684	1 911	1 859
F_r	983	1 482	1 987	2 332	2 756	3 331	3 883	4 377	4 185

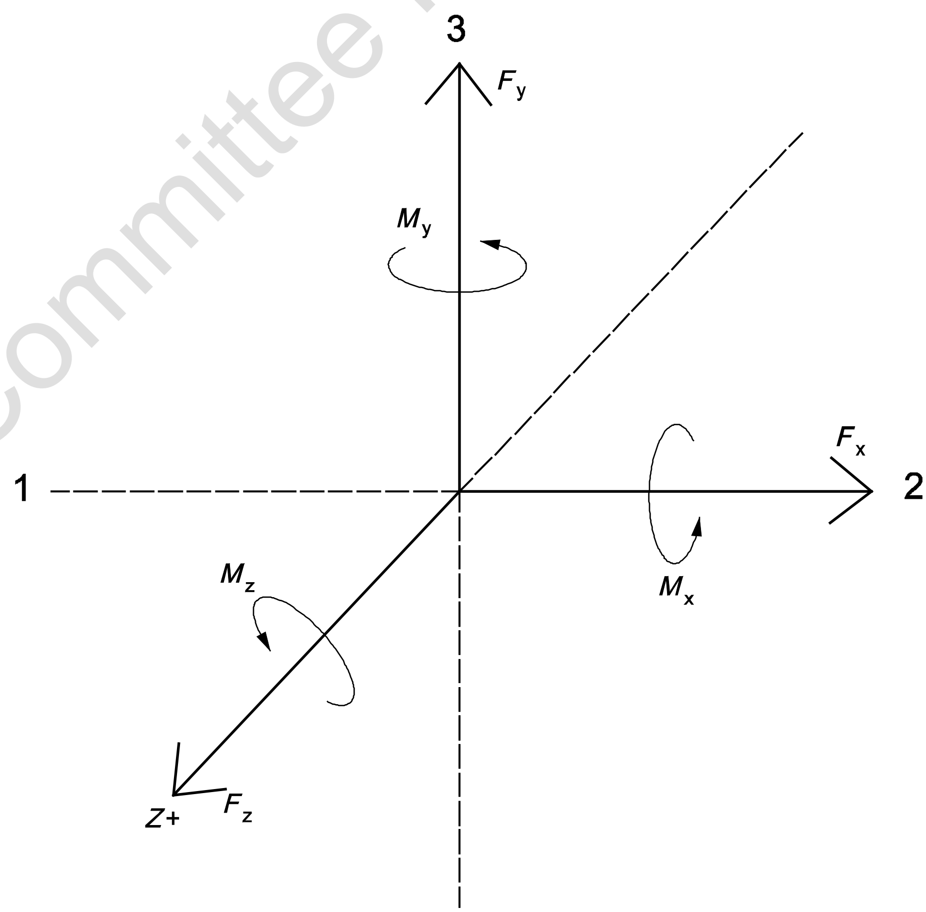
NOTE Nozzle nominal size DN is expressed in millimetres, nozzle nominal size NPS is expressed in inches.

Table B.2 — Allowable moments

Moment N·m	Nozzle nominal size DN								
	100	**150**	**200**	**250**	**300**	**350**	**400**	**450**	**500**
M_x	2 069	2 754	3 672	4 212	5 097	6 232	7 316	9 605	9 191
M_y	1 253	2 126	2 836	3 648	4 190	5 656	6 781	7 153	6 762
M_z	1 253	1 698	2 264	2 814	3 334	4 491	5 450	7 153	6 762
M_r	2 724	3 871	5 163	6 242	7 393	9 539	11 367	13 949	13 264
Moment ft·lb_f	**Nozzle nominal size NPS**								
	4	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**
M_x	1 526	2 031	2 709	3 107	3 759	4 597	5 396	7 084	6 779
M_y	924	1 568	2 091	2 691	3 090	4 171	5 001	5 275	4 988
M_z	924	1 252	1 670	2 076	2 459	3 312	4 020	5 275	4 988
M_r	2 009	2 855	3 808	4 604	5 453	7 036	8 384	10 288	9 783
NOTE Nozzle nominal size DN is expressed in millimetres, nozzle nominal size NPS is expressed in inches.									

Equations

The x, y and z axes are defined in Figure C.1.



Key

1 drive end

2 axes parallel to compressor shaft

3 vertical axes

Figure C.1 — Definition of axes

The resultant force, F_r, is given by Equation (C.1):

$$F_r = \sqrt{F_x^2 + F_y^2 + F_z^2} \tag{C.1}$$

where F_x, F_y and F_z are the force components along the x-, the y- and the z-axis, respectively.

The resultant moment, M_r , is given by Equation (C.2):

$$M_r = \sqrt{M_x^2 + M_y^2 + M_z^2} \tag{C.2}$$

where M_x, M_y and M_z are the moments around the x-, the y- and the z-axis, respectively.

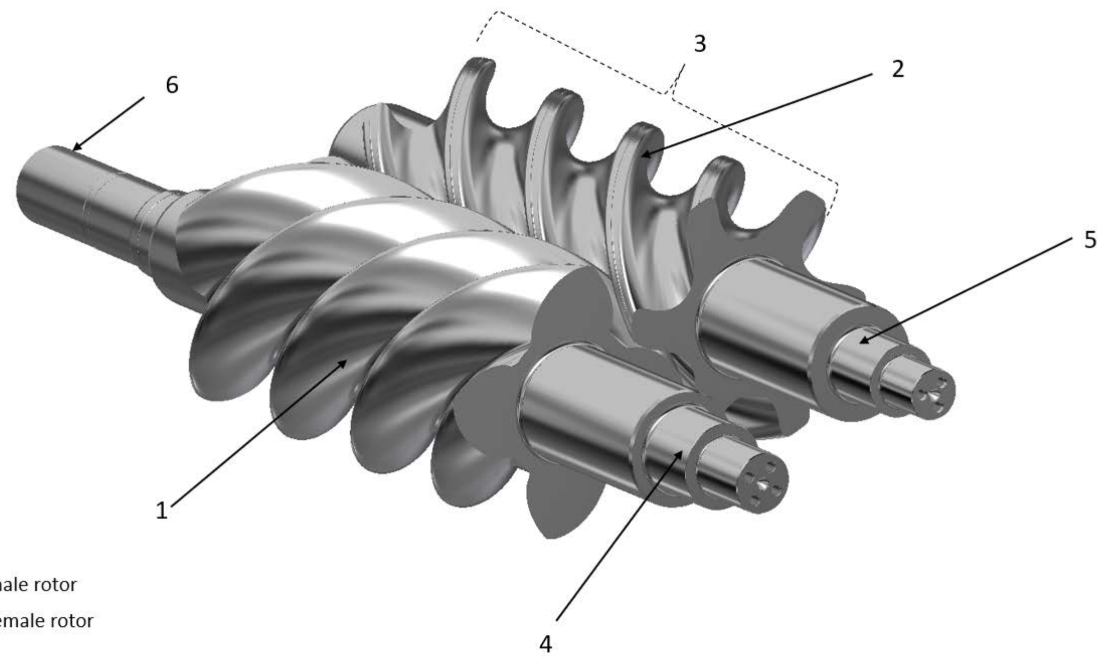
Petroleum, petrochemical and natural gas industries — Rotary-type positive-displacement compressors —

Part 3: Oil-Flooded Compressors

6th Edition Ballot Draft - March 2024

1 Scope

This part of API 619, in conjunction with requirements of API 619 Part 1, specifies minimum requirements for rotary-type positive displacement oil flooded twin screw compressors (see Figure 1) used for vacuum or pressure or both, in special purpose applications that handle gas or process air in the petroleum, chemical, and gas industries.



Key

1	Male rotor
2	Female rotor
3	Rotor body
4	Shaft extension – male rotor
5	Shaft extension – female rotor
6	Drive shaft

Figure 1 — Oil-Flooded twin screw compressor rotors

2 Normative references

Referenced documents indispensable for the application of this document are listed under Part 1, Section 2

3 Terms and definitions

For the purposes of this document, the terms, definitions, acronyms, abbreviations, and symbols given in Part 1, Section 3 apply.

4 Dimensions and Units

The dimensions and unit requirements of Part 1, Section 4 shall apply.

5 Requirements

5.1 Statutory Requirements

The statutory requirements in 5.1 of Part 1 shall apply.

5.2 Unit Responsibility

The unit responsibilities in 5.2 of Part 1 shall apply.

5.3 Documentation Requirements

The documentation requirements in 5.3 of Part 1 shall apply.

6 Basic Design

6.1 General

General design requirements shall be in accordance with 6.1 of Part 1.

6.2 Pressure Casings

6.2.1 Casings shall be in accordance with 6.2 of Part 1 and as follows.

6.2.2 For oil-flooded screw compressors, the gas system pressure protection shall be furnished by the vendor and sized in accordance with API 520 (including fire case) or other criteria as specified by the purchaser.

6.3 Casing Appurtenances

6.3.1 Casing appurtenances shall be in accordance with 6.3 of Part 1 and the following.

6.3.2 If slide valves are supplied, instrumentation shall be provided to indicate the position of the slide valve.

6.4 Casing Connections

Pressure casing connections shall be in accordance with 6.4 of Part 1.

6.5 External forces and moments

6.5.1 The compressor shall be designed to withstand external forces and moments on each nozzle as tabulated in Annex C Tables C.1 and C.2.

NOTE Compressor casing allowable external nozzle loads lower than values of Annex C may be mutually agreed upon between purchaser and vendor. In such case, other measures may be utilized to reduce applied piping load to the compressor nozzles such as modified pipe support design, modified pipe route, use of expansion joint, etc.

6.5.2 The vendor shall furnish the allowable forces and moments for compressor nozzles and process tie-in point nozzles of the package in tabular form.

6.5.3 Casing and supports shall be designed to have sufficient strength and rigidity to limit distortion of coupling alignment due to pressure, torque and allowable forces and moments to 50 µm (0.002 in.).

NOTE For applications with distortion in the supporting structure, such as offshore, the coupling distortion limit may not be limited to the above value. In that case, vendor and purchaser should mutually agree on acceptable values.

6.6 Rotating Elements

6.6.1 Rotating Elements shall be in accordance with 6.6 of Part 1 and the following paragraphs.

6.6.2 Rotors for flooded screw compressors shall be solid body.

6.6.3 Rotors shall be single piece forged.

6.6.4 Rotor bodies with finished diameters less than 200 mm (8 in.) may be hot-rolled barstock purchased to the same quality and heat treatment criteria as shaft forgings.

6.7 Shaft Seals

6.7.1 Shaft seals shall be in accordance with 6.7 of Part 1 and the following paragraphs.

6.7.2 Mechanical contact type seals (a typical seal is shown in Part 1 Figure 4) shall be provided.

6.7.3 Seals shall have labyrinths, slingers, or restrictive rings to minimize oil leakage to the atmosphere. Oil furnished under pressure to the rotating faces may be supplied from the lube-oil system in accordance with 6.10.3.

6.7.4 [●] If specified that gas leakage to atmosphere is not permissible, oil-flooded screws require dual seal designs with an independent seal-fluid system.

NOTE 1 Oil leaking from seals could contain small amount of process gas.

NOTE 2 Dual seal designs with independent seal fluid systems can be designed with gas free leakage.

6.7.5 For refrigeration and/or other services where accumulation of non-condensable gases has negative impact on system performance introduction of inert gases into the system shall be prevented.

6.8 Dynamics

Dynamics shall be in accordance with 6.8 of Part 1 and Table 1.

Table 1 — Vibration limits for oil-flooded screw compressors

Measurement on bearing housing	Hydrodynamic bearings[a,b]	Rolling element bearings[a,b]
Vibration at any speed within operating range		
— Overall	V_u < 8.0 mm/s RMS (0.3 in/s RMS)	V_u < 8.0 mm/s RMS (0.3 in/s RMS)
— Increase in allowable vibrations at speeds beyond operating speed but less than trip speed	50 %	50 %
Measurement on shaft adjacent to bearing		
Overall vibration at any speed within the operating speed range	"A" shall be the lesser value of — $\sqrt{\left(1{,}03 \times 10^7/n\right)}$ µm $\left(\sqrt{\left(16\ 000/n\right)}\text{ mils}\right)$ — or 50 % bearing clearance	

NOTE The pulsating oil flow through the oil-flooded screw compressor causes increased vibration. Oil-flooded screw compressors with hydrodynamic bearings typically operate with higher compression ratios and/or higher discharge pressures than machines with rolling element bearings.

a V_u is the unfiltered velocity.

b RMS is the root mean square.

c A is the unfiltered peak-to-peak amplitude of vibration.

d n is the max. continuous speed in revolutions per minute (r/min).

6.9 Bearings and Bearing Housings

Bearings and bearing housings shall be in accordance with 6.9 of Part 1.

6.10 Lubrication

6.10.1 The compressor vendor shall specify the lubricant type, grade, and required properties.

6.10.2 If the lubricant is supplied by the purchaser, the purchaser's preferred lubricant shall be approved by the compressor vendor.

6.10.3 Lube-oil and seal-oil systems

6.10.3.1 [●] The purchaser shall specify flooded screw compressor shaft seal-support systems.

a) Combined lubrication, control and seal oil system feeding mechanical seal.

b) Combined lubrication, control and seal oil system feeding mechanical seal with secondary dry running seal using separation gas.

c) Externally supplied unpressurized buffer oil to dual seals.

d) Externally supplied pressurized barrier oil to dual seals.

NOTE API 682 provides more information on externally supplied buffer or barrier fluid systems for dual seals.

6.10.3.2 A pressurized oil system shall be furnished to supply oil at a suitable pressure or pressures, as applicable, to the following:

a) bearings of the driver and of the driven equipment;

b) any governor and control-oil system;

c) seal-oil system, if combined with the lube-oil system;

d) rotor internal cooling;

e) rotors of oil-flooded compressors including slide valve.

6.10.3.3 Oil-Flooded screw compressors shall utilize a pressurized reservoir and separation vessels.

6.10.3.4 Oil systems for Oil-flooded screw compressors are designed with consideration of the following:

a) Lube oil is in contact with process-gas.

b) Lube-oil system forms a part of process-gas system.

c) Lube-oil system is segregated from the atmosphere.

d) Lube oil is pressurized to the discharge-gas pressure. In some cases, the lube oil can flow into the compressor bearing and seal sections without pumping-up (driven by differential pressure).

NOTE-1: Typical lubrication systems described in Annex D,

NOTE-2: The system described in API 619, Annex D Figure D.1 supersedes Figure H.10 from API 614, 6th Edition, Table 2, Figure for oil-flooded compressors.

6.10.3.5 The oil system shall utilize a lubricant compatible with the process gas. Compatibility issues can include, but not be limited to, the following:

a) dilution;

b) degassing;

c) corrosion;

d) viscosity changes;

e) moisture absorption;

f) oil affecting the process;

g) shaft-seal type;

h) lubricant additive reactions;

i) process gas temperature;

j) oil supply temperature;

k) elastomer compatibility;

l) toxicity;

m) seal oil compatibility;

NOTE Refer to Informative Annex E for oil selection guideline.

6.10.3.6 [●] If specified optional lube-oil components (including sampling points, etc.) are required.

NOTE Refer to Annex D for examples of typical lube-oil systems and their arrangements.

NOTE Optional features can include oil make-up system, sampling points, etc.

6.10.3.7 The discharge temperature shall be maintained at least 10 K (18 °F) higher than the dew point of the process-gas components and water vapor in any specified operating condition including start-up, shut down, and stand still.

NOTE Heating of lube oil, package depressurization, and preheating in recycle mode are some of the methods used to reduce the risk of compressor damage due to insufficient dew point margin during stand still condition.

6.10.3.8 The gas pipe between the compressor discharge nozzle and the first oil separator, including the first oil separator shall be designed to withstand pulsation, high-volume mixed-phase flow, and vibration loads.

6.10.3.9 Oil filters

6.10.3.9.1 Oil filters shall conform to the requirements of API 614 and 6.10.3.9.2 and 6.10.3.9.3.

6.10.3.9.2 Oil filters minimum particle removal efficiency for compressors with a rolling element bearing, shall be 99.5 % for 10 µm particles (*ß* > 200).

NOTE For more detail analysis regarding rolling element bearing life including filter rating refer to annex D.

6.10.3.9.3 Oil filter minimum particle removal efficiency for compressors with hydrodynamic radial and thrust bearings shall comply with API 614.

6.10.3.9.4 Unless otherwise specified particle removal by oil filters for rotor-supply (injection) oil shall be same level as bearing, seal, and control-oil supply.

6.10.3.9.5 Filter housing material shall be carbon steel.

6.10.3.9.6 If specified, filter housing material shall be stainless steel.

6.10.3.10 Oil Coolers

6.10.3.10.1 A single oil cooler shall be provided in accordance with API 614. The cooler shall be liquid-cooled shell-and-tube or plate type, or air-cooled type, as specified. Internal oil coolers are not acceptable.

6.10.3.10.2 The vendor shall include in the proposal complete details of any proposed shell-and-tube-type, plate-type or air-cooled-type cooler.

6.10.3.10.3 [●] If specified, dual coolers shall be provided.

6.10.3.10.4 The cooler shall be sized to handle the full heat load of any specified operating condition and the unloaded condition.

6.10.3.10.5 Cooler housing material shall be carbon steel.

6.10.3.10.6 [●] If specified, cooler housing material shall be stainless steel.

6.10.3.11 Pumps

6.10.3.11.1 Dual pumps shall be furnished in accordance with API 614. At least one pump shall be motor-driven.

6.10.3.11.2 Lube oil pumps shall be rotary positive displacement type.

6.10.3.11.3 [●] If specified, lube oil pumps shall comply with API 676.

6.10.3.11.4 [●] If specified a single pump may be furnished.

NOTE On some systems, the pump is required for start-up only.

6.10.3.11.5 A strainer shall be provided upstream of the pump(s).

6.10.3.12 Oil separators

6.10.3.12.1 For flooded screw compressors, an oil-separation vessel or vessels shall be supplied as specified in 6.10.3.12.2 to 6.10.3.12.10.

6.10.3.12.2 [●] The allowable oil carryover at the certified point (in parts per million by mass) in the process gas stream that leaves the separator shall be specified.

NOTE 1 The oil carryover can increase at operating conditions other than the certified point.

NOTE 2 Multiple separators can be required for services that have stringent limits on oil carryover.

6.10.3.12.3 If the allowable oil carry over is not specified by the purchaser, then the vendor shall identify the allowable oil carryover in the proposal.

6.10.3.12.4 [●] Separators shall be designed in accordance with the specified pressure design code.

6.10.3.12.5 Separators shall be constructed of carbon steel with a 3 mm (1/8 in.) corrosion allowance.

NOTE Austenitic stainless steel can be required for corrosive services or applications where the vessel interior is frequently exposed to the atmosphere.

6.10.3.12.6 Separators shall be equipped with the following characteristics and appendages:

a) capacity to avoid frequent filling and to provide adequate allowance for system rundown.

b) a minimum 2-minute retention time.

NOTE 1 Oil retention time is required for sufficient degassing to maintain the required oil characteristics and for certain application need to increase.

NOTE 2 Oil retention time can be reduced for some closed loop applications.

c) internal coalescing filtration and impingement baffles, as necessary to achieve the specified allowable oil-carryover concentration;

d) a flanged, safety relief valve in accordance with 7.7.4.6 of Part 1;

e) flanged opening [152.4 mm (6.0 in.) minimum] for servicing and cleaning of the separator internals;

f) separate flanged vent, filter drain (if applicable), oil-return, oil-fill and drain connections;

g) flanged, armored level gauge;

h) baffle by the gas inlet opening to help direct gas upward and oil downward;

i) stilling tubes on oil-fill and return connections to direct oil to a level below the minimum operating level;

j) vortex breaker upstream of the oil-outlet connection;

6.10.3.12.7 The vendor shall specify in the proposal, the proposed separator dimensions, and retention time, as well as maximum, minimum and normal operating levels. See Figure D.2.

6.10.3.12.8 [●] If specified separators shall have separate, flanged connections for instrumentations including level transmitters, pressure differential indicator, pressure indicator, oil-conditioner inlet, oil-conditioner outlet, and electric heater.

6.10.3.12.9 [●] If specified separators shall be equipped with separate austenitic stainless steel thermowell connections for a temperature transmitter and/or gauge.

6.10.3.12.10 [●] if specified, separators shall have an electric heater with temperature control.

6.11 Materials

Materials shall be in accordance with 6.11 of Part 1.

6.12 Nameplates and rotation arrows

Nameplates and rotation arrows shall be in accordance with 6.12 of Part 1.

7 Accessories

7.1 Drivers

Drivers shall be in accordance with 7.1 of Part 1.

7.2 Adjustable Frequency Drives (AFD) and Devices

AFD’s shall be in accordance with 7.2 of Part 1.

7.3 Couplings

Coupling shall be in accordance with 7.3 of Part 1.

7.4 Guards

Guarding shall be in accordance with 7.4 of Part 1.

7.5 Belt Drives

Belt drives are not permitted for oil-flooded compressors.

7.6 Baseplates and Soleplates

Baseplate and soleplate shall be in accordance with 7.6 of Part 1.

7.7 Controls and Instrumentation

Controls and instrumentation shall be in accordance with 7.7 of Part 1.

7.8 Piping

Piping shall be in accordance with 7.8 of Part 1 and the following.

7.8.1 Auxiliary Piping

The material of piping upstream of oil filters shall be agreed by the purchaser and the vendor.

NOTE The material of the oil separator and piping upstream of oil filters in oil-flooded screw-compressor systems is typically carbon steel.

7.8.2 Instrument Piping

Instrument piping and tubing, if furnished, shall be in accordance with API 614 or API 692, whichever applies.

7.8.3 Process Piping

Interconnecting piping between the compressor discharge and the separator vessel shall be sized to run no more than half-full of liquid and shall be designed with a minimum slope of 1:24 to ensure drainage toward the separator.

7.9 Special Tools

Special Tools shall be in accordance with 7.9 of Part 1.

7.10 Coatings, Insulation, Insulation, and Jacketing

Insulation shall be in accordance with 7.10 of Part 1.

7.11 Enclosures

Enclosure shall be in accordance with 7.11 of Part 1.

8 Inspection, Testing and Preparation for Shipment

Refer to Section 8 of Part 1 for inspection, testing and preparation for shipment requirements.

9 Vendor’s Data

Vendor’s data shall be in accordance with Section 9 of Part 1.

Annex A
(normative)
Oil-Flooded Screw Compressor Datasheets

A representation of the datasheets is enclosed in this annex; however, MS Excel format datasheets have been developed and are available, for purchase from API publications distributors, with this standard. The MS Excel electronic datasheets can have additional functionality over printed hard copies.

ROTARY-TYPE POSITIVE DISPLACEMENT COMPRESSOR OIL-FLOODED SCREW DATA SHEET SI UNITS

JOB NO. ______ ITEM NO. ______
PURCHASE ORDER NO. ______ DATE ______
REQUISITION NO. ______
INQUIRY NO. ______

DRAWING UNITS: SI US CUSTOM DUAL (4.3)

1 APPLICABLE TO: PROPOSAL PURCHASE AS BUILT DATE ______ REVISION ______
2 FOR ______ UNIT ______
3 SITE ______ SERIAL NO. ______
4 SERVICE ______ NO. REQUIRED ______
5 MANUFACTURER ______ MODEL ______ DRIVER (6.1) ______
6 NOTE: INDICATES INFORMATION TO BE COMPLETED BY PURCHASER BY MANUFACTURER

7 **OPERATING CONDITIONS**

	NORMAL	MAXIMUM	OTHER CONDITIONS (5.1.4)			
8						
9 **ALL DATA ON PER UNIT BASIS**	(3.28) (5.1.3)		A	B	C	D
10						
11 CERTIFIED POINT ( ) (5.1.4)						
12 GAS HANDLED (ALSO SEE PAGE 2)						
13 REQUIRED CAPACITY Nm^3/h (1.013 bar & 0 °C) (DRY) (3.4)						
REQUIRED CAPACITY Nm^3/h (1.013 bar & 0 °C) (WET)						
14 WEIGHT FLOW, kg/hr ~~(WET)~~(DRY)						
WEIGHT FLOW, kg/hr (WET)						
15 **INLET CONDITIONS:** COMPRESSOR INLET FLANGE CUSTOMER CONNECTION						
16 PRESSURE - ~~absolute~~ (bar a)						
17 TEMPERATURE (°C)						
18 RELATIVE HUMIDITY (%)						
19 MOLECULAR WEIGHT ~~(M)~~						
20 Cp/Cv (K_1) ~~OR (K_{AVG})~~ (5.1.15.d)						
21 COMPRESSIBILITY (Z_1) ~~OR (Z_{AVG})~~ (5.1.15 e)						
22 INLET VOLUME FLOW (m^3/h) (3.16)						
23 **DISCHARGE CONDITIONS:** COMPRESSOR DISCHARGE FLANGE CUSTOMER CONNECTION						
24 PRESSURE - ~~absolute~~ (bar a)						
25 TEMPERATURE (°C)						
26 Cp/Cv (K_2) ~~OR (K_{AVG})~~						
27 COMPRESSIBILITY (Z_2) ~~OR (Z_{AVG})~~						
28 DEW POINT (°C)						
29 OIL CARRYOVER (PPM-BY WT.)						
30 ~~kW REQUIRED (ALL LOSSES INCL)GAS POWER~~						
COMPRESSOR SHAFT POWER (kW)						
REQUIRED DRIVER POWER (ALL LOSSES INCL.) (kW)						
INSTALLED DRIVER POWER (KW)						
31 COMPRESSOR INPUT ROTOR SPEED (RPM)						
32 PRESSURE RATIO ~~(R)~~						
33 VOLUMETRIC EFFICIENCY (%)						
ADIABATIC EFFICIENCY (%)						
34 ~~SILENCER D P (bar) (6.9.2)~~						
35 SETTLE OUT PRESSURE - absolute (bar) (5.1.5)						
36 PERFORMANCE CURVE NO.						
37						

38 **PROCESS CONTROL:** (6.4.2.1)
39 METHOD: SLIDE VALVE CONTROL RANGE FROM ______ (Vol %) TO ______ (Vol %)
40 BYPASS FROM ______ TO ______
41 ~~BYPASS:~~ ~~MANUAL~~ ~~AUTO~~
42 SPEED VARIATION FROM ______ TO ______
43 OTHER ______
44 SIGNAL: SOURCE (6.4.2.1) ______
45 TYPE ELECTRONIC ______ Other ______
46 RANGE: ______ mA ~~FOR PNEUMATIC CONTROL~~ ______ ~~rev/min @~~ ______ ~~kPa (bar) &~~ ______ ~~rev/min @~~ ______ ~~kPa (bar)~~
47 OTHER ______
48 **SERVICE:** ~~SPECIAL PURPOSE (3.51)~~ ~~GENERAL PURPOSE (3.13)~~
49 CONTINUOUS INTERMITTENT STANDBY (3.53) ~~DRY SCREW (3.8)~~ ~~FLOODED SCREW (3.10)~~
50 **REMARKS:** ~~Unless otherwise noted, all pressures are GAUGE pressures.~~
51 ~~(Example: bar refers to gauge pressure; bar abs. refers to absolute pressure)~~
52 Purchaser can provide expected compresssor performance information in the remark.
53

ROTARY-TYPE POSITIVE DISPLACEMENT COMPRESSOR DATA SHEET SI UNITS

JOB NO. ______ ITEM NO. ______
REVISION NO. ______ DATE ______
 BY ______

GAS ANALYSIS (5.1.15.4) MOL %	M.W.	NORMAL	MAXIMUM	OTHER CONDITIONS A	B	C	D	REMARKS
	M.W.							
AIR	28.966							
OXYGEN	32.000							
NITROGEN	28.016							
WATER VAPOR	18.016							
CARBON MONOXIDE	28.010							
CARBON DIOXIDE	44.010							
HYDROGEN SULFIDE	34.076							(5.11.1.10)
HYDROGEN	2.016							
METHANE	16.042							
ETHYLENE	28.052							
ETHANE	30.068							
PROPYLENE	42.078							
PROPANE	44.094							
I-BUTANE	58.120							
n-BUTANE	58.120							
I-PENTANE	72.146							
n-PENTANE	72.146							
HEXANE PLUS								
CORROSIVE								(5.11.1.7)
SOLID PARTICLE								(5.1.25)
LIQUID PARTICLE								(5.1.25)
NACE MATERIALS								(5.11.1.10)
TOTAL								
RELATIVE MOLECULAR MASS								

SITE DATA:

LOCATION:

INDOOR HEATED UNDER ROOF
OUTDOOR UNHEATED PARTIAL SIDES
GRADE MEZZANINE ______
WINTERIZATION REQ'D. TROPICALIZATION REQ'D.
ELEVATION ______ m BAROMETER ______ (bar abs.)
RANGE OF AMBIENT TEMPS.:

	DRY BULB	WET BULB
SITE RATED °C		
NORMAL °C		
MAXIMUM °C		
MINIMUM °C		

ELECTRICAL AREA CLASSIFICATION: (5.1.18, IEC 60079)

ZONE ______ GROUP ______ CLASS ______
AREA: CL. ___ GR. ___ DIV. ___ NON-HAZARDOUS

UNUSUAL CONDITIONS: DUST FUMES
OTHER ______

VENDOR HAVING UNIT RESPONSIBILITY: (3.56) ______

NOISE SPECIFICATIONS: (5.1.19)

APPLICABLE TO MACHINE
SEE SPECIFICATION ______
APPLICABLE TO NEIGHBORHOOD
SEE SPECIFICATION ______
YES NO
SOUND LEVEL ______ dB @ ______ m ______
dB RE: 20 MICRO PASCAL

APPLICABLE SPECIFICATIONS:

ACOUSTIC ______
MOTOR ______

PAINTING:

MANUFACTURER'S STD.
APPLICABLE SPECIFICATIONS: ______
ISO 12944 CATEGORY ______
OTHER ______

SHIPMENT: (7.4.1)

DOMESTIC EXPORT EXPORT BOXING REQ'D
OUTDOOR STORAGE MORE THAN 6 MONTH ______ MONTHS
LIFTING TOOLS (7.4.9)

SPARE ROTOR ASSEMBLY PACKAGE

METAL STORAGE CONTAINER
N2 PURGE OTHER ______

REMARKS: ______

ELECTRICITY:

	DRIVERS	CONTROL	SHUTDOWN
VOLTAGE			
HERTZ			
PHASE			

ROTARY-TYPE POSITIVE DISPLACEMENT COMPRESSOR DATA SHEET SI UNITS

JOB NO. ______ ITEM NO. ______
REVISION NO. ______ DATE ______
 BY ______

Line		
1	**SPEEDS:**	**SHAFT:** (5.5.1.2)
2	MAX. CONT. (3.22) ______ RPM TRIP (3.55) ______ RPM	MATERIAL ______
3	MAX. TIP SPEEDS: ______ m/s @ MAX. OPER. SPEED	DIA @ ROTORS (mm) ______ DIA @ COUPLING (mm) ______
4	MIN. ALLOW (3.25) ______ RPM	SHAFT END. TAPERED CYLINDRICAL (5.5.1.5 & 5.5.1.6)
5	LATERAL CRITICAL SPEEDS: (5.7.1.4)	**SHAFT SLEEVES:**
6	FIRST CRITICAL ______ RPM	AT SHAFT SEALS ______ MATL. ______
7	DAMPED ______ UNDAMPED ______	~~**TIMING GEARS:** (5.5.2)~~
8	MODE SHAPE ______	~~PITCH LINE DIAMETER (mm)~~ ~~MALE:~~ ______ ~~FEMALE:~~ ______
9	LATERAL CRITICAL SPEED - BASIS:	~~MATERIAL~~ ______ ~~TYPE~~ ______
10	DAMPED UNBALANCE RESPONSE ANALYSIS	**SHAFT SEALS:** (5.6)
11	OTHER TYPE ANALYSIS: ______ (SPECIFY)	SEAL SYSTEM TYPE (5.6.1.7) ______
12	**POCKET PASSING FREQUENCY AT RATED SPEED:** ______ Hz	OIL LEAKAGE (CC/MIN/SEAL) ______
13	**TORSIONAL CRITICAL SPEEDS:** (5.7.2)	TYPE BUFFER GAS (5.6.2.1) ______
14	FIRST CRITICAL ______ RPM	BUFFER GAS FLOW (PER SEAL)
15	SECOND CRITICAL ______ RPM	NORMAL: ______ kg/hr. @ ______ (bar)
16	**VIBRATION:** (5.7.3.6) ______	MAX.: ______ kg/hr. @ ______ (bar)
17	HOUSING ______ mm/s RMS	**BEARING HOUSING:** (5.9)
18	SHAFT ______ μm	~~TYPE (SEPARATE, INTEGRAL)~~ ______ ~~SPLIT~~ ______
19	**ROTATION, LOOKING AT COMPRESSOR DRIVEN END:** CW CCW	MATERIAL ______
20	**CASING:**	**HYDRODYNAMIC RADIAL BEARING:** (IDENTIFY HIGHEST LOADED BEARING) (5.8.3.1)
21	MODEL ______	TYPE ______ SPAN (mm) ______
22	CASING SPLIT ______	AREA (mm^2) ______ LOADING (N/mm^2): ACT. ______ ALLOW. ______
23	MATERIAL ______ CLADDING (5.2.10) ______	~~NO. PADS~~ ______ ~~ROTOR ON~~ ______ ~~OR BETWEEN~~ ______ ~~PADS~~
24	~~OPERATION:~~ ~~DRY~~ ~~FLOODED, w/~~ ______ ~~LIQUID~~	~~PAD MATERIAL~~
25	~~THICKNESS (mm.)~~ ______ CORR. ALLOW (mm.) ______	TYPE BABBITT ______ THICKNESS ______ (mm)
26	MAX. ALLOWABLE WORK PRESS. (3.21) ______ (bar)	TEMP SENSORS (5.8.1.5) ______
27	RELIEF VALVE SETTING ______ (bar)	TC RTD TYPE ______
28	~~MARGIN FOR ACCUMULATION~~ ______ ______ ______ ~~(bar)~~	NO PER BRG ______
29	LEAK TEST GAS: ______ PRESS (barg)~~(kPa)~~: ______ (7.3.3.4.3)	**ROLLING ELEMENT RADIAL BEARING** (5.8.2)
30	TEST PRESS. (barg) (7.3.4.7) ______ HYDRO (7.3.2) ______	TYPE: ______ , Ndm: ______ mm/min
31	MAX. ALLOW. TEMP. ______ °C MIN. OPER. TEMP. ______ °C	______
	MIN DESIGN METAL TEMP ______ °C	______
	AT CONCURRENT PRESSURE ______ bar (G)	~~ENERGY DENSITY (kW-RPM):~~ ______
32	COOLING JACKET YES NO	**HYDRODYNAMIC THRUST BEARING:** (IDENTIFY HIGHEST LOADED BEARING)(5.8.3.2)
33	**ROTORS:** (5.5.1)	TYPE ______
34	DIAMETER (mm.): MALE: ______ FEMALE: ______	MFR. ______ AREA (mm^2) ______
35	NO. LOBES: MALE ______ FEMALE ______	LOADING (N/mm^2): ______ ACT. ______ ALLOW. ______
36	TYPE: SYMMETRIC ASYMMETRIC	NUMBER OF PADS ______
37	~~TYPE FABRICATION~~ ______	~~PAD~~ BACKING MATERIAL ______
38	MATERIAL ______	TYPE BABBITT ______ THICKNESS ______ (mm)
39	MAX. YIELD STRENGTH (N/mm^2) ______	TEMP SENSORS (5.8.1.5) ______
40	BRINELL HARDNESS. MAX. ______ MIN. ______	TC RTD TYPE ______
41	ROTOR LENGTH TO DIAMETER RATIO (L/D) ~~MALE:~~ ______	NO PER BRG ______ ACTIVE INACTIVE
42	~~ROTOR CLEARANCE (mm)~~ ______	**ROLLING ELEMENT THRUST BEARING** (5.8.2)
43	______	TYPE: ______ , Ndm: ______ mm/min
44	______ ______	______
45	~~INTERNALLY COOLED~~ ______ ~~YES~~ ~~NO~~	______
46		~~ENERGY DENSITY (kW-RPM):~~ ______
47		
48		
##	**REMARKS:** ______	
52	______	
53	______	

ROTARY-TYPE POSITIVE DISPLACEMENT COMPRESSOR DATA SHEET SI UNITS

JOB NO. ______ ITEM NO. ______

REVISION NO. ______ DATE ______

 BY ______

PROCESS CONNECTIONS - COMPRESSOR CASING(5.3):

	SIZE	RATING	FACING	ORIENTATION
INLET				
DISCHARGE				
INTERSTAGE				

PROCESS CONNECTIONS - CUSTOMER INTERFACE:

	SIZE	RATING	FACING	ORIENTATION
INLET				
DISCHARGE				

CASING - ALLOWABLE PIPING FORCES AND MOMENTS: (5.4)

		INLET		DISCHARGE		INTERSTAGE	
		FORCE N	MOMT N-m	FORCE N	MOMT N-m	FORCE N	MOMT N-m
AXIAL	X						
VERTICAL	Y						
HORIZ. 90°	Z						
AXIAL	X						
VERTICAL	Y						
HORIZ. 90°	Z						

OTHER CONNECTIONS:

SERVICE:	NO	SIZE	TYPE/RATING
LUBE OIL INLET			
~~LUBE OIL OUTLET~~			
SEAL ~~OIL~~ INLET			
SEAL OIL OUTLET			
CASING DRAINS (5.3.4)			
VENTS			
~~COOLING WATER~~ INLET			
~~COOLING WATER OUTLET~~			
LIQUID INJECTION			
OIL INJECTION			
~~PURGE FOR:~~			
~~BRG. HOUSING~~			
~~BETWEEN BRG. & SEAL~~			
~~BETWEEN SEAL & GAS~~			
OTHER			

VIBRATION DETECTORS: (6.4.4.3)

IN ACCORDANCE WITH: API670

SEE ATTACHED API 670 DATASHEET

TYPE: SEISMIC DISPLACEMENT

MODEL ______

MFR. ______

NO. AT SHAFT/HOUSING ______ TOTAL NO. ______

OSCILLATOR-DETECTORS SUPPLIED BY ______

MFR. ______ MODEL ______

MONITOR SUPPLIED BY ______

LOCATION ______ ENCLOSURE ______

MFR. ______ MODEL ______

SCALE RANGE ______ ALARM. ______ SET @ ______

SHUTDN: SET @ ______ TIME DLY. ______ SEC

PHASE REFERENCE TRANSDUCER

CASING VIBRATION TRANSDUCERS

TORSIONAL SHAFT VIBRATION PICKUP

OTHER

AXIAL POSITION DETECTOR: (6.4.4.3)

IN ACCORDANCE WITH: API 670 ______

SEE ATTACHED API 670 DATASHEET

TYPE ______ MODEL ______

MFR. ______ NO. REQ'D per Shaft/Total ______ / ______

OSCILLATOR-DETECTORS SUPPLIED BY ______

MFR. ______ MODEL ______

MONITOR SUPPLIED BY ______

LOCATION ______ ENCLOSURE ______

MFR. ______ MODEL ______

SCALE RANGE ______ ALARM: SET @ ______

SHUTDOWN: SET @ ______ TIME DELAY ______

COUPLINGS: (6.2)

IN ACCORDANCE WITH: API 671

SEE ATTACHED API 671 DATASHEET ~~IN ACCORDANCE WITH: API 671~~

OTHER (SPECIFY) ______

COUPLING FURNISHED BY ______ MOUNTED BY ______

COUPLING GUARD FURNISHED BY ______

	DRIVER-COMP ~~OR DRIVER~~	~~GEAR-COMP~~
MANUFACTURER ~~MAKE~~		
MODEL		
COUPLING TYPE		
MOUNT CPLG. HALVES		
~~SPACE REQUIRED~~ DBSE mm		
LIMITED END FLOAT REQ'D		
MOMENT SIMULATOR REQUIRED (6.2.5)		
CPLG. RATING (kW/100 RPM)		
KEYED (1) OR (2) OR HYDR. FIT		
COUPLING GUARD TYPE		

BASEPLATE & SOLEPLATES: (6.3.2 & 6.3.3)

SOLE PLATES FOR: COMPRESSOR GEAR DRIVER

BASEPLATE:

COMMON (UNDER COMP. GEAR & DRIVER)

UNDER COMP. ONLY OTHER ______

DECKED WITH NON-SKID DECK PLATE OPEN CONSTR.

DRIP RIM WITH OPEN DRAIN SUBPLATE

HORIZONTAL ADJUSTING SCREWS FOR EQUIPMENT

SUITABLE FOR COLUMN SUPPORT (6.3.2.4)

SUITABLE FOR PERIMETER SUPPORT

EPOXY GROUT/EPOXY PRIMER (6.3.1.6)

LUBE OIL SYSTEM (5.10)

LUBRICANT MANUFACTURER ______

LUBRICANT TYPE ______ GRADE (ISO 3448) ______

614 LUBE OIL SYSTEM FOR AUXILLIARIES (~~5.10.2.3 & 5.10.3, APPENDIX D~~)

API 614 Data Sheet No.:

~~COMMON (5.10.2.1)~~ ~~DEDICATED SYSTEM~~

OIL FILTER (5.10.3.6)

Housing Material Stainless Steel Other

OIL COOLER (5.10.3.3): ______ Dual ______

TYPE ______

Housing Material Stainless Steel Other

OIL PUMP (5.10.3.4): TYPE ______ NO: ______

OIL SEPARATOR (5.10.3.5)

TYPE ______ NO ______

OIL CARRYOVER (PPM-BY WT.) (LITER/DAY) ______

RETENTION TIME (MIN) ______

RELIEF VALVE ELECTRIC HEATER

OTHER

ROTARY-TYPE POSITIVE DISPLACEMENT COMPRESSOR DATA SHEET SI UNITS

JOB NO. ______ ITEM NO. ______
REVISION NO. ______ DATE ______
 BY ______

1 UTILITY CONDITIONS: (ALL UNITS ARE GAUGE)

			DRIVERS	HEATING
2 STEAM				
3	INLET	MIN.	___ kPa (bar) ___ °C	~~kPa (bar)~~ ___ ~~°C~~
4		NORM	___ kPa (bar) ___ °C	~~kPa (bar)~~ ___ ~~°C~~
5		MAX.	___ kPa (bar) ___ °C	~~kPa (bar)~~ ___ ~~°C~~
6	EXHAUST	MIN.	___ kPa (bar) ___ °C	~~kPa (bar)~~ ___ ~~°C~~
7		NORM	___ kPa (bar) ___ °C	~~kPa (bar)~~ ___ ~~°C~~
8		MAX.	___ kPa (bar) ___ °C	~~kPa (bar)~~ ___ ~~°C~~
	UTILITY	MIN.	___ kPa (bar) ___ °C	
		NORM	___ kPa (bar) ___ °C	
		MAX.	___ kPa (bar) ___ °C	

9 ELECTRICITY:

10	LOW VOLTAGE	MEDIUM VOLTAGE	HEATING	CONTROL	~~SHUT-DOWN~~
DRIVER(MAIN/AUX.)	___	___	___	___	
11 VOLTAGE	___	___	___	___	
12 HERTZ	___	___	___	___	
13 PHASE	___	___	___	___	

14 COOLING WATER
15 TEMP. INLET ______ °C MAX. RETURN ______ °C
16 PRESS. NORM ______ kPa (bar) DESIGN ______ kPa (bar)
17 MIN. RETURN ___ kPa (bar) MAX. ALLOW Δ P ______ kPa (bar)
18 WATER SOURCE ______
19 INSTRUMENT AIR:
20 MAX PRESS ______ kPa (bar) MIN. ______ kPa (bar)
DEW POINT ______ °C

21 TOTAL UTILITY CONSUMPTION:
22 COOLING WATER ______ m^3/h
23 STEAM, NORMAL ______ kg/h
24 STEAM, MAX ______ kg/h
25 INSTRUMENT AIR ______ Nm^3/h
26 HP (DRIVER) ______ kW
27

28 SHOP INSPECTION AND TESTS: (7.1)	REQ'D	WITNESS	OBSERVE
29 SHOP INSPECTION (7.1.5)	o	o	o
30 HYDROSTATIC (7.3.2)	o	o	o
31 HELIUM LEAK (7.3.4.7)	o	o	o
32 MECHANICAL RUN (7.3.3)	o	o	o
Real-time vibration data provided (7.3.3.3.3)			
Lube oil & seal oil pressure & temperature varied (7.3.3.3.4)			
33 MECHANICAL RUN SPARE ROTORS (7.3.3.4.2)	o	o	o
34 CASING LEAK TEST (7.3.3.4.3)	o	o	o
35 PERFORMANCE TEST (GAS) (AIR) (7.3.4.2)	o	o	o
36 COMPLETE UNIT TEST (7.3.4.2)	o	o	o
TORSIONAL VIBRATION MEASUREMENT (7.3.4.3)			
37 USE SHOP LUBE ~~& SEAL~~ SYSTEM	o	o	o
USE SHOP SEAL SYSTEM			
38 USE JOB LUBE & SEAL SYSTEM (7.3.4.9)	o	o	o
39 USE SHOP VIBRATION ~~PROBES~~ INSTRUMENTATIONS, ETC.	o	o	o
40 USE JOB ~~VIBRATION & AXIAL DISP. PROBES~~ INSTRUMENTATIONS	o	o	o
41 USE SHOP MONITORING EQUIPMENT ~~JOB SEISMIC TRANSDUCERS~~	o	o	o
42 USE JOB MONITORING EQUIPMENT	o	o	o
43 PRESSURE COMP. TO FULL OPER. PRESSURE	o	o	o
44 POST-TEST INSPECTION ~~DISASSSEMBLE-REASSEMBLE COMP.~~			
45 ~~AFTER TEST (7.3.4.10)~~	o	o	o
46 SOUND-LEVEL TEST (7.3.4.8)	o	o	o
47 TANDEM TEST (7.3.4.5)	o	o	o
48 AUX.-EQUIPMENT TEST (7.3.4.9)	o	o	o
49 FULL-LOAD TEST (7.3.4.11)	o	o	o
50 RESIDUAL UNBALANCE CHECK (5.7.3.5)	o	o	o
51			

WEIGHTS ~~MASSES~~ (~~KG~~kg):
COMPR. ______ GEAR ______ DRIVER ______ BASE ______
ROTORS: COMPR. ______ DRIVER ______ GEAR ______
COMPR. UPPER CASE ______
L.O. CONSOLE ______ S.O. CONSOLE ______
MAX. FOR MAINTENANCE (IDENTIFY) ______
TOTAL SHIPPING WEIGHT ~~MASS~~ ______

SPACE REQUIREMENTS (mm):

	L	W	H
COMPLETE UNIT			
L.O. CONSOLE			
S.O. CONSOLE:			

MISCELLANEOUS:
~~RECOMMEND STRAIGHT RUN OF PIPE DIA. BEFORE SUCTION~~
VENDOR'S REVIEW & COMMENTS ON PURCHASER'S PIPING & FOUNDATION (5.1.16)
VENDOR'S REVIEW & COMMENTS ON PURCHASER'S CONTROL SYSTEMS
VENDOR REPRESENTATIVE OBSERVATION AT THE SITE (5.1.17)
~~OPTICAL ALIGNMENT FLATS REQUIRED ON COMPRESSOR, GEAR & DRIVER~~
LATERAL ANALYSIS REPORT REQUIRED (5.7.1.4)
TORSIONAL ANALYSIS REPORT REQUIRED (5.7.2.1)
~~CASING MOUNTED TORSIONAL SHAFT VIBRATION PICKUP~~
COORDINATION MEETING (8.1.3)
KICK OFF MEETING
DESIGN REVIEW MEETING
PRE-INSPECTION MEETING
MODEL REVIEW MEETING
HAZOP MEETING

INLET & DISCHARGE DEVICES:
HIGH EFFICIENCY INLET SEPARATOR REQUIRED (6.8.2)
INLET AIR FILTER DP INDICATION TYPE (6.7.3) Check with general team
~~PULSATION SUPPRESSORS FURNISHED BY~~ ______
STRAINER DP INDICATION TYPE ______
NON RETUEN VALVE TYPE
LOCATION

SPARE PARTS TO BE SUPPLIED (8.2.3F)
o ROTOR ASSEMBLY
o SEALS GASKETS, O-RINGS Bearings
o START-UP/COMMISSIONING
o 2 YEARS SUPPLY
o OTHER: ______

REMARKS: ______

ROTARY-TYPE POSITIVE DISPLACEMENT COMPRESSOR DATA SHEET SI UNITS

JOB NO. ____ ITEM NO. ____
REVISION NO. ____ DATE ____
 BY ____

VENDOR MUST FURNISH ALL PERTINENT DATA FOR THIS SPECIFICATION SHEET BEFORE RETURNING.
ITEM NO. ____ SERVICE ____ JOB NO. ____
MANUFACTURER ____

1 ~~REFERENCE SPECIFICATIONS: (6.4.1.2)~~
2 ~~ISO 10438~~ o ~~YES~~ o ~~NO~~
3 ~~NOTE For the purposes of this provision API 614 is equivalent to ISO 10438~~
4 ____
5 ____
6 ____
7 ____

~~APPLICABLE SPECIFICATIONS:~~ ~~IEC~~ ____ ~~NEMA~~ ____
~~AREA CLASSIFICATION:~~
O ~~ZONE~~ ____ ~~GROUP~~ ____ ~~CLASS~~ ____
O ~~AREA: CL.~~ ____ ~~GR.~~ ____ ~~DIV.~~ ____ ~~NON-HAZARDOUS~~
MOTOR CONTROL & INSTRUMENT VOLTAGE:
VOLTS ____ PHASE ____ CYCLES ____
ALARM & SHUTDOWN VOLTAGE:
VOLTS ____ PHASE ____ CYCLES OR ____ DC

8 ~~LOCAL~~ **CONTROL PANEL: (6.4.3)**
9 FURNISHED BY: ○ VENDOR ☐ PURCHASER OTHERS ____
☐ LOCAL ____ ☐ REMOTE ____
10 FREE STANDING WEATHERPROOF TOTALLY ENCLOSED ~~EXTRA CUTOUTS~~
11 VIBRATION ISOLATORS ☐ ~~STRIP~~ CABINET HEATERS ☐ PURGE CONNECTIONS
12 ANNUNCIATOR: FURNISHED BY: VENDOR ☐ PURCHASER OTHERS ____
13 ANNUNCIATOR LOCATED ON ☐ ~~LOCAL~~ CONTROL PANEL ☐ MAIN CONTROL BOARD
14 CUSTOMER CONNECTIONS BROUGHT OUT TO TERMINAL BOXES BY VENDOR

These symbols to be updat

15 **INSTRUMENT SUPPLIERS:**

16	PRESSURE GAUGES:	MFR.	____	SIZE & TYPE:	____
17	TEMPERATURE GAUGES:	MFR.	____	SIZE & TYPE:	____
18	LEVEL GAUGES:	MFR.	____	SIZE & TYPE:	____
19	DIFF. PRESSURE GAUGES:	MFR.	____	SIZE & TYPE:	____
20	PRESSURE ~~SWITCHES~~ TRANSMITTERS:	MFR.	____	SIZE & TYPE:	____
21	DIFF. PRESSURE ~~SWITCHES~~ TRANSMITTERS:	MFR.	____	SIZE & TYPE:	____
22	TEMPERATURE ~~SWITCHES~~ TRANSMITTERS:	MFR.	____	SIZE & TYPE:	____
23	LEVEL ~~SWITCHES~~ TRANSMITTERS:	MFR.	____	SIZE & TYPE:	____
24	CONTROL VALVES:	MFR.	____	SIZE & TYPE:	____
25	PRESSURE RELIEF VALVES: (6.4.4.6)	MFR.	____	SIZE & TYPE:	____
26	THERMAL RELIEF VALVES: (6.4.4.6.4)	MFR.	____	SIZE & TYPE:	____
27	OIL SIGHT FLOW INDICATORS: (6.4.4.9)	MFR.	____	SIZE & TYPE:	____
28	~~GAS FLOW INDICATOR~~ FLOW TRANSMITTER:	MFR.	____	SIZE & TYPE:	____
29	VIBRATION EQUIPMENT:	MFR.	____	SIZE & TYPE:	____
30	TACHOMETER: (6.4.4.2)	MFR.	____	RANGE & TYPE:	____
31	SOLENOID VALVES	MFR.	____	SIZE & TYPE:	____
32	ANNUNCIATOR: (6.4.5.4)	MFR.	____	MODEL & NO. POINTS	____
33	DEPRESSURIZATION VALVE (6.4.4.7)	MFR.	____	SIZE & TYPE:	____
34	THERMOCOUPLES ____	MFR.	____	SIZE & TYPE:	____
	RTDs ____	MFR.	____	SIZE & TYPE:	____
	THERMOWELLS ____	MFR.	____	SIZE & TYPE:	____

35 NOTE: SUPPLIED BY VENDOR SUPPLIED BY PURCHASER

Use the following code letters for details of panel mounted items:

L - Locally mount on piping	**B** - Local equipment panel	**C** - Remote equipment panel
F - Flush mount on front	**H** - Purchaser remote mount (control room)	**CP** - Cutout for purchaser item
S - Surface mount on front	**P** - Purchaser supply and mount	**M** - Mount by vendor of purchaser item
R - Rear of panel mount	**V** - Vendor supply and mount	

36 **PRESSURE INDICATOR ~~GAUGE~~ REQUIREMENTS** ~~LOCALLY~~ L ~~LOCALLY~~ B C
37 **FUNCTION** ~~MOUNTED (3.12)~~ ~~PANEL (3.31)~~

	FUNCTION		LOCALLY MOUNTED	PANEL
38	O LUBE OIL PUMP DISCHARGE	____	☐	☐
39	O LUBE OIL FILTER ∆ P	____	☐	☐
40	O LUBE OIL SUPPLY	____	☐	☐
41	O SEAL OIL PUMP DISCHARGE	____	☐	☐
42	O SEAL OIL FILTER ∆ P	____	☐	☐
43	O SEAL OIL SUPPLY (EACH LEVEL)	____	☐	☐
44	O SEAL OIL DIFFERENTIAL	____	☐	☐
45	O REFERENCE GAS	____	☐	☐
46	O BALANCE LINE	____	☐	☐
47	O ~~SEAL EDUCTOR~~	____	☐	☐
48	O BUFFER SEAL	____	☐	☐
49	O OIL/GAS COALESCING FILTER ∆ P	____	☐	☐

FUNCTION ~~LOCALLY MOUNTED (3.12)~~ L ~~LOCALLY PANEL (3.31)~~ B C

FUNCTION		LOCALLY MOUNTED	PANEL
O ~~GOV. CONTROL OIL~~	____		○
O ~~GOV. CONTROL OIL D-P~~	____		○
O ~~MAIN STEAM IN~~	____		○
O ~~1ST STAGE STEAM~~	____		○
O ~~STEAM CHEST~~	____		○
O ~~EXHAUST STEAM~~	____		○
O ~~EXTRACTION STEAM~~	____		○
O ~~STEAM EJECTOR~~	____		○
O COMPRESSOR SUCTION	____		○
O COMPRESSOR DISCHARGE	____		○
O ____	____		○

ROTARY-TYPE POSITIVE DISPLACEMENT COMPRESSOR DATA SHEET SI UNITS

JOB NO. ______ ITEM NO. ______
REVISION NO. ______ DATE ______
 BY ______

VENDOR MUST FURNISH ALL PERTINENT DATA FOR THIS SPECIFICATION SHEET BEFORE RETURNING.
ITEM NO. ______ SERVICE ______ JOB NO. ______
MANUFACTURER ______

1 **TEMPERATURE GAUGE REQUIREMENTS:**

	FUNCTION	~~LOCALLY~~ ~~MOUNTED (3.12)~~	~~LOCALLY~~ B ~~PANEL (3.31)~~	C
2–3	**FUNCTION**			
4	~~LUBE OIL DISCHARGE FROM EA.~~	☐	☐	
5	~~COMPR. JOURNAL BEARING~~	☐	☐	
6	~~DRIVER JOURNAL BEARING~~	☐	☐	
7	~~GEAR JOURNAL BEARING~~	☐	☐	
8	~~COMPRESSOR THRUST BEARING~~	☐	☐	
9	~~DRIVER THRUST BEARING~~	☐	☐	
10	~~GEAR THRUST BEARING~~	☐	☐	

FUNCTION	~~LOCALLY~~ L ~~MOUNTED (3.12)~~	~~LOCALLY~~ B C ~~PANEL (3.31)~~
COOLER OIL INLET & OUTLET		☐
SEAL OIL INLET		
SEAL OIL OUTLET		☐
COMPRESSOR SUCTION		☐
COMPRESSOR DISCHARGE		☐
LUBE OIL		
LUBE OIL		

Use the following code letters for details of panel mounted items:
- L - Locally mount on piping
- F - Flush mount on front
- S - Surface mount on front
- R - Rear of panel mount
- B - Local equipment panel
- H - Purchaser remote mount (control room)
- P - Purchaser supply and mount
- V - Vendor supply and mount

Refer to API 614 DATASHEET

11 **MISCELLANEOUS INSTRUMENTATION:**
12 DRIVER START/STOP ☐ B ~~LOCAL PANEL~~ ☐ ~~SEPARATE PANEL~~ ☐ C ~~MAIN BOARD~~
13 ~~SIGHT FLOW INDICATORS, EACH JOURNAL & THRUST BEARING & EACH COUPLING OIL RETURN LINE~~
14 ~~SIGHT FLOW INDICATORS, EACH SEAL OIL RETURN LINE~~
15 LEVEL GAUGES, ~~LUBE~~ SEPARATOR AND/OR SEAL OIL RESERVOIR, S.O. DRAIN POT ~~TRAPS & S.O. OVERHEAD TANK~~
16 VIBRATION AND SHAFT POSITION PROBES & PROXIMITORS
17 VIBRATION AND SHAFT POSITION ~~READOUT~~ MONITORING EQUIPMENT
18 VIBRATION READOUT LOCATED ON: B ~~LOCAL PANEL~~ ☐ ~~SEPARATE PANEL~~ ☐ C ~~MAIN BOARD~~
19 ~~TURBINE SPEED PICKUP DEVICES~~
20 ~~TURBINE SPEED INDICATORS~~
21 ~~TURBINE SPEED INDICATORS LOCATED ON:~~ LOCAL PANEL MAIN BOARD
22 REMOTE HAND SPEED CHANGER - MOUNTED ON LOCAL PANEL
23 ALARM HORN & ACKNOWLEDGMENT SWITCH
HEAT DETECTOR
GAS DETECTOR
SLIDE VALVE POSITION

24 **ALARM & SHUTDOWN: (6.4.5.2)**

	FUNCTION	ALARM	TRIP	SHUTDOWN
26	LOW BEARING LUBE OIL DIFF. PRESSURE			
27	HI LUBE OIL FILTER Δ P			
28	HI SEAL OIL FILTER Δ P			
29	LOW LUBE OIL SEPARATOR ~~RESERVOIR~~ LEVEL			
30	LOW SEAL OIL RESERVOIR LEVEL			
31	HI SEAL OIL DRAIN POT LEVEL			
32	~~LOW SEAL OIL LEVEL~~			
33	HI SEAL OIL PRESSURE			
34	LOW SEAL OIL PRESSURE			
35	AUX. SEAL OIL PUMP START			
36	AUX. LUBE OIL PUMP START			
37	HI SEAL OIL OUTLET TEMP. (COOLER)			
38	HI LIQUID LEV. SUCT. SEPARATOR			
39	COMPRESSOR HI DISCH. TEMP.			
	COMPRESSOR VIBRATION			
	COMPRESSOR AXIAL POSITION			
40	HI LUBE OIL SUPPLY TEMPERATURE			

FUNCTION	~~PRE-~~ ALARM	TRIP	SHUTDOWN
~~TURBINE VIBRATION~~			
~~TURBINE AXIAL POSITION~~			
GEAR VIBRATION			
GEAR AXIAL POSITION			
COMPRESSOR MOTOR SHUTDOWN			
~~TRIP & THROTTLE VALVE SHUT~~			
~~HI TURB. STEAM SEAL LEAKAGE~~			
HI COMPR. THRUST BRG. TEMP.			
HI COMPR. ~~JOURNAL~~ RADIAL BRG. TEMP.			
~~HI DRIVER THRUST BRG. TEMP.~~			
HI DRIVER ~~JOURNAL~~ RADIAL BRG. TEMP.			
HI GEAR THRUST BRG. TEMP.			
HI GEAR ~~JOURNAL~~ RADIAL BRG. TEMP.			
~~COMPRESSOR~~ Δ P			
~~LOW SEAL GAS PRESSURE~~			
HI COALESCING GAS/OIL FILTER Δ P			

41 ~~**CONTACTS:**~~
41 ~~ALARM CONTACTS SHALL:~~ ~~OPEN~~ ~~CLOSE TO SOUND ALARM AND BE NORMALLY~~ ~~ENERGIZED~~ ~~DE-ENERGIZED~~
42 ~~SHUTDOWN CONTACTS SHALL:~~ ~~OPEN~~ ☐ ~~CLOSE TO TRIP AND BE NORMALLY~~ ~~ENERGIZED~~ ~~DE-ENERGIZED~~
43 ~~**NOTE:**~~ ~~NORMAL CONDITION IS WHEN COMPRESSOR IS IN OPERATION.~~
44 ~~**MISCELLANEOUS:**~~
45 ~~INSTRUMENT TAGGING REQUIRED.~~
46 ~~ALARM AND SHUTDOWN SWITCHES SHALL BE SEPARATE.~~
47 ~~PURCHASERS ELECTRICAL AND INSTRUMENT CONNECTIONS WITHIN THE CONFINES OF THE BASEPLATE AND CONSOLE SHALL~~
48 ~~BE:~~ ~~BROUGHT OUT TO TERMINAL BOXES.~~ ~~MADE DIRECTLY BY THE PURCHASER.~~
49 ~~COMMENTS REGARDING INSTRUMENTATION:~~ ______
50

ROTARY-TYPE POSITIVE DISPLACEMENT COMPRESSOR DATA SHEET SI UNITS

JOB NO. ______ ITEM NO. ______
REVISION NO. ______ DATE ______
 BY ______

~~APPLICABLE TO:~~ ~~PROPOSAL~~ ~~PURCHASE~~ ~~AS BUILT~~
~~FOR~~ ______ ~~UNIT~~ ______
~~SITE~~ ______ ~~DRIVEN EQUIP.~~ ______
~~SERVICE~~ ______ ~~NO. REQUIRED~~ ______
~~MANUFACTURER~~ ______ ~~MODEL~~ ______ ~~SERIAL NO.~~ ______
~~NOTE:~~ ~~INDICATES INFORMATION TO BE COMPLETED BY PURCHASER~~ ~~BY MANUFACTURER~~

~~MOTOR DESIGN DATA~~

~~APPLICABLE SPECIFICATIONS:~~
~~IEC~~ ______ ~~NEMA~~ ______
~~API 541 (6.1.2.2)~~ ______
______
~~SITE DATA:~~
~~ZONE~~ ______ ~~GROUP~~ ______ ~~CLASS~~ ______
~~AREA:~~ ~~CL.~~ ______ ~~GR.~~ ______ ~~DIV.~~ ______ ~~NON-HAZARDOUS~~
~~ALT.~~ ______ ~~m~~ ~~AMB. TEMPS: MAX.~~ ______ ~~°C, MIN~~ ______ ~~°C~~
~~UNUSUAL CONDITIONS:~~ ~~DUST~~ ~~FUMES~~
~~OTHER~~ ______
~~DRIVE SYSTEM:~~
~~DIRECT CONNECTED~~ ~~GEAR~~ ~~OTHER~~ ______
~~TYPE MOTOR: (6.1.2.1)~~
~~SQUIRREL-CAGE INDUCTION~~ ~~NEMA DESIGN~~ ______
~~SYNCHRONOUS~~ ______
~~POWER FACTOR REQD.~~ ______
~~EXCITATION:~~ ~~BRUSHLESS~~ ~~SLIP-RING~~
~~FIELD DISCHARGE RESISTOR BY MOTOR MFR.~~
~~WOUND-ROTOR INDUCTION~~
______
~~ENCLOSURE: (6.1.2.1.c)~~
~~TEFC~~
~~TEWAC~~ ______ ~~TEIGF, USING~~ ______ ~~GAS~~
~~DOUBLE WALL CARBON STEEL TUBES~~
~~WATER SUPPLY: PRESS.~~ ______ ~~(bar) (kPa) TEMP~~ ______ ~~°C~~
~~WATER ALLOW. D-P~~ ______ ~~(bar) (kPa) & TEMP RISE~~ ______ ~~°C~~
~~WATER SIDE MIN. CORR. ALLOW.~~ ______ ~~mm~~
~~AND FOUL FACTOR~~ ______
~~(AIR) (GAS) SUPPLY PRESS.~~ ______ ~~(bar) (kPa)~~
______
~~WEATHER PROTECTED, TYPE~~ ______
~~FORCED VENTILATED~~
~~OPEN DRIPPROOF~~
~~OPEN~~
~~EExe~~ ~~EExpe~~
~~EExd(e)~~ ~~Ex, xp / ExN~~
~~BASIC DATA:~~
______ ~~VOLTS~~ ______ ~~PHASE~~ ______ ~~HERTZ~~
~~NAMEPLATE kW~~ ______ ~~SERVICE FACTOR (6.1.2.1.g)~~ ______
~~SYNCHRONOUS RPM~~
~~INSULATION: CLASS~~ ______ ~~TYPE~~ ______
~~TEMP. RISE:~~ ______ ~~°C~~ ~~ABOVE~~ ______ ~~°C~~ ~~BY~~ ______
______ ______ ______

~~MOTOR DESIGN DATA (CONT'D)~~

~~STARTING: (6.1.2.1 b)~~
~~FULL VOLTAGE~~ ~~REDUCED VOLTAGE~~ ______ ~~%~~
~~LOADED~~ ~~UNLOADED~~
~~VOLTAGE DIP~~ ______ ~~%~~
~~VIBRATION:~~
~~IEC STANDARD~~ ______ ~~NEMA STANDARD~~ ______
~~NOISE:~~
~~IEC STANDARD~~ ~~NEMA STANDARD~~ ______

~~ACCESSORY EQUIPMENT~~

~~BASEPLATE~~ ~~SOLEPLATE~~ ~~STATOR SHIFT~~
~~MFR. STD. FANS~~ ~~NON-SPARKING FANS~~
~~D.C. EXCITATION:~~
~~KW REQD~~ ______ ~~VOLTS~~ ______
~~BY:~~ ~~PURCHASER~~ ~~MANUFACTURER~~
~~DESCRIPTION~~ ______
~~ENCLOSED COLLECTOR RINGS:~~
~~PURGED: MEDIUM~~ ______ ~~PRESS.~~ ______ ~~(BAR) (KPa)~~
~~EXPLOSION-RESISTANT NON-PURGED~~
~~FORCED VENTILATION~~
~~m^3/h~~ ~~PRESS. DROP~~ ______ ~~mm H_2O~~
~~BEARING TEMP DEVICES:~~
~~LOCATION~~
~~DESCRIPTION~~
~~SET @~~ ______ ~~°C FOR ALARM~~ ______ ~~°C FOR SHUTDOWN~~
~~SPACE HEATERS:~~
______ ~~KW~~ ______ ~~VOLTS~~ ______ ~~PHASE~~ ______ ~~HERTZ~~
~~MAX. SHEATH TEMP.~~ ______ ~~°C~~
~~WINDING TEMPERATURE DETECTORS:~~
~~THERMISTORS:~~ ~~NO./PHASE~~ ______
~~TYPE:~~ ~~POS. TEMP. COEFF.~~ ~~NEG. TEMP. COEFF.~~
~~TEMPERATURE SWITCH:~~ ~~YES~~ ~~NO~~
~~RESISTANCE TEMPERATURE DETECTORS: NO./PHASE~~ ______
~~RESISTANCE MATL.~~ ______ ______ ~~OHMS~~
~~SELECTOR SWITCH & INDICATOR BY:~~ ~~PURCHR.~~ ~~MFR.~~
~~MAX. STATOR WINDING TEMPS:~~
______ ~~°C~~ ~~FOR ALARM~~ ______ ~~°C FOR SHUTDOWN~~
~~WINDING TEMP. DETECTOR & SPACE HEATER LEADS:~~
~~IN SAME CONDUIT BOX~~
~~IN SEPARATE CONDUIT BOXES~~
~~MOTOR ARRANGED FOR DIFFERENTIAL PROTECTION:~~
~~SELF-BALANCE PRIMARY-CURRENT METHOD~~
~~C.T. DESCRIPTION~~ ______
~~EXTENDED LEADS~~ ~~LENGTH~~ ______ ~~m~~
~~SURGE CAPACITORS~~

ROTARY-TYPE POSITIVE DISPLACEMENT COMPRESSOR DATA SHEET SI UNITS

JOB NO. ______ ITEM NO. ______

REVISION NO. ______ DATE ______

 BY ______

1	ACCESSORY EQUIPMENT (CONT'D)	MANUFACTURER'S DATA (CONT'D.)
2	LIGHTNING ARRESTERS	BEARING: TYPE ______ LUBR. ______
3	C.T. FOR AMMETER	LUBE OIL REQUIRED: ______ l/min @ ______ kPa (bar)
4	DESCRIPTION ______	TOTAL SHAFT END FLOAT ______
5	MAIN CONDUIT BOX SIZED FOR:	LIMIT END FLOAT TO ______
6	MAIN MOTOR LEADS TYPE: ______	MOTOR ROTOR: SOLID SPLIT
7	INSULATED NON-INSULATED	MOTOR HUB: SOLID SPLIT
8	C.T.'S FOR DIFF. PROTECTION (MOUNTED BY ______)	FOR TEWAC & TEIGF MOTORS:
9	SURGE CAPACITORS (MOUNTED BY ______)	COOLING WATER REQD. ______ m^3/h
10	LIGHTNING ARRESTERS (MOUNTED BY ______)	C.W. TEMP. RISE ______ °C PRESS. DROP ______ kPa (bar)
11	C.T. FOR AMMETER (MOUNTED BY ______)	(AIR) (GAS) REQD. ______ m^3/h PRESS. MAINT. ______ mm H2O
12	SPACE FOR STRESS CONES	CURVES REQD. BASED ON MTR SATURATION @ RATED
13	AIR FILTERS:	VOLTAGE:
14	MFR ______ TYPE ______	SPEED VS TORQUE (ALSO @ ______ % RATED VOLTAGE)
15	MANUFACTURER'S DATA	SPEED VS. POWER FACTOR
16	MANUFACTURER ______	SPEED VS CURRENT
17	FRAME NO. ______ FULL LOAD RPM (IND.) ______	MASSES (kg):
18	EFFICIENCY: F.L. ______ 3/4 L ______ 1/2 L ______	NET MASS ______ SHIPPING MASS ______
19	PWR. FACTOR (IND.): F.L. ______ 3/4 L ______ 1/2 L ______	ROTOR MASS ______ MAX. ERECTION MASS ______
20	CURRENT (RATED VOLT.): FULL LOAD ______ LOCKED ROT. ______	MAX.. MAINT. MASS (IDENTIFY) ______
21	LOCKED ROTOR POWER FACTOR ______	DIMENSIONS (MILIMETERS):
22	LOCKED ROTOR WITHSTAND TIME (COLD START) ______	L ______ W ______ H ______
23	TORQUES (N·m): FULL LOAD ______	SHOP INSPECTION AND TESTS
24	LOCKED ROTOR ______ STARTING (SYN.) ______	REQUIRED WITNESS
25	PULL-UP (IND) ______ PULL-IN (SYN.) ______	SHOP INSPECTION
26	BREAKDOWN (IND.) ______ PULL-OUT (SYN.) ______	TESTING PER IEC NEMA
27	______	MFR. STD. SHOP TESTS
28	OPEN CIRCUIT TIME CONSTANT (SEC.) ______	IMMERSION TEST
29	SYMMETRICAL CONTRIBUTION TO 30 TERMINAL FAULT:	SPECIAL TESTS (LIST BELOW)
30	AT 1/2 CYCLES ______ AT 5 CYCLES ______	______
31	REACTANCES: SUB-TRANSIENT (X"d)	______
32	TRANSIENT (X'd) ______ SYNCHRONOUS (Xd) ______	______
33	A.C. STATOR RESISTANCE ______ OHMS @ ______ °C	______
34	RATED KVA ______	PAINTING:
35	KVA INRUSH @ FULL VOLT. & LOCKED ROTOR (SYN.) ______ %	MANUFACTURER'S STANDARD
36	KVA. @ FULL VOLTAGE & 95% SPEED ______ %	
37	MAX. LINE CURR. IN STATOR ON 1ST SLIP CYC. @ PULL-OUT	SHIPMENT
38	(SYN.) ______	DOMESTIC EXPORT EXPORT BOXING REQUIRED
39	ACCELERATION TIME (MTR ONLY @ RATED VOLT.) ______ SEC	OUTDOOR STORAGE OVER 3 MONTHS
40	ACCEL.TIME (MTR & LOAD @ 85% RATED VOLT.) ______ SEC	
41	ROTOR/FIELD WK^2 @ MTR SHAFT ($N \cdot m^2$) ______	REMARKS:
42	ROTATION FACING COUPLING END ______	______
43	NO. OF STARTS PER HOUR ______	______
44	______	______
45	FIELD DISCHARGE RESISTOR ______ OHMS	______
46	RATED EXCITATION FIELD VOLTAGE ______ D.C.	______
47	RESISTANCE OF EXCITATION FIELD @ 25°C ______ OHMS	______
48	EXCITATION FIELD AMPS @ FULL LOAD & RATED P.F. ______	______
49	EXCITATION FIELD AMPS: MAX. ______ - MIN. ______	______
50	EXCITATION FIELD RHEOSTAT FIXED RESTR REQD.	______
51	SUPPLIED BY ______	______

Annex B
(Informative)
Typical Dry Screw Compressor Nomenclature

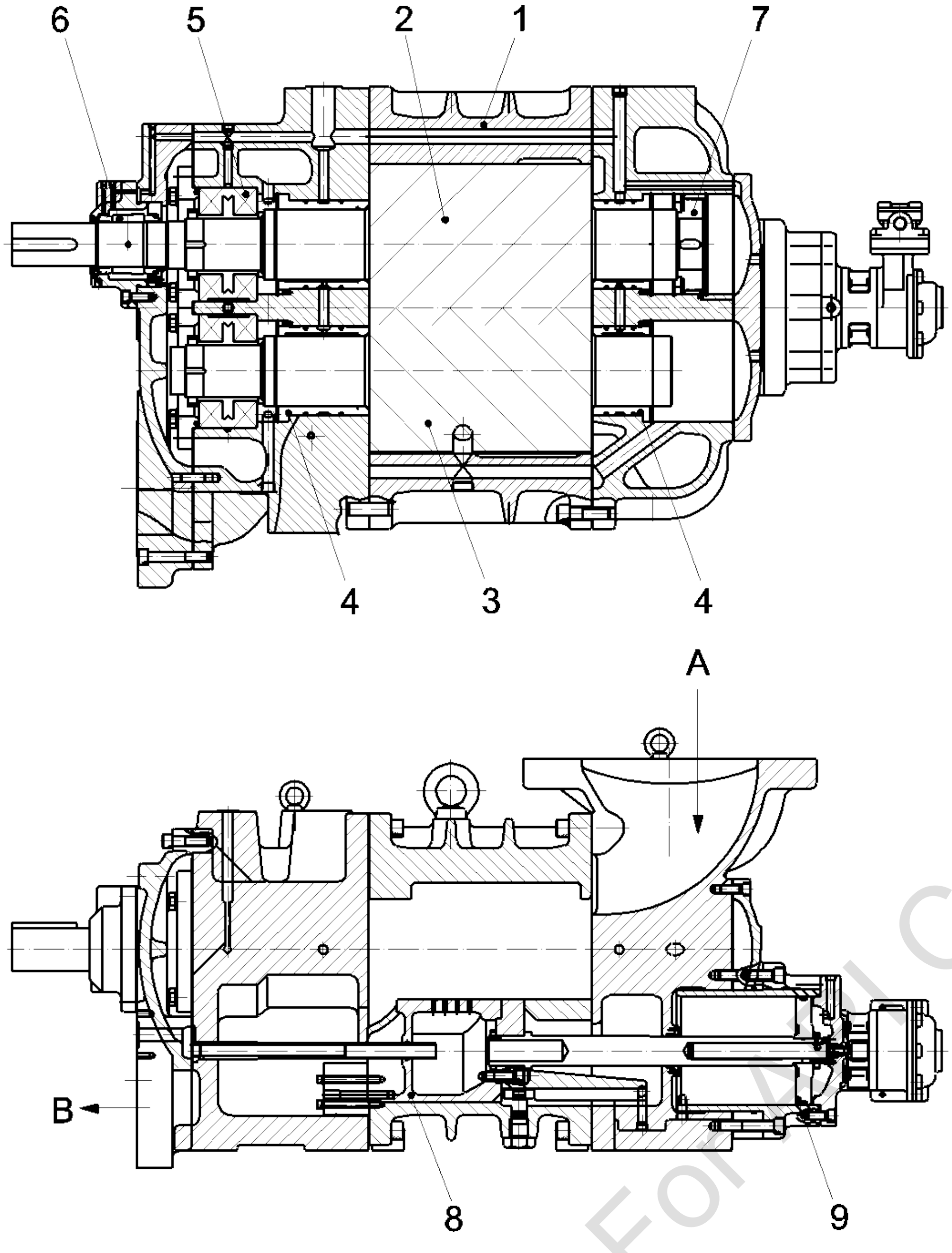


Figure B.1 — Sections through flooded screw compressor

Annex C
(Informative)
External Forces and Moments

General

C.1 As a minimum, the compressor shall be designed to withstand external forces and moments on each nozzle as tabulated in Tables C.1 and C.2. The vendor shall furnish the allowable forces and moments for each nozzle in tabular form.

C.2 These values of allowable forces and moments pertain to the compressor structure only. They do not pertain to the forces and moments in the connecting pipes, flanges and flange bolting, which shall not exceed the allowable stress specified by applicable codes and regulatory bodies.

C.3 Loads may be increased by mutual agreement between the purchaser and vendor; however, it is recommended that expected operating loads be minimized.

C.4 For nozzle sizes not given in Tables C.1 and C.2, the allowable forces and moments shall be agreed between the purchaser and vendor.

Table C.1 — Allowable forces

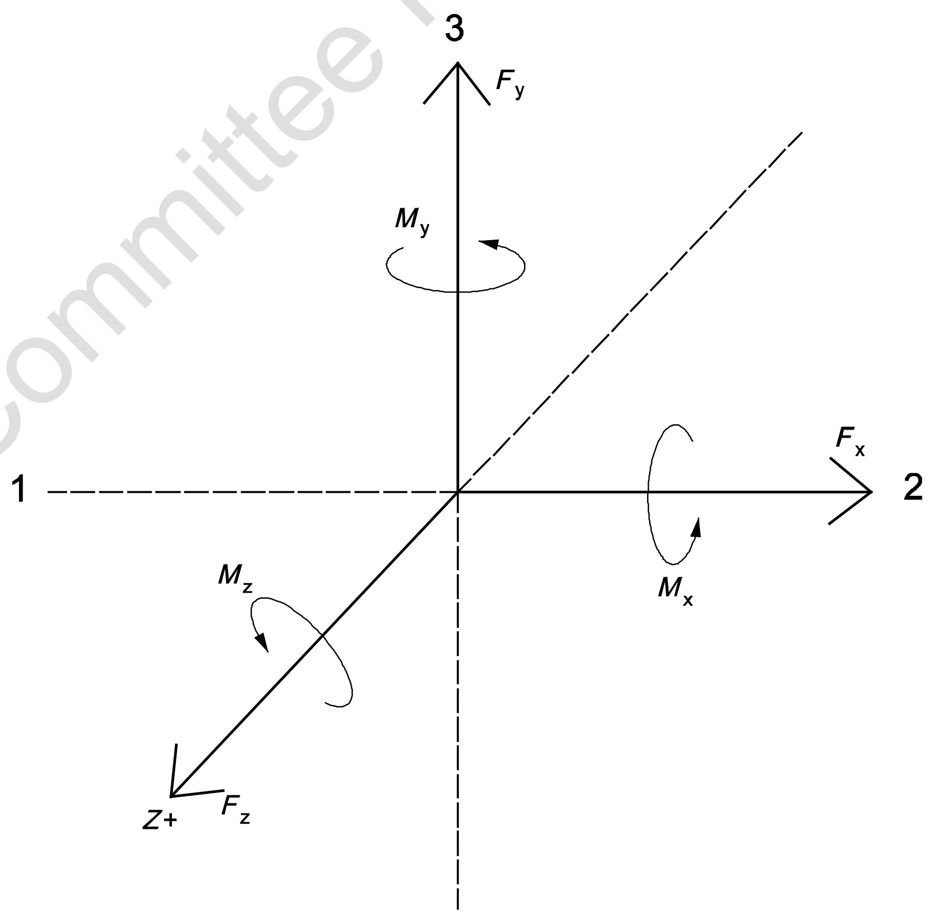
Force N	Nozzle nominal size DN								
	100	150	200	250	300	350	400	450	500
F_x	1 368	2 094	2 815	3 328	3 960	4 908	5 772	6 492	6 182
F_y	3 434	5 253	7 052	8 349	9 938	12 294	14 455	16 269	15 490
F_z	2 336	3 383	4 527	5 178	5 992	6 662	7 492	8 499	8 270
F_r	4 373	6 590	8 841	10 373	12 261	14 819	17 274	19 469	18 615
Force lb_f	Nozzle nominal size NPS								
	4	6	8	10	12	14	16	18	20
F_x	308	471	633	748	890	1103	1297	1 460	1 390
F_y	772	1 181	1 585	1 877	2 234	2 764	3 250	3 657	3 482
F_z	525	761	1 018	1 164	1 347	1 498	1 684	1 911	1 859
F_r	983	1 482	1 987	2 332	2 756	3 331	3 883	4 377	4 185
NOTE Nozzle nominal size DN is expressed in millimetres, nozzle nominal size NPS is expressed in inches.									

Table C.2 — Allowable moments

Moment N·m	Nozzle nominal size DN								
	100	150	200	250	300	350	400	450	500
M_x	2 069	2 754	3 672	4 212	5 097	6 232	7 316	9 605	9 191
M_y	1 253	2 126	2 836	3 648	4 190	5 656	6 781	7 153	6 762
M_z	1 253	1 698	2 264	2 814	3 334	4 491	5 450	7 153	6 762
M_r	2 724	3 871	5 163	6 242	7 393	9 539	11 367	13 949	13 264
Moment ft·lb$_f$	Nozzle nominal size NPS								
	4	6	8	10	12	14	16	18	20
M_x	1 526	2 031	2 709	3 107	3 759	4 597	5 396	7 084	6 779
M_y	924	1 568	2 091	2 691	3 090	4 171	5 001	5 275	4 988
M_z	924	1 252	1 670	2 076	2 459	3 312	4 020	5 275	4 988
M_r	2 009	2 855	3 808	4 604	5 453	7 036	8 384	10 288	9 783
NOTE Nozzle nominal size DN is expressed in millimetres, nozzle nominal size NPS is expressed in inches.									

Equations

The x, y and z axes are defined in Figure C.1.



Key

1 drive end

2 axes parallel to compressor shaft

3 vertical axes

Figure C.1 — Definition of axes

The resultant force, F_r, is given by Equation (C.1):

$$F_r = \sqrt{F_x^2 + F_y^2 + F_z^2} \tag{C.1}$$

where F_x, F_y and F_z are the force components along the x-, the y- and the z-axis, respectively.

The resultant moment, M_r , is given by Equation (C.2):

$$M_r = \sqrt{M_x^2 + M_y^2 + M_z^2} \tag{C.2}$$

where M_x, M_y and M_z are the moments around the x-, the y- and the z-axis, respectively

Annex D
(informative)

Typical schematics for pressurized oil systems for flooded screw compressors

D.1 Requirements for oil systems and oil-system components for flooded compressors are detailed in 6.10.3.

D.2 Oil-Flooded screw compressors incorporate a pressurized reservoir and gas/oil separator(s) in their oil system, which results in unique arrangements. Typical arrangement is presented in this annex. The system illustrated in Figures D.1 may be modified as necessary and as mutually agreed upon by the purchaser and the vendor to achieve a system or systems adequate for a particular application.

NOTEThe oil separator's relief valve is shown on the downstream side of the coalescing filter to minimize oil loss during system depressurization.

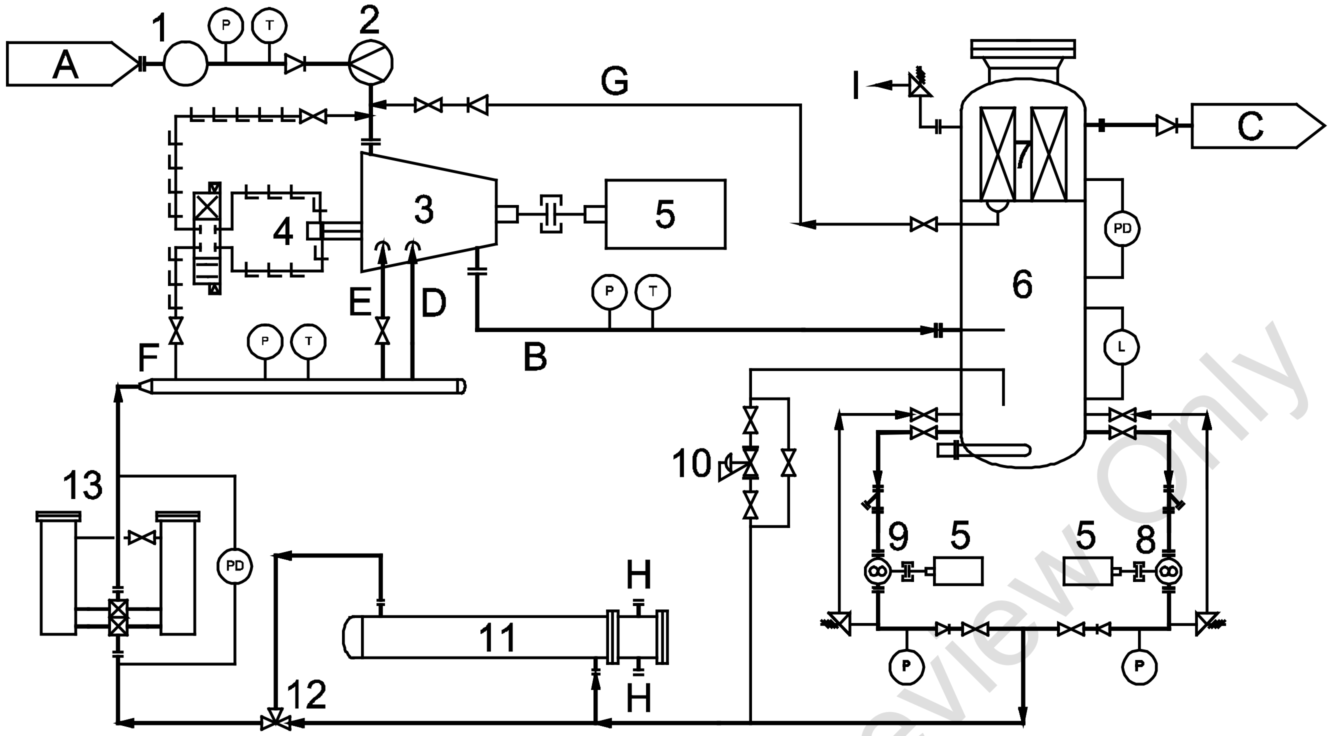
D.3 The oil separator supplied on an oil-flooded screw compressor skid package is a specialized piece of equipment often employing the manufacturer's proprietary internal design features. It is designed to effectively remove the oil entrained in the process-gas stream prior to final process-gas discharge from the package. Oil carryover rates should be agreed by the vendor and the purchaser (see 6.10.3.12). In some cases, multiple stages of oil separation have been employed to achieve lower acceptable oil carryover rates. Typical oil separator arrangements are shown in Figures D.2 and D.3.

NOTE: Oil separator orientation may be vertical or horizontal.

D.4 The symbols used on Figures D.1 to D.3 are listed in Table D.1.

Table D.1 — Symbols used on Figures D.1 to D.3

P	Pressure instrument
PD	Pressure differential instrument
T	Temperature instrument
L	Level instrument



Key

System components

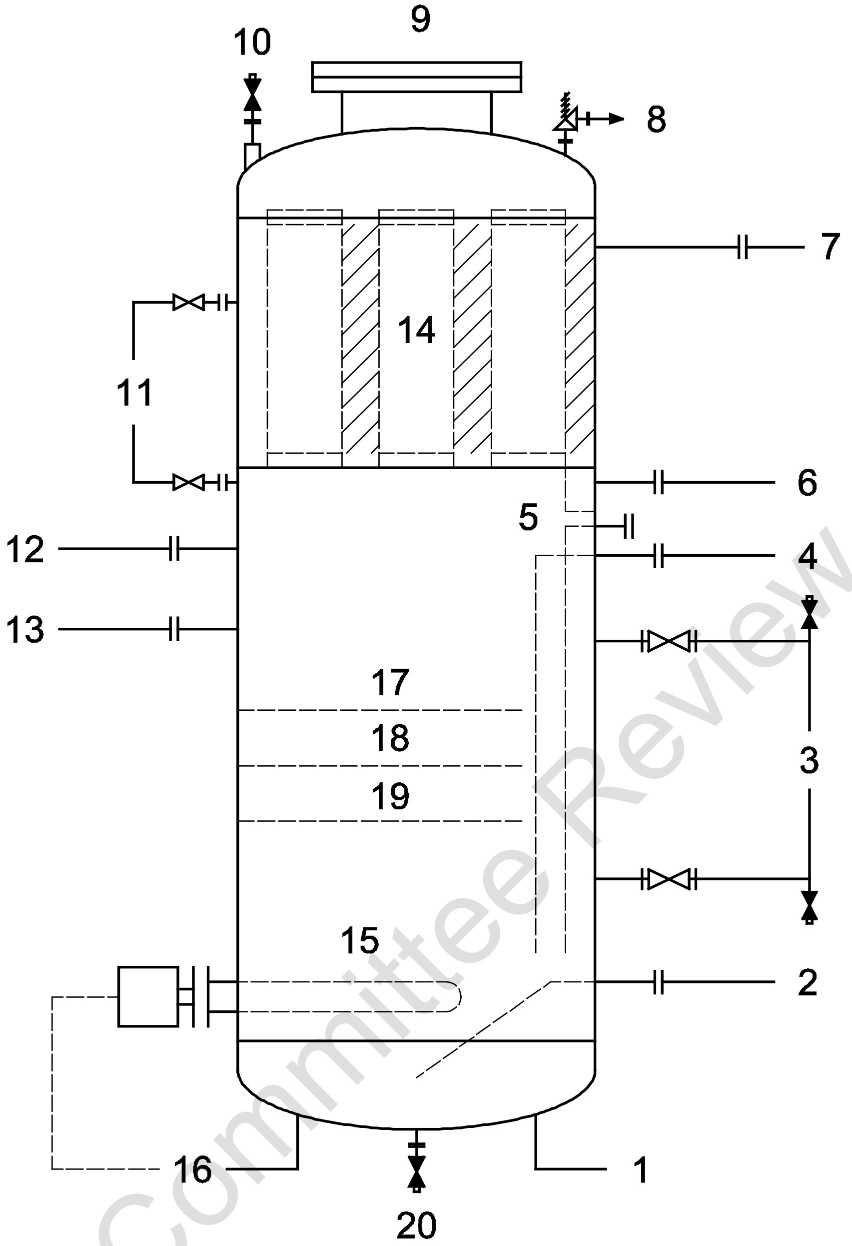
1	inlet scrubber
2	strainer
3	compressor
4	slide valve
5	motor
6	oil separator
7	coalescing element
8	oil pump
9	oil pump (stand-by)
10	pressure control valve
11	oil cooler
12	temperature control valve
13	oil filter

Gas/oil/cooling-water stream

A	suction gas
B	discharge gas and oil
C	discharge gas
D	lubrication and seal oil
E	injection oil
F	control oil
G	oil recovery
H	cooling water
I	relief valve discharge

API 614 System configuration code: LCSO-PRAA0-R1-HE-BP0-CS1-F2-A0-PV1B-TV3-0T0

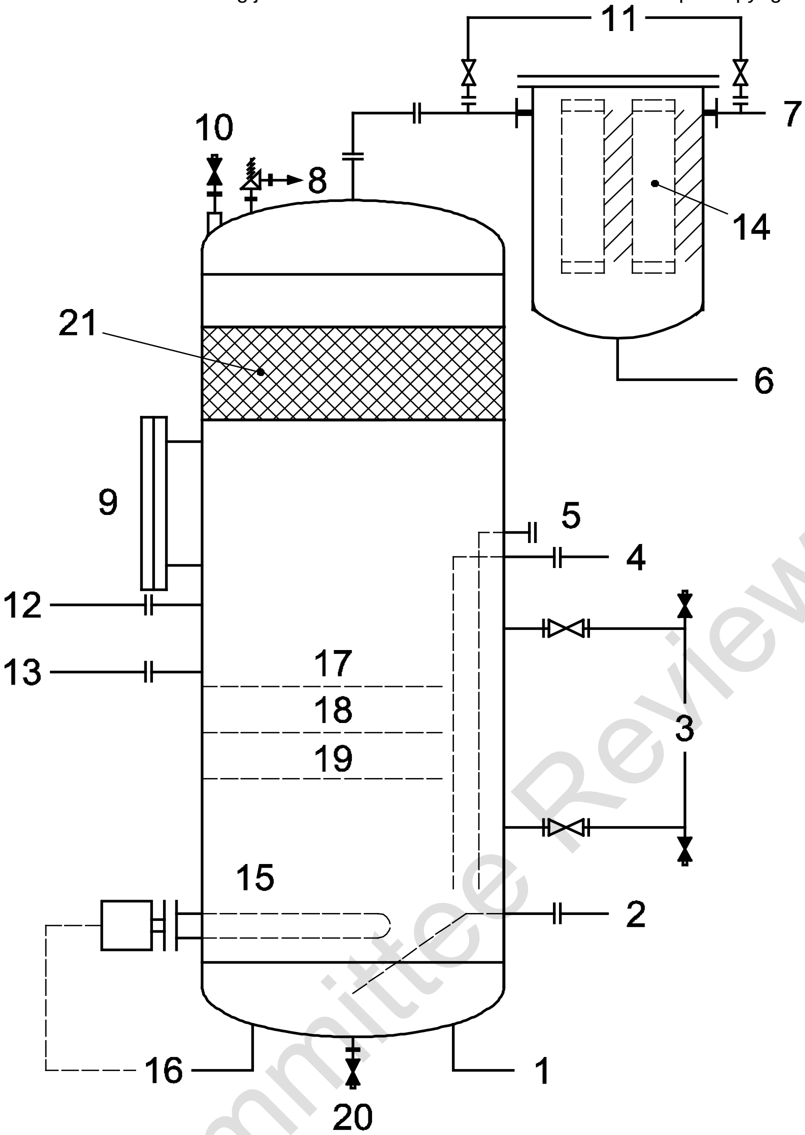
Figure D.1 — Typical arrangement 1



Key

1	temperature device	11	pressure differential indicator
2	oil-to-oil pumps or cooler connection	12	return from oil pump relief valve
3	level gauge (armoured)	13	gas and oil from compressor discharge connection
4	oil return from pressure differential control valve	14	coalescing filter element
5	oil fill	15	electric heater
6	coalesced oil drain	16	temperature control device
7	discharge gas outlet connection	17	maximum level
8	pressure safety valve	18	normal level
9	inspection hatch	19	minimum level
10	vent	20	drain

Figure D.2 — Oil separator with internal coalescer chamber



Key

1	temperature device	12	return from oil pump relief valve
2	oil-to-oil pumps or cooler connection	13	gas and oil from compressor discharge connection
3	level gauge (armoured)	14	coalescing filter element
4	oil return from pressure differential control valve	15	electric heater
5	oil fill	16	temperature control device
6	coalesced oil drain	17	maximum level
7	discharge gas outlet connection	18	normal level
8	pressure safety valve	19	minimum level
9	inspection hatch	20	drain
10	vent	21	demister pad
11	pressure differential indicator		

Figure D.3 — Oil separator with external coalescer chamber

Annex E
(informative)

Lubricant Selection for Oil-Flooded Screw Compressor

E.1 Introduction

This annex is a guideline of lubricant selection for oil-flooded screw compressor.

Compared with other rotating equipment, lubricant in oil-flooded screw compressors is under different operating conditions and has different fundamental requirements.

1. Exposed to compressor discharge pressure and temperature.
2. Mixed with process gas during compression process.
3. Separated from process gas in oil separator.

These items must be considered prior to lubricant selection.

Lubricant Selection for Oil-Flooded screw compressor is in Table E.1

E.2 Lubricant Selection

The selection of a lubricant depends on many factors. The most obvious is the ability to provide lubrication. Other important factors include the Physical and Chemical properties and, in some cases, environmental friendliness.

There are four major areas of concern for the use of lubricated positive-displacement compressors in gas applications: solubility, operating viscosity, reactivity, and effect of lubricant as a contaminant in the compressed gas.

The solubility of a gas in the lubricant is a major concern for the selection of the lubricant for oil-flooded screw compressors. Gas dilution reduces oil viscosity. Excessive dilution may cause a loss of film thickness of the lubricant and a loss of efficiency. Liquid components in the gas stream can wash the lubricant off surfaces to be lubricated, resulting in rotor-rotor contact, bearing contact, or other undesirable impacts.

API 1509 (reference 3) categorizes base fluids into categories including mineral oils and synthetic lubricants. The original purpose of API 1509 was for engine oil licensing, but the categories are useful for other lubricants. Paraffinic mineral oils fall into Group I, II and III. In general, the degree of refining, and the higher the viscosity index the mineral oil, the higher the category. Polyalphaolefin (PAO) into Group IV. Naphthenic oils and all other base stocks not classified in Group I – IV fall into Group V, including all other synthetic base stocks.

In many applications, synthetic lubricants may offer advantages over mineral oil (reference 1)

E.3 Lubricant Types

E.3.1 Mineral Oil. Paraffinic mineral oils are generally used in gas compressor applications as they have a higher viscosity index than naphthenic mineral oil. Group II base stocks have a higher viscosity index than Group I and, may provide a lower solubility with water. Group III base stocks, with a higher viscosity index than Group II, are currently not available in higher viscosity grades. Both are made up primarily of highly saturated hydrocarbon. The higher degree of refining with high pressure hydrogen, the less unsaturated hydrocarbon, and the less opportunity for reactions. Either Group II or Group III can be blended with synthetic base fluids such as PAO to increase their viscosity and/or viscosity index. Highly refined and dewaxed naphthenic mineral oils are used primarily in refrigeration applications where they may be miscible with the refrigerant for oil return from the evaporator. These lubricants have a low viscosity index, may have limited availability in higher viscosity grades and are not generally used in hydrocarbon gas applications.

E.3.2 PAO, polyalphaolefin, is a type of synthetic lubricant that consists of only carbon and hydrogen. The name is misleading, there is no remaining olefin once manufactured. Benefits of PAO over paraffinic mineral oils are numerous. The PAO offers exceptional purity for improved chemical stability, a wide variety of viscosity grades, a high viscosity index, better high temperature stability, lower vapor pressure, and low temperature fluidity. This allows for a wider operating temperature range (ref 1). PAO is widely used for certain refrigeration applications due to its excellent stability, high viscosity index and exceptionally good low temperature properties. These include lower molecular weight hydrocarbon refrigerants and ammonia, R717.

E.3.3 PAG, Polyalkylene Glycols, consists of a group of synthetic base stocks. They are polymers derived from alkylene oxides such as ethylene oxide (EO) and/ or 1,2-propylene oxide (PO) (reference 1.) Only a terminal hydroxyl group (like an alcohol) on the long chain polymer makes these not a true polyether. These lubricant base fluids consist of carbon, hydrogen, and oxygen. A high content of EO in their manufacture increases the water solubility but decreases hydrocarbon solubility. The use of all EO can result in complete water solubility and very low hydrocarbon solubility, but the pour point suffers as the viscosity grade increases. Special structures for the EO PAGs are used for a reasonable pour point. The use of all PO reduces the water solubility to a low amount. The solubility behavior of the base oils can be adjusted by combining the EO and PO. For example, there are PAGs which can have inverse solubility with water, as temperature increases (generally over 70°C) the solubility of water decreases so that at a higher operating temperature the water can be controlled to a relatively low level. Oil soluble PAGs using butylene oxide (BO) are less commonly used in gas applications as they increase solubility with hydrocarbon gases. PAGs have exceptionally high viscosity index. This combined their lower solubility with hydrocarbons allows for their superior operating viscosity in higher pressure applications. These fluids also have a low pour point and improved fluidity at low temperatures. When used for hydrocarbon refrigeration their solubility and miscibility are considered.

E.3.4 POE, Polyol Ester, is made by a reaction of a polyfunctional alcohol with monofunctional acid(s) produces a polyol ester. Complexed type may use a difunctional acid. Properties may vary widely for and within these classes. The result is that care should be taken in their selection. These lubricant base fluids consist of carbon, hydrogen and oxygen but are characterized by the inclusion of an ester functionality group. While solubility with water is low, their compatibility with over a few hundred ppm water can suffer. These fluids have been used with hydrocarbon refrigerants as they have less solubility with the refrigerant than mineral oil or PAO and can be available with a high viscosity index. They are available in a wide range of viscosity grades, and with very low pour points. Special POEs are used with dry carbon dioxide (R-744) in refrigeration applications due to their miscibility (reference 1). They are also commonly used for HFC, HFO and HFC/HFO blends for their miscibility. Care is taken to keep water less than about 100 ppm.

E.3.5 Alkyl Benzene (AB) are synthetic hydrocarbons. These lubricant base fluids consist of Carbon and Hydrogen. The name is misleading as there is no benzene, it has all been alkylated. It is considered the synthetic alternative to naphthenic refrigeration oil. AB were originally developed for their use with HCFC refrigerants due to excellent miscibility and low floc point. Their use in ammonia refrigeration, R717, resulted due to their lower pour point and excellent stability as well as the ease of keeping one lubricant for use with two types of refrigerants. They have a relatively low viscosity index which limits their application with hydrocarbon refrigerants.

E.3.6 Polyether (PVE) & end capped PAG are both considered polyether. Polyether generally refers to polyvinyl ether (PVE) but other types are available. End capped PAGs are similar to PAGs but the hydroxyl end group has been replaced by Hydrogen, and/or an alkyl group making it a true ether (reference 1). This lowers water solubility, can increase viscosity index, and improve stability. As with most other refrigeration lubricants, improved miscibility is the main criteria. While not currently widely used, the end capped PAGs can offer advantage in wet CO2 applications due to excellent stability and superior viscosity temperature properties.

E.4 Lubricant Selection

The following factors should be considered for lubricant selection:

1. Review process gas conditions for lubricant selection.
   a. This should include all upset cases, turndown, cold start, and hot start. The worst (controlling) operating case is often not the normal or design case.
2. Review entire process system (upstream & downstream of compressor), lube system and seal system for lubricant selection.
3. Seal oils with reduced viscosity grades and without additives are typically recommended for mechanical seals.
   a. Note that seal oil leakage from an external Plan 53a,53b, or 54 system can mix with lube oil, so the two must be compatible.
4. Process fluid dilution into the Lubricant should be considered for Lubricant operating viscosity.
   a. Hydrocarbon and water dew points should be calculated at all points within the system and thermal margin maintained.
5. The compatibility of the lubricant with the gas, catalysts and contaminants should be verified. (note this was added and the below section renumbered)
6. Lubricant viscosity should be considered under dilution condition. (Temp. Press, Process gas & others)
   a. Lubricant viscosity is per each compressor OEM recommendation. Most OEMs will recommend a range of min and max viscosities during startup and operation, and viscosity limits at the discharge flange and the oil injection point. The oil selection and temperature control are used to stay within these guidelines.
   b. PAO is used unless the dilution requires using too high of viscosity grade. Low moisture content in the oil can have an advantage for helium and hydrogen applications (Consult with OEM). Dry and pure hydrogen gas, by itself, does not cause embrittlement/cracking.
   c. Condensed water, from the hydrogen gas, creates a galvanic cell around the roller/ball bearing.
   d. A galvanic cell drives hydrogen ions into the stainless-steel structure causing embrittlement. The high thermal conductivity of hydrogen-rich gases mostly likely promotes condensation of water.

E.5 General Considerations

This annex is for indicative purposes only and the compressor OEM should be consulted in all cases.

1. Check lubricant availability at compressor installation location (these can be specialist lubricants not readily available).
2. Periodical oil sample testing is recommended.
3. If any lubricant mixing is intended (e.g. flushing oil or pressurized seal oil) then compatibility of lubricants is essential.
4. Dehydration may be requested for PAG. Different types of PAGs can hydrogen bond water (no free water). Typical permissible water levels by PAG type at new condition are 0.1% wt. to 0.2% wt., prior to first use (operating level can be much higher and consultation with OEM is required to check condemning limits).

   Note: that for comparison PAO, high quality mineral oils are generally <50 ppm water. Esters generally <100 ppm water.
5. Avoid water condensation in the oil loop of the compressor, e.g. ensuring that the discharge temperature is at least +10 deg K above the dew point. See Paragraph 7,6,9 for details.

E.6 References

1. Rudnick, L.R. (Ed.). (2020). Synthetics, Mineral Oils, and Bio-Based Lubricants: Chemistry and Technology (3rd ed.). CRC Press. https://doi.org/10.1201/9781315158150
   Chapter 55, Natural and Process Compressors
   Chapter 40, Refrigeration Lubricants
   Chapter 21, Comparison of Synthetic, Mineral Oil and Biobased Lubricants
   Chapter 1, Polyalphaolefins
   Chapter 6, Polyalkylene Glycols
2. Escobar, Will, understanding poly alkylene glycols (and where to apply them), Volume 64 issue 5, May 2008, pp 34-39"
3. American Petroleum Institute, Industry Services Department, Engine oil licensing and certification system, API Publication 1509, Washington, DC, 22nd ed., October 2023.

Table E.1

Lubricant Selection for Oil-Flooded Screw Compressor

Handling Gas	Dry Light HC	Dry Heavy HC	Dry Ammonia	Wet Light HC (1)	Wet Heavy HC (1)	Wet CO2	Refrigerant HC (2)	Refrigerant HFC & HFO (2)	Refrigerant HCFC (2)	Refrigerant CO2	Refrigerant Ammonia
Compression cycle	Open	Open	Open	Open	Open	Open	Closed	Closed	Closed	Closed	Closed
Service (for example)	LNG base Pipeline gas, Boil Off Gas	Boil Off Gas	Boil Off Gas	Chemical Process, Vapor Recovery, Coker Gas	Chemical Process, Vapor Recovery	Process CO2, CO2 Capture	Refrigeration, Propylene, Propane, Butane, Ethylene	Refrigeration	Refrigeration	Refrigeration, R744	Refrigeration, R717
Lubricant - Mineral oil including Semi and Partial Synthetic Oil											
Paraffinic base	• (3)		•			•					•
Naphthenic base	•		•	•					•		•
Lubricant - Synthetic Oil											
PAO	• (3)	• (4)	•	•	•	•	•			•	•
PAG	• (5)	• (5)		• (5)	• (5)	• (5)	• (5)				-
POE							•	•	•	•	
Alkyl benzene			•						•		•
Polyether & end capped PAG						•		•		•	

Notes:

1. See paragraph E.5.6
2. Refrigerant Information:
   Propane: R290, Propylene: 1270, Ethylene: R1150, ISO-Butane: R600a.
   HFC Refrigerant: R-134a, R-404A, R-407C/H, R-410A, R-507 & others.
   HFO Refrigerants: R1234yf, R1234ze and others.
   HFC/HFO Blends: R450A, R448A, R449A, R516A, R513A and others.
   HCFC Refrigerant: R-22 & others
3. See paragraph E.4.4
4. See paragraph E.4.6
5. See paragraph E.5.5
6. This table does not list every oil type or every process. It is for reference only and must never be used in place of an engineered oil selection/analysis.

Annex F
(informative)

Oil Separation and Removal

F.1 Introduction

Maximum permissible oil carryover shall be specified by the purchaser (see 6.10.3.12). The vendor determines the components required to meet the specified oil carryover. In some cases, multiple stages of oil separation may be required to meet lower oil carryover. The purchaser should also specify whether oil recovery through a drain or recovery system is required.

Typical multiple oil separator arrangement is shown in Figure F.1. The resulting carryover of oil from each stage and type of separator is approximated in Table F.1.

There are different types of separators. A brief description of each type is provided below.

F.2 Separator Types

F.2.1 Coalescers:

A coalescer is used to cause liquid aerosols to form larger, heavier droplets which are filtered out of the system. The coalescing filters trap the liquid while allowing the gas to pass through the filters. The efficiency of coalescence is dependent on the type and quality of the coalescing media. Coalescers are typically used for oil removal and not water or hydrocarbon, however coalescing of both oil and condensable from the gas is possible with the proper design and material of the coalescing filter elements. Coalescer separators collect aerosol/oil mist only. In the case of oil vapor removal, charcoal bed is a practical solution. Coalescers utilize coalescing elements to provide the coalescence.

F.2.1.1 Coalescing Elements

The coalescing elements used within coalescers are available in many styles and materials.

When selecting coalescing elements, the following factors should be considered:

1. operating conditions,
2. gas composition,
3. liquid presence (droplets/aerosol),
4. contaminants/particle sizes,
5. efficiency required,
6. recommended/allowable replacement frequency of the filter elements,
7. if stacking of filter elements is allowed (not recommended)
8. amount of oil carryover allowed
9. testing methodology and results
10. resulting filter element velocity,
11. whether oversizing from manufacturer recommendations desired.

Coalescer typically have limitations of the inlet gas temperature and the amount of oil in the inlet gas.

F.2.2 Adsorption (Carbon) Beds

When a minimal amount of oil carryover is required, typically a 4th stage adsorption unit is added to the system.

Mechanical devices only remove the liquid phase of the oil. The vapor phase of oil takes time for the droplets of oil to form. The vapor phase of the oil is removed by temperature or by an adsorber (such as carbon bed).

Active carbon beds are commonly recommended and requested for anything < 1 ppm by weight (lubricant) or anything going into a catalyst or other oil sensitive component. Theoretical coalescing filter calculations predict ideal performance into the ppb range of oil carryover, but this is at a single point in the process at a single pressure/temperature/flow with perfectly operating/maintained equipment and clean oil. As a result, these sorts of levels are almost never actually achieved in real life.

F.3 General Considerations

F.3.1 Oil carryover cannot be guaranteed anywhere other than the discharge of the package. When the process pressures and temperatures change and oil has time to change phases, significant quantities of oil may change from vapor to liquid and may accumulate downstream. Even if the process conditions are correct for this change to occur, time is still a factor. As a result, some oil separation may need to be placed a significant distance away from the compressor package to be effective.

F.3.2 Real coalescing filter performance and predicted coalescing filter performance may vary dramatically (by orders of magnitude). Any requirements for < 1 ppm of oil carryover (liquid phase) should require additional discussion between the purchaser and vendor.

F.3.3 “No oil carryover” is not possible with an oil-flooded screw compressor. Even an active carbon bed does not result in “No oil carryover”.

F.3.4 Services that are impacted by contaminants downstream may require more restrictive (efficient) systems

F.3.5 There is no instrumentation that measures the oil carryover for pressurized flammable or toxic gas. Therefore, the purchaser only has the predictions of the vendor, packager and/or the manufacturer of the oil removal components.

F.3.6 One way to measure the oil carry over is to determine how much oil is added vs length of time and gas volume. This also requires measuring the downstream vessels, and it is often difficult to obtain an accurate measurement.

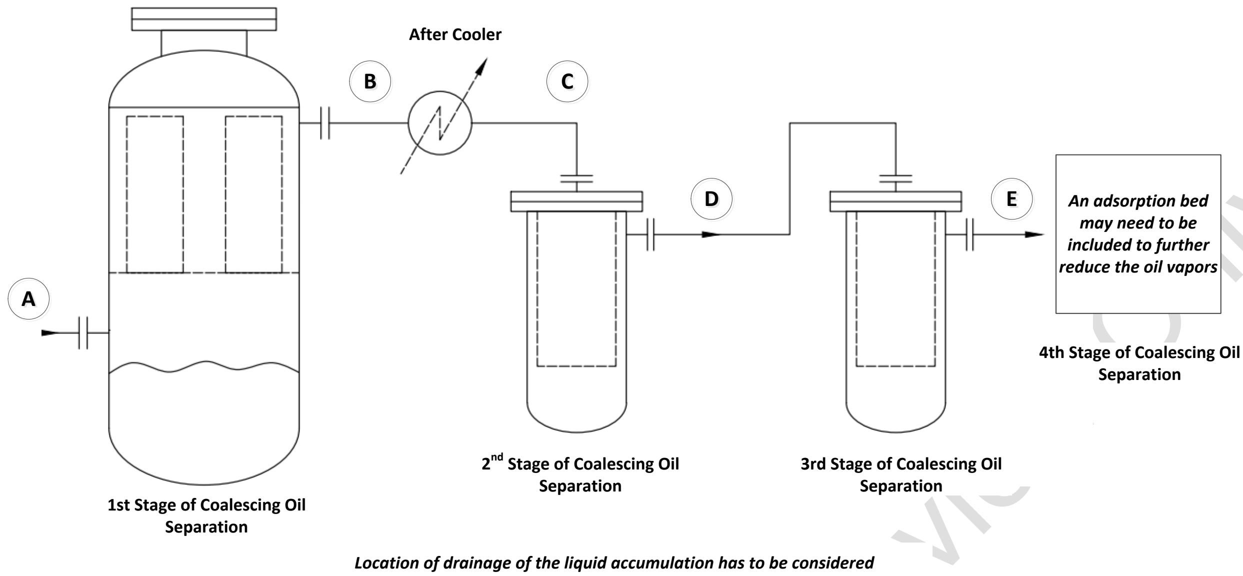


Figure F.1

Typical Multiple Oil Separator Arrangement

Table F.1

Typical oil carryover of different types of oil separators

Oil Separator Stage	Separator Function	Configuration	Inlet Oil Carry Over	Outlet Oil Carry Over (W. PPM)	Gas & Oil		Typical Gas & Oil Pressure Drop
			(W.PPM)	(W.PPM)	Inlet Temperatures	Outlet Temperatures	PSI (bar)
					Deg F (Deg C)		
1st Stage Oil Separator	Pre-filtration	Baffle plate + Pre filter grade coalescer	**"A"** > 200	**"B"** ~ 20 to ~ 100	> 200 (> 90)	> 200 (> 90)	~ 1.5 (~ 0.1)
After Cooler	Gas Cooling	N/A	**"B"** ~ 20 to ~ 100	**"C"** ~ 20 to ~ 100	> 200 (> 90)	~ 100 to ~ 120 (~ 40 to ~ 50)	~ 1.5 (~ 0.1)
2nd Stage Oil Separator	Fine Separation	Fine grade coalescer	**"C"** ~ 20 to ~ 100	**"D"** ~ 1 to ~ 10	~ 100 to ~ 120 (~ 40 to ~ 50)	~ 100 to ~ 120 (~ 40 to ~ 50)	~ 2 to ~ 4.4 (~ 0.2 to ~ 0.3)
3rd Stage Oil Separator	Finer Separation	Very fine grade coalescer	**"D"** ~ 1 to ~ 10	**"E"** ~ 0.1 to ~ 1	~ 100 to ~ 120 (~ 40 to ~ 50)	~ 100 to ~ 120 (~ 40 to ~ 50)	~ 4.4 to ~ 6 (~ 0.3 to ~ 0.4)
4th Stage Oil Separator	Adsorption (carbon) Bed	Adsorb all remaining oil (liquid & water phase) in the gas stream	**"E"** ~ 0.1 to ~ 1		~ 100 to ~ 120 (~ 40 to ~ 50)	~ 100 to ~ 120 (~ 40 to ~ 50)	~ 7 to ~ 15 (~ 0.5 to ~ 1)

Annex G
(informative)

Packaging Guide

SCOPE:

This annex is to provide guidance for discussions to ensure that specific items are clarified and discussed.

G.1 Overall

G.1.1 General

The purpose of the information within this Annex is to provide information for the selection of a package that best fits the application and expectations. Understanding the process conditions, process condition ranges, off design conditions, alternate conditions, details of the equipment, and package design are crucial for the proper selection and operational/maintenance requirements of/for the components for the package. Specific information identified within this Annex should be discussed between the compressor manufacturer, packager, and the purchaser.

NOTE In this Annex, the term "abnormal conditions" refers to operational conditions which are not defined as normal and/or rated operating conditions of the equipment. Such "abnormal conditions" may occur for short or extended time periods. Typical "abnormal conditions" are identified, such as:

1) Process parameters varying beyond the specified range of defined operating conditions, due to operating modes such as: start-up, turndown, shutdown, operational upsets, process gas composition change during the life time of the equipment, etc.
2) Extreme ambient conditions

G.1.2 Inlet Process Gas

G.1.2.1 General

The inlet gas to the compressor should be as dry and clean as possible. Liquids, contaminants, and/or particles should be eliminated prior to the inlet of the compressor to prevent damage to the compressor.

The quantity, type and size of any liquid droplets, contaminants, and/or particles to the inlet of the compressor influences which type of screw compressor is appropriate and the associated components for the package. The compressor manufacturer should be consulted to provide information on the risks from the liquid, contaminants, and/or particles. Correction of any potential issues will be beneficial to the continual operation and increased reliability of the compressor and the package components. Figure G.1 provides a chart identifying the method of removal of inlet gas non desirable conditions.

NOTE If a single train gas conditioning system is used, a compressor may require to be shut down for service to conditioning components.

G.1.2.2 Process Gas Properties and Information

The properties of the inlet gas should be well identified. Conditions identified as abnormal conditions, such as: start-up, different loading, shutdown, operational upsets, or alternative gases should be considered and discussed. The range of any of these inlet gas conditions should be identified so that the range of the inlet gas properties can be considered as best as practical. Changes with the process conditions such as pressures or temperatures could result in variation of the vapor phase, molecular weight of the process gas and/or other thermodynamic properties of the gas. A gas phase diagram is used to determine the condition of the gas through the different components within the package. It is these adverse conditions that often cause issues with the operation or reliability of the packages.

Gas analysis should take normal and abnormal operations into account including:

a. Well chemical injection
b. Change of seasons and ambient temperature changes
c. Different stages of gas well life (initial, and as time marches on, gas composition after fracking)

The base gas analysis may not change, but the water and any hydrocarbon loading may change significantly. Consider:

a. Where the gas analysis is taken is important
b. When the gas analysis is taken (different stages of well life)
c. Many gas analyses don't take free liquids into account.

The effects of compositions such as paraffins, waxes, or tars that may be present in the process gas stream may cause issues such as with rotor deposits or pluggage of heat exchangers and should be considered within the analysis. Chemicals that may be injected up stream of the compressor package or in the wells may affect the operation or chemical compatibility of the process gas.

The vendor is responsible to select appropriate equation of for calculating gas properties, including dew point. In this calculation vendor shall consider presence of water, hydrocarbon and pseudo components as specified by purchaser.

While the gas may be above the dew point at the suction of the compressor, if it drops below the dew point at the discharge nozzle of the compressor or within the oil separator, condensate will build-up in the oil. This is most common with high pressure ratios. For reliable operation, this must be avoided.

G.1.2.3 System Simulations

The process gas properties and information are used to develop a simulation through the package to determine what is occurring to the gas stream. The different process gas properties along with their ranges should be included with any simulations. The closer these different conditions can be predicted and simulated, the better the required compressor and package components can be determined that will minimize risks. The ranges and the potentially different gases will vary the results of the simulation and thus may require different or additional package components. An accurate simulation of what is occurring within the package is important to understanding the requirements of the package and which components are appropriate. Performing process simulations of the system is a joint effort of the compressor manufacturer, packager, and the purchaser that may require several iterations for the simulations. Division of responsibilities in this joint effort should be agreed between all parties involved. An initial analysis may be completed in the early stages, and after progress of the package design, a simulation can be updated prior to the finalization of package design. The simulation may have to be re-run several times for an accurate system simulation. The simulations should be done as early within a project as practical so that the identification of specific components can be included, which will the outcome of the simulations. The expectation from the simulation study is to provide as accurate a prediction of the operation of the package as possible for all defined process conditions.

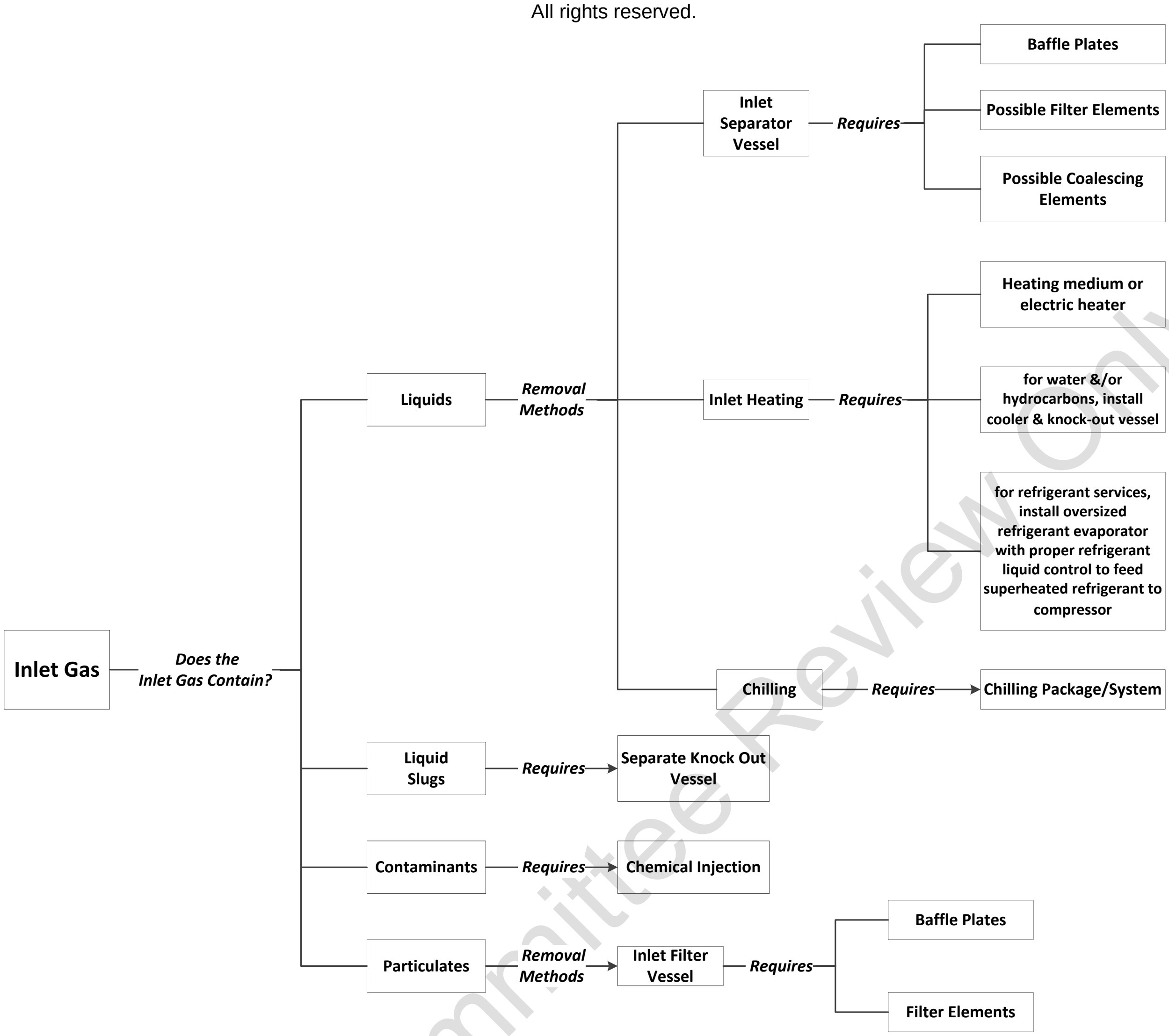


Figure G.1 - Chart identifying the method of removal of inlet gas non desirable conditions

G.1.2.4 Liquids in process gas

Liquids of hydrocarbons, water, or other chemicals may exist in the inlet process gas stream. This can be free liquids or entrained liquids with the process gas. Oil flooded screw compressors are designed for gas handling and thus are not a liquid pump nor a bi-phase pump. Liquids & slugs should be eliminated by an upstream process system.

The ability to separate the liquid is determined by the type of inlet gas conditioning, if included. The quantity and type of liquids for all conditions should be evaluated and accounted for. A gas analysis should include both free and entrained liquids. Free liquids may not always be included with the gas composition.

G.1.2.4.1 Potential sources of liquids

Even if liquids are not anticipated for normal operation, the potential for liquids should be evaluated such as for start-up, different loading, shutdown, operational upsets, and/or temperature changes.

Condensation of the gas can occur in the system due to gas temperature variation, which can be caused by variation of ambient temperature pressure reduction of the stream, etc. The system should be reviewed to determine if tracing and / or insulation should be included.

G.1.2.4.2 Issues with liquids

A. Liquids may be mixed with the lubricant and cause bearing and other compressor mechanical issues.

B. Mixing of liquids within the oil separator may result with an emulsion that is difficult to separate. This emulsion will be the fluid that is pumped to the compressor bearings, seals, and hydraulic components which will not provide the desired properties and result in issues.

C. Liquids can be damaging to the compressor or other components within the system. The liquid or vapor (hydrocarbon, water, or refrigerant) in the inlet gas stream coming through the compressor suction port could cause compressor damage, such as:
   i. Incoming liquid will be mixed with the lubricant at the compression chamber and may create a less or no lubrication condition. This could cause contact between the rotor(s), casing and other mechanical equipment.
   ii. If the incoming liquid stays as a liquid phase and moves to the discharge port of the compressor, it will be mixed or diluted into the lubricant at the oil separator. The lubricant viscosity may become out of the specified range for the oil pump, bearings, compressor mechanical seals, and the hydraulic system components.
   iii. If the incoming liquid is vaporized at the compression chamber, it may blow off the lubricant from the compression chamber to the discharge port. This may reduce the lubrication within the compression chamber causing rotor to casing contact. This is sometimes referred to as “Liquid Back”.

G.1.2.4.3 Methods for liquid removal:

The removal of liquids from the inlet gas stream can be accomplished using methods such as inlet separators, inlet heating, or inlet chilling. The liquid removal method is dependent on the liquids to be removed, capability required, and operational/maintenance involvement. Table G.1 provides the different typical methods of liquid removal and information for each method.

Table G.1 – Typical Methods for Liquid Removal

METHODS	Liquid Removal			How is Separation Accomplished	Additional Requirements	Comments
	Water	HC	Refrigerant			
Inlet Separator	Yes	Yes	No	Combination of internal: - baffle plates - Filters - Coalescing elements	- Drain (may be negative pressure) - Routine replacement of internal components may be required	
Inlet Heating	Yes	Yes	Yes	Superheats liquid/gas stream	- Heating medium or electricity - for water &/or hydrocarbons, install cooler & knock-out vessel - for refrigerant services, install oversized refrigerant evaporator with proper refrigerant liquid control to feed superheated refrigerant to compressor	
Inlet Chilling	Yes	Yes	Yes	Chills inlet liquid/gas stream	Chiller package/system	Inlet vapor or liquid removal by chilling system is commonly used for water saturated gas compressor services. It helps to bring lower dew point at the compressor discharge.

						Chilling is typically more efficient for water than hydrocarbons Gas chilling and then re-heating is very well documented. It is the default in much of the biogas industry where the gas is saturated with water and contains significant CO_2 and H_2S (resulting in carbonic and sulfuric acid). Chilling, then re-heating can increase the time intervals such as for oil changes or compressor overhaul intervals from weeks or months to years. Chilling is not typically used in upstream and midstream oil and gas applications due to non-technical considerations. If the gas chilling conditioning system stops working, the compressor should be shut down. If it is not, the oil may foul within hours or days leading to compressor failure.

G.1.2.4.4 Considerations of slugs of liquids:

A liquid slug is the accumulation of liquids. Liquid slugs can be damaging to components and/or the compressor due to the impact of the slug. The normal sized liquid removal system may not be able to handle the volume from the liquid slug. Liquid slugs can cause high mechanical forces which can damage components. The potential source for a liquid slug should be evaluated and provisions taken in case of a liquid slug. Review piping arrangements (low spots), well stream data, typical process applications, and potential upsets as applicable to determine the potential for a liquid slug. Special components for handling a liquid slug should be considered if there is a potential for the liquid slug such as a separate vessel for the knocking out of the slug.

G.1.2.5. Contaminants in Process Gas:

Contaminates are a broad category of substances that could affect the operation or longevity of the operation of the compressor or package components. Contaminants can include other chemicals substances such as H_2S or chlorides that could destroy components. Contaminates should be eliminated prior to the entry into the compressor. It is the responsibility of the purchaser to provide information for the potential for contaminants. The main point is that contaminants should be identified and the method of dealing with them is to be identified. The control of contaminants may be chemical injection in the inlet gas stream or specific packages designed to remove the specific product.

G.1.2.5.1 Issues with contaminants:

Contaminates within the gas stream can cause issues, such as:

A. damage to the compressor internals
B. dilution of the oil used for lubrication, sealing, or the functioning of the hydraulic system
C. condense and result with a build-up on components

G.1.2.6 Particulates in Process Gas:

Particulates include piping scale, weld splatter, catalyst, debris from corrosive, coke, coal fines, metal particles, or particles within the gas stream. In order to know if the particulates are an issue, the type, size, hardness, and quantity are to be identified and discussed with the compressor manufacturer. The compressor manufacturer can provide information on what is acceptable and what are the risks. It is best if the particulates can be removed at the inlet to the compressor package to minimize issues with the compressor package and components. If possible, perform tests of the gas stream to identify particulates. Potential sources of particulates are:

a. suction piping inadequately cleaned or has been a long time since the cleaning occurred
b. catalyst from upstream process units

G.1.2.6.1 Issues with particulates:

Potential problems with particulates may include:
a) compressor component abnormal wear (scoring)
b) fouling of heat exchangers
c) plugging of coalescers

G.1.2.6.2 How to remove particulates:

G.1.2.6.2.1 General:

The particulates may be able to be removed from the inlet gas stream, depending on the properties of the particles. Smaller particles may be able to pass through the compressor (discuss with the compressor manufacturer), mixed with the lubricant, and then filtered out with the oil filtration system. To prevent compressor bearing, seal, hydraulic components & rotor damage from particles may require an adequately designed suction knock out drum, inlet filter/strainer and oil filter system. Larger size particles are typically captured by a filter or in the suction knock out drum. It may be practical to:

a) install removable start up screens (piping allowance even if not initially included)
b) leave room, provisions for potentially adding inlet filtration systems in the future when uncertain of particulates

G.2 Equipment

G.2.1 Separators

G.2.1.1 General

Separators are used to separate liquids (free or entrained) from the process gas and/or different types of liquids and for pulsation dampening. Applications for separators for flooded screw compressor packages include inlet to the compressor, interstage for two stage, two compressor casings packages, and the discharge from the compressor.

The effectiveness of the separator depends on the volume of the vessel, velocities, types and volume of liquids, and the types of internals.

The capability/effectiveness of the separator may vary with the difference of flowrate such as with variable speed compressors, compressors with variable capacity control, or two compressors in parallel, sharing vessels, and one compressor is shut down.

Too high of a velocity of the process gas/liquid in a separator may not allow for efficient separation of the liquid from the gas. The velocity through the separator should be low enough to allow separation to occur.

The different types of internals along with their capability are identified (in order of liquid separation capability):

i. no internals (typically not recommended)
   a) minimal separation of liquids from process gas
   b) for discharge separators separating oil, highest carryover of oil to discharge and may possibly damage process unit downstream

ii. baffle plates ONLY (typically not recommended)
   a) gas impinges onto a plate (may be a pipe cap for on vertical)
   b) may be a plate on the end for a horizontal orientation
   c) typically used as combination of vane and mesh pad (demister)
   c) expectation may be < 100 ppm

iii. baffle plate and coalescing filter elements
   a) efficiency depends on quantity of liquid, type of liquid
   b) may expect < 1ppm
   c) number of filter elements are based on the flow rate and gas velocity
      NOTES:
      1) frequency and logic for filter element changing is normally considered in the design
      2) It may be more desirable to use separate vessel in case of coalescing filters due to additional height required. Separate vessel may be horizontal
      3) Wire mesh is typically no longer used
      4) The lower the effectiveness for separating liquids from the process gas for the discharge separator could cause a higher level of dilution of the lube oil. This oil dilution reduces the viscosity of the lube oil and thus could not provide the required viscosity to adequately lubricate the bearings and mechanical seals which could result in component damage.

G.2.1.2 Separator Considerations:

G.2.1.2.1 Internal separators
Internal separators should be designed to ensure that the inlet stream is not deflected toward the upper portion of the vessel.

G.2.1.2.2 Arrangement
Spacing of the inlet nozzle, of mist extractors, liquid-level controls and high-liquid-level shutdowns should be such that liquid would never reach the compressor inlet.

G.2.1.2.3 Liquid-level control devices
Any liquid-level control device shall be positioned outside turbulent areas.

G.2.1.2.4 Mist extractor

Unless otherwise specified, vane- or mesh-type mist extractors should be furnished. They should be constructed from austenitic stainless steel or other materials of a superior corrosion resistance. Mesh-type mist extractors, when furnished, should be supported both above and below the mesh material.

G.2.1.2.5 Equipment

The minimum equipment furnished on separators should be as follows:

- manual drain;
- automatic drain valve with liquid level controller;
- high-level shutdown device.
- If an external liquid-level gauge is specified, it shall be equipped with isolating, vent and drain valves.
- If a pressure gauge is specified, it shall be equipped with isolating and vent valves.

G.2.1.3 Installation considerations for oil separator stages:

a. Each of these vessels will have liquid accumulation that has to be periodically drained. Depending on the system requirements will determine the location of the liquid to be drained such as back to the compressor suction or to another location.
b. The slope of the piping from the compressor to the 1st stage oil separation is provided in 6.5.4.4. The slope of the piping at each additional stage of oil separation should be the same as the inlet piping to the first stage.
c. Coalescers typically do not allow back flow operation
d. Maintenance activities should be considered for the placement of each oil separator stage.

G.2.1.4 Inlet separators:

Screw compressors packagers typically do NOT review the inlet separator when the inlet separator is purchased outside the scope of package. Packager is usually ONLY concerned with what is coming out of inlet separator into the screw compressor. Inlet separator shall be designed to meet the screw compressors limitations of liquid carry.

G.2.1.5 Intermediate (oil) separators (for two stage compressor packages):

The information in this section is to be used In addition to the information in section G.2.1.

Intermediate separators are typically used for two stage compressor packages and are located in between the two compressors. The intermediate separator is designed to:

- Remove oil and other liquids from the first compressor
- May provide for partial exiting of process gas prior to second stage compressor
- May allow entry of a side stream of process gas from an outside the package source
- Are typically similar to the discharge separators

G.2.1.6 Discharge (oil) separators:

General:

The information in this section is to be used in addition to the information in section G.2.1.

Flooded screw compressors incorporate a pressurized reservoir and gas/oil separator(s) in their oil system, which results in unique arrangements. Some typical arrangements are presented in this Annex. The systems illustrated in Annex D, Figures D.1, D.2 and D.3 may be modified as necessary and as mutually agreed upon by the purchaser and the vendor to achieve a system or systems adequate for a particular application.

The oil separator supplied on an oil-flooded screw compressor skid package is designed to effectively remove the condensed process gas and oil entrained in the process-gas stream prior to final process-gas discharge from the package. Any liquids such as water or hydrocarbons should be vaporized and moved downstream.

Oil carryover rates should be agreed by the vendor and the purchaser (see 6.10.3.12). In some cases, multiple stages of oil separation have been employed to achieve lower acceptable oil carryover rates. Typical oil separator arrangements are shown in Annex D, Figures D.2 and D.3. Oil separator orientation may be vertical or horizontal.

The process gas condensation and the other liquids such as water can cause dilution of the lube oil resulting in lube oil viscosity changes. Discharge separators are also referred to as oil separators for flooded screw compressors. If the lube oil is not maintained in the range recommended by the equipment manufacturer, damage to the screw compressor could result.

The discharge separator separates liquids from the compressor discharge process gas stream. The heat of compression typically allows the water and hydrocarbon liquids to vaporize and be discharged from the separator with the process gas. Remaining liquids in the discharge separator should only be the lube oil. Flooded screw compressors utilize the oil to lubricate the compressor bearings and mechanical seals, function the hydraulic systems, and to provide cooling of the compressor internal components. The discharge separator maintains a volume of oil that is circulated through the compressor for these functions. The separator typically has internal components/devices or additional components that causes the oil to separate from the process gas stream. A discharge separator can have a heater in the bottom of the separator that is to additionally vaporize the condensed liquids and allow them to remix with the process gas flow.

Many factors influence the efficiency of the separation of the liquids from the process gas stream. The lower the efficiency for separating liquids from the process gas for the discharge separator could cause more dilution of the lube oil. Oil dilution reduces the viscosity of the lube oil and thus could not provide the required viscosity to adequately lubricate the bearings and mechanical seals which could result in component damage.

The customer establishes the amount of oil carryover, and the packager determines the components required to meet these expectations. The customer should also determine whether oil recovery is to be considered such as a drain or recovery system.

NOTE 1 There is no instrumentation that measures the oil carry over for pressurized flammable / toxic gas. Therefore, the customer should take the predictions of the packager and the manufacturer of the oil removal components.

NOTE 2 *One way to measure the oil carry over is to determine how much oil is added vs length of time and gas volume. This also requires measuring the downstream vessels. This is difficult to determine an accurate measurement.*

If a discharge separator and other components are not efficient, the separation of the oil and other liquids from the process gas may not occur resulting with the oil and other liquids being entrained with the discharge process gas and potential dilution of the oil. With the entrained liquids in the discharge process gas, the replacement (addition) of the oil will be required and the liquids may cause damage to the downstream process components or processes. With dilution of the oil, damage may result with the compressor. The compressor manufacture has requirements for the range of the viscosity of the oil. If the oil is not maintained in the range recommended by the equipment manufacturer, damage to the screw compressor could result.

Inefficiencies of the oil separator can be caused by designs that do not consider:

- abnormal conditions
- adverse conditions
- non steady flowrates
- alternate gases
- higher than normal gas velocities that does not allow separation of the liquids from the gas

The oil separator supplied on an oil-flooded screw compressor skid package is a specialized piece of equipment often employing the manufacturer's proprietary internal design features. It is designed to effectively remove the oil entrained in the process-gas stream prior to final process-gas discharge from the package. A typical mechanical separation system using coalescer elements can collect the oil mist and droplets while the oil vapor cannot be collected. If oil vapor removal is required, typically an adsorption bed should be included. Oil carryover rates should be agreed by the vendor and the purchaser (see 6.10.3.12). In some cases, multiple stages of oil separation may be required to meet the lower oil carryover rates. Typical oil separator arrangements are shown in Annex D, Figures D.2 and D.3. Oil separator orientation may be vertical or horizontal.

The oil separation by different types of separators and components are shown in Figure F.1. An example of the resulting carryover of oil from each type of separator is approximately identified in Table G.1. These values in Table F.1 are estimated values and are shown only as an example. The projected carryover from the different types of separators and components for the actual application may vary. The operation of the system along with any alternatives should be considered to meet the customer's expectations. Different components are required to be able to meet the oil carryover requirements. There are many different types and materials of coalescing elements as identified in G.2.2. Each of these coalescer manufacturers typically have limitations of the inlet gas temperature and the amount of oil in the inlet gas. When a minimal amount of oil is required, typically a 4th stage adsorption unit is added to the system.

NOTE 1 Oil carryover cannot be guaranteed anywhere other than the discharge of the package. When the process pressures and temperatures change and oil has time to change phases, significant quantities of oil may change from vapor to liquid and may accumulate downstream. Even if the process conditions are correct for this change to occur, time is still a factor. As a result, some oil separation may need to be placed at a significant distance away from the compressor package.

NOTE 2 Real coalescing filter performance and predicted coalescing filter performance may vary dramatically (by orders of magnitude). Any requirements for < 1 ppm of oil carryover (liquid phase) should require additional discussion between the purchaser and OEM.

NOTE3 "No oil carryover" is not possible with an oil-flooded screw compressor. Even an active carbon bed does not result in "No oil carryover".

NOTE 4 Services that are impacted by contaminants downstream may require more restrictive (efficient) systems.

G.2.1.7 Oil Retention time:

The volume of the oil should be sufficient to provide a time (retention time) in the separator to allow this separation from the process gas and the other liquids. The retention time needed depends on the type of gas, type of oil, discharge pressure, degassing rate, discharge temperature, and ambient temperatures. The retention time should be discussed. The longer retention time typically allows for a higher vaporization of the lighter liquids within the oil/other liquids. Instrumentation is requirement along with the capability of the installation of this instrumentation (need room in the vessels to monitor & function),

The longer retention time provides a greater volume of oil which also increases the size of the volume of the separator.

Two minutes minimum retention time is a considered a good practice. This may vary depending on application. For example, refrigeration-based packages may only have 30-60 seconds of retention time. API 614 suggests minimum 8 minutes for special purpose lube oil system the retention time may reduce to 45 second in Gas wells.

In addition, retention time may vary depending on type of oil. A hydrocarbon process gas using mineral oil may require a longer retention time as compared to the hydrocarbon process gas with a synthetic oil.

Pre-lube/rundown or post lube needs to be considered with respect to volume of oil:

- Some cavities retain oil within compressor that will require higher volume of oil.
- May require certain features to accomplish for continual pre-lube.
- The volume of oil should be considered for applications that use pre-lube/rundown/post lube as these may require additional retention times.

Longer retention times typically allows more separation of the oil to other liquids and water. However, it requires a larger volume separator, greater volume of oil and larger footprint.

G.2.1.8 Active Carbon Beds:

Active carbon beds are commonly recommended and requested for anything < 1 ppm by weight (lubricant) or anything going into a catalyst or other oil sensitive component. Theoretical coalescing filter calculations predict ideal performance into the ppb range of oil carryover, but this is at a single point in the process at a single pressure/temperature/flow with perfectly operating/maintained equipment and clean oil. As a result, these sorts of levels are almost never actually achieved in real life.

G.2.2 Heaters:

In a flooded screw compressor, a heater is normally used for startup or standby applications in order to achieve the required oil viscosity for start up. When heaters are located in the separator, ensure that the minimal retention time volume such as for pre-lube/rundown/post lube provides adequate heater submergence.

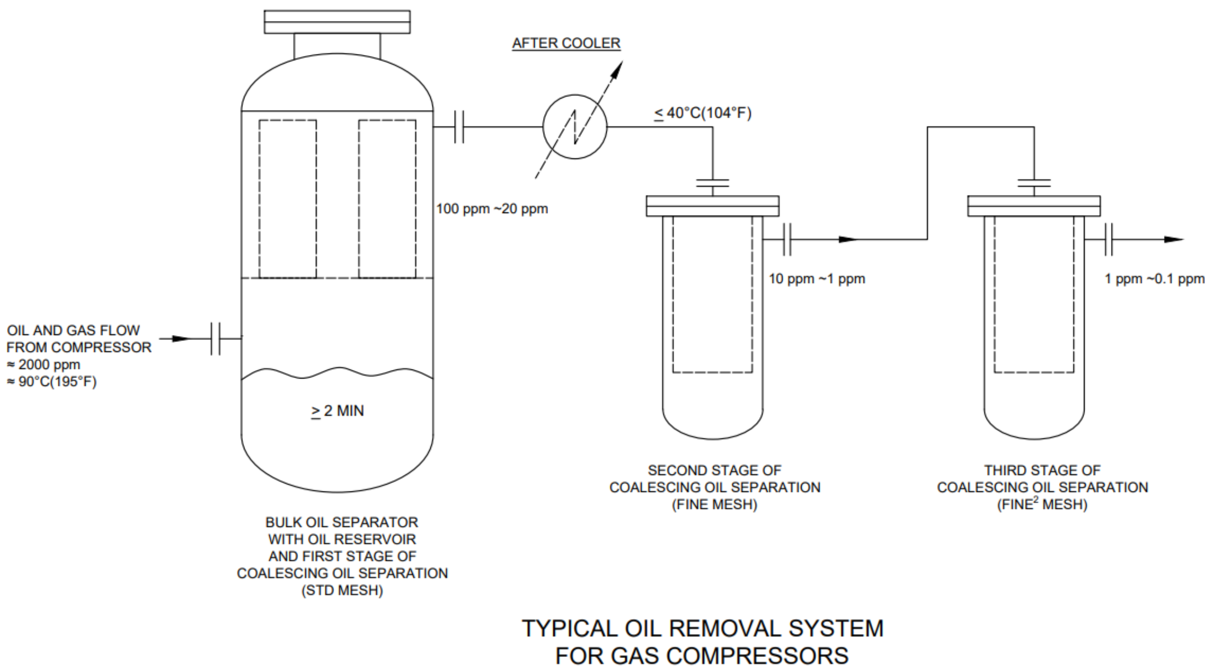


Figure G.2 – Typical Oil Removal System for Gas Compressors

G.2.3 Coalescers:

A coalescer is used to cause liquid aerosols to form larger, heavier droplets which are filtered out of the system. The coalescing filters trap the liquid while allowing the gas to pass through the filters. The efficiency of coalescence is dependent on the type and quality of the coalescing media. Coalescers are typically used for oil removal and not water or hydrocarbon, however coalescing of both oil and condensable from the gas is possible with the proper design and material of the coalescing filter elements. Coalescer separator collect aerosol/oil mist only. In the case of oil vaper removal, charcoal bed is a practical solution. Coalescers utilize coalescing elements to provide the coalescence.

G.2.3.1 Coalescing Elements

Coalescing elements are available in many styles and materials.

When considering coalescer elements, consider:

1. operating conditions,
2. gas composition,
3. liquid presence (droplets/aerosol),
4. contaminants/particle sizes,
5. efficiency required,
6. recommended/allowable replacement frequency of the filter elements,
7. if stacking of filter elements is allowed (not recommended)
8. amount of oil carryover allowed
9. testing methodology and results
10. resulting filter element velocity,
11. is oversizing from manufacturer recommendations desired.

ITEM	DESCRIPTION	QTY	MATERIAL
1	FLANGE	1	ALUMINUM
2	GASKET	1	NEOPRENE
3	OUTER CORE	1	PERFORATED STEEL
4	SUPPORT MESH	1	18 MESH BLACK
5	FILTER MATERIAL	1	FIBREGLASS
6	SUPPORT MESH	1	18 MESH BLACK
7	FILTER MATERIAL	1	FIBREGLASS WRAP
8	OUTER PROTECTIVE MESH	1	18 MESH BLACK
9	OUTER CORE	1	PERFORATED STEEL + COTTON SOCK
10	BOTTOM CAP	1	CARBON STEEL

Figure G.3 Typical Coalescer Element

Figure G.3 – Typical Coalescer Element

G.2.4 Adsorption (Carbon) Beds

Mechanical devices only remove the liquid phase of the oil. The vapor phase of oil takes time for the droplets of oil to form. The vapor phase of the oil is removed by temperature or by an adsorber (such as carbon bed).

G.3.0 Systems

G.3.1 General

G.3.1.1 Viscosity

Viscosity must consider oil dilution due to the gas mixture. Dilution occurs from gas AND liquids. Even a completely dry gas far above the dew points has significant oil dilution / gas impact on oil viscosity.

Oil viscosity at the discharge flange of the compressor is also important.

G.3.2 Lube oil system

G.3.2.1 General

- Locate lube oil pumps, filters, switching valves, temperature control valves, etc, off skid to reduce tripping hazards and provide room for maintenance.
- Specify direct drive lube pumps to reduce failure points and alignment complexity.
- Including a gearbox in the lube pump drive train adds alignment complexity (thermal growth) and increases the number of failure modes.
- Specify a lube pump/motor that operates near middle of pressure and flow capabilities for lowest lube viscosity (due to oil dilution) that compressor bearings can tolerate.
- Design lube pump installation per the requirements of API 686.
- Lube oil must be selected with both operations and maintenance personnel input. Work with the packager and OEM and field lube providers to select the oil up front for first fill and use that oil in the future. Consider other flooded screw applications that are in use. Many major lubricating oil providers have relationships with the OEM's that the packager may not be privy to. Don't get locked into an OEM/packager supplied oil for a long term, single service type of contract.
- Reference API 614 and Annex D for preferred schematics for pressurized oil systems for flooded screw compressors. Specify which schematic to use and when.
- Lube filters should be oversized for the application's oil flow requirements for each filter case installed. For example, a duplex filter system should have 2 cases, each capable of handling full flow.

G.3.2.2 Pre-lube

- After pre-lube, all lubricant in the compression chamber must be drained.
- be reminded, all lubricant (Function oil: feed to Shaft seal, Bearings, Balance piston) as well as Injection oil should feed to compression chamber.
- In general, compressor is in an unloaded condition during pre-lube period. The compressor discharge port is smaller in the unloaded condition. It takes time to drain pre-feed oil. Please see compressor cutout sketch as attached.

G.3.2.3 Oil Requirements:

Determine oil type, cleanliness, & viscosity of oil (with ranges) required by manufacturer for bearings, mechanical seals & controls.

G.3.2.4 Oil Viscosity:

In order to defined required oil viscosity, bearing and mechanical seal requirements should be considered as the primary factor. Type of oil and viscosity should be selected to meet this fundamental requirement. Viscosity of oil should be maintained during start up and other operating conditions. Normally viscosity of oil during start up, and ambient min site ambient temperature, along with the time required time for reaching the minimum start up viscosity are the determining factor in sizing the oil heater.

There are other factors that affect the oil viscosity as follows:

Oil mixing issues with process gas/inlet liquids/condensed liquids may cause:

- Synthetic or mineral oil dilution from liquids in gas stream
- PAG oils dilution with water

NOTE Most mineral oils do not dilute with ammonia gas

Vaporization of incoming, minimizing LO contamination

- Infinite pre-lube prior to start-up without risk of flooding
  - Some units may not be able to start up as flooded
  - Critical for cold climates
  - Critical for testing/troubleshooting

Remember the following for Oil Flooded Screw Compressor package design:

1) Lubricant system to be a part of process. Lube oil is contacting process gas, vapor and particles all the time.
2) Lubrication system is under compressor discharge pressure (higher after oil pump) & temp (up to oil cooler).
3) This lubrication system is different from other compressor’s lubrication system. (Not apply for API-614 design)
4) Incoming liquid to be mixed with lube oil.
5) Incoming particles are mostly collected at oil filter.

G.3.2.5. Lube oil pumps

Single mechanical seals are a key point of failure on lube oil-pumps on oil-flooded screw compressors. They must contain very high pressure. Any coupling misalignment, poor lubrication, or other typical site/installation/maintenance/process issues can result in failure. Failure can release process gas and oil. The most reliable pump will use a face mounted motor and a magnetic coupling rather than a mechanical seal. These may not match API 686 or 676 requirements.

Pumps must be specified for all cases including cold start. Cold start is often the worst case: suction pressure can be very low, cavitation is possible, and oil viscosity can be very high.

G.3.2.6 Lube oil system flushing

Lube Oil system flushing may be required in following circumstances:

1. Start up
2. Changing type of lubricants
3. Process gas degraded LO & a complete change of LO is needed
4. Detecting particles in the LO sampling analysis

When designing the lube oil system, take future oil flushing into account and include flanged connections to break the system down (isolating system sections) into appropriate lengths for flushing. include flanged connections to make the flushing more convenient. Install multiple vent, drain, and block valves to allow for partial system drainage, venting and to support future flushing.

Equipment and lines that should be flushed:

- Sections upstream and downstream the LO filter.

- Vessel cleaning out
  a. Varies with system size due to capabilities and velocities
  b. Openings to physically enter to clean (must be very large vessel)
  c. Carbon steel vs stainless steel
  d. Pickle vessels
  e. Vessels that cannot get into –
  f. High velocity air or nitrogen blows
  g. Drain line sizes
  h. Full removable top
  i. Sludge build-up in the bottom
  j. Stand pipe in the bottom for oil
  k. Vortex at bottom
  l. More concerned about the gas entry plugging up the coalescers, etc.
  m. Sizing of coalescing for having manways - Rule of thumb manway/access flange is half the diameter of the vessel if done

Following considerations should be take into account to facilitate flushing of the system:

- Avoid piping that is "fully welded" which makes it difficult to break lube system down for flushing. Additional flange pairs do incur a cost, but time is saved during the life of the project.
- Include operations/maintenance/flush contractor personnel in flush procedure design including volume, circulating flow, velocity, temperature, filtering methods, cleanliness standards.
- Make sure sufficient sized drain (2" minimum) are available
- Refer to API 614
- Bypass compressor for flushing
- May have to remove preservation material on startup
- Observation of all vessel closures
- Sensing lines for instrumentation should be drained, flushed & redrained

G.3.2.7 Flushing Hydraulic systems

Hydraulic components require very clean oil. in this process, following should be considered:

- Isolate the hydraulic system when doing flushing.
- If separate oil filters and/or circuit is considered, the specific hydraulic oil system is to be flushed.
- Field flushing connections should be provided. Typically tubing is used which makes it practical for flushing without special provisions. Typically, these connections are small enough to remove and shop clean.

G.3.3. Mechanical seals

For single mechanical seals, seal oil typically comes from the main lube oil system. There will be process gas entrained in the seal oil leakage and seal condition monitoring is difficult other than via oil leakage rate. These are normally used for general purpose systems. Reliability will be lower and a single point failure will result in process leakage to atmosphere.

Double-mechanical seals should be applied to all toxic gases. With an API Plan 53 or similar seal oil system, the condition of each seal face may be monitored and all seal oil leakage will be gas-free. This may also be required to meet site insurance requirements. These are applied for 99% of the special purpose oil-flooded screw compressors.

All seals should be cartridge type unless component type has specific approval from the purchaser.

G.5.0 Controls

Load control is accomplished via one or a combination of the following methods:

- Slide valve: Slide valves normally provide linear capacity control over the approximate range of ~ 20% to ~ 100% of the rated capacity and it is the most efficient approach in flooded screw compressors.
- Recycle valve CV – This method may result in highest inefficiency in the system and in flooded screw compressors is normally utilized in combination with sliding valves. In such cases it is used usually during the start up.
- Inlet pressure control valve
  Used to throttle (maintain desired suction pressure when have situations with higher than normal suction pressure)
- Back pressure control valve
  a back pressure control valve may be required to prevent sudden high gas velocity such as for start up to prevent excessive oil carryover

G.6.0 Packaging

G.6.1 General

G.6.1.1 The arrangement of the equipment, including piping and auxiliaries, should be developed jointly by the purchaser and the vendor. The layout should allow appropriate and safe access to all items which may require adjustment during normal operation and obstruction free access for those items that may need to be removed during normal maintenance, e.g. compressor and its driver, strainers, coolers, control valves, instrumentation, root valves etc.

G.6.1.2 All components of the flooded screw package should be completely assembled within the confines of the skid. All connections terminations should be flanged at the skid edge and supported by the structure. Connection locations should be agreed between the purchaser and the vendor. Connection locations should be approved by the purchaser.

G.6.1.3 Cooler tube bundles (if supplied) should be removable without the need of removing any other package item or equipment or structural members or the cooler itself.

G.6.1.4 Space above major equipment or its components, or both, should be free for lifting device approach required for their removal.

G.6.1.5 Maintenance or overhaul, or both, of the equipment should not require steel structure dismantling.

G.6.1.6 Where redundant equipment is supplied, the stand-by equipment should be completely removable without affecting continuous operation of the package.

G.6.1.7 Size and area of the skid platform should be agreed upon to provide safe and easy operation and maintenance access. Also, the skid dimensions should be reviewed between the vendor and purchaser for available plot space, shipping, and transportation requirements, as well as purchaser's health, safety, and environmental requirements.

G.6.1.8 Lifting points and lugs should be clearly identified on the equipment or equipment package. Lugs and pad eyes should be designed with a clear space around the eye.

G.6.1.9 Component location

Component locations should be determined in a joint effort between, the vendor and purchaser with consideration of applicable ergonomic standards, accessibility for operation and maintenance, access, and egress ways around the equipment skid, as well as location of tie-in points and the arrangement of the interconnecting cable trays.

G.6.2 Piping and Tubing

G.6.2.1 Piping and tubing should be routed in a safe way, not obstructing required access for installation, operation, and maintenance.

G.6.2.2 All piping and tubing should be arranged so that all maintainable items of equipment are capable of removal with minimum dismantling of piping or tubing, or both.

G.6.2.3 Main or auxiliary piping should not be routed near machine hold-down bolts and anchor bolts.

G.6.2.4 Temporary strainers, blinds etc. if used, should have tags reading “temporary” and protruding out of line/ insulation diameter indicating their presence.

G.6.3 Electrical, Control System and Instrumentation

G.6.3.1 API RP 540 and API RP 552 can be used as guidelines for electrical, control and instrumentation installation on the package such as cabling, conduits and cable trays, signal transmission, etc.

G.6.3.2 Electrical and control systems cabinets, terminal boxes and junction boxes door hinges should allow 180° opening-or have easily removable doors.

G.6.3.3 If the local start/stop/hand-off-auto switches for electric motors is provided and installed by vendor, it should be located at a close and safe distance from the electric motor to allow the operator to observe the operation of the equipment.

G.6.3.4 Push buttons, HMI panels, indicators lights and terminal strips should be easily accessible on the control panel. The minimum and maximum height of installation of components that need frequent access should be agreed.

G.6.3.5 Junction boxes, gauge boards and field instrument panels should be located at the skid edge in a safe place, easily accessible from back and front, away from vibration and heat sources. They should also be fitted with stands/brackets. If specified for outdoor installations sunshade should be provided.

G.6.3.6 Main Terminal box cable entry should be located to provide enough space for routing the power cable into the terminal box without exceeding the cable bend limit.

G.6.3.7 Where cable trays are specified, appropriate drainage should be provided.

G.6.3.8 Extension wires or cables should be run inside a cable tray or metal conduit suitable for the environmental conditions.

G.6.3.9 Local manual shutdown mechanism(s) should be safely and easily accessible. Approach to the local manual shutdown mechanism(s) and the escape route should be jointly reviewed between the vendor and purchaser.

G.6.3.10 Changing individual instrument items should not cause changing or removal of any other mechanical parts.

G.6.3.11 Gauges, sight glasses and other instruments should be installed such that they are not obscured from easy access and observation.

G.6.3.12 Cable trays and rigid conduit should not be routed over the cases of horizontally split rotating machinery. They should not be routed over or in front of removable heads on vessels and exchangers, or where they impair the functionality of inspection openings or panel doors.

G.6.3.13 Where the packaged equipment is required to be disassembled for shipment, mating parts should be match marked to aid the reassembly at the job site.

- Vibration transducers such as accelerometers should be directly mounted to equipment, not mounted on braces, extensions, bolt on mounting plates, etc., and should be installed per the requirements of API 670.

- Minimize length of thermowells and take flow induced vibration into account (Strouhall, vortex shedding)
- Consider the use of TIC loops rather than thermostat. Field personnel will have preferences.
- Mount transmitters off skid on a separate panel to minimize impact of vibration and pulsation effects.
- Assure that thrust probes will be accessible externally to the compressor once compressor is fully assembled.
- Care should be taken when using combination PLC/DCS systems to maintain instrument naming integrity.

G.6.4 Walkways, Ladders, and Platforms Access

G.6.4.1 Any special clearance or safe access areas located on the skid (such as proper evacuation route for emergency situation) should be specified by the purchaser. Sufficient head clearance should be available in all walkways and around the equipment.

G.6.4.2 Non-skid surfaces should be provided covering all walk and work areas.

G.6.4.3 Vendor should identify access areas sufficient for removal of major components such as cooler bundle, heater element etc. Maintenance and removal of main components, as well as maintenance and removal of control valve and instruments should be possible without removal or dismantling of adjacent equipment, piping, or structure.

G.6.4.4 Vendor and purchaser should agree on the required platform access to main equipment and auxiliaries, such as valves and instruments.

G.6.4.5 Vendor and purchaser should review safe and appropriate approach for handling the package components as required for installation and maintenance.

G.6.5 Layout

- Consult operations/maintenance on overall screw compressor system layout, including auxiliary equipment such as coolers, filers, fans, pumps, motors, valving.
- Be wary of “identical machine” philosophies. Very few truly identical installations out there as many things are field fit. Can have high vibration on one but not an “identical” installation due to small bore piping, supports, and clamps.
- Do not use specialty components without including operations and maintenance personnel in those decisions. For example, filter selections, relief valves, valves, and instrumentation, should only be selected that are typically available in the area the machine will be placed. Ops and maintenance can assist.
- Consult with operations and maintenance personnel regarding the type and quantity of spare parts. For example, replacement seals (process and lube oil) should be supplied with the machine and normal maintenance spares/deliveries should be understood. Take the location/logistics of installation site into account.
- The mechanical seal OEM must be included in the seal design including flush and orifice sizing. Many times, “standard” seals are provided, and the OEM hasn’t reviewed the proposed installation until a replacement seal is ordered.
- Don’t rely on the packager for seal support whether process or lube oil.
- Assure all bolting for piping and components such as clamps, braces, supports are accessible in a fully assembled condition with standard tooling. Many sites don’t allow use of “homemade” tools.
- Mounting pads between skid and compressor must be machined flat to within 2.0 mils, corner to cover in any direction. The goal is to provide a surface parallel with the machine’s feet.

- Welding of the mounting pads to the skid will cause dishing of the pad surface, requiring finish machining.
- Grouted sole plates should be designed and installed per requirements of API 686.
- Skids must be leveled in the shop prior to equipment installation, grouting, machining to the same requirements as in the field. Use of benchmarks is recommended to minimize incremental differences in alignment of not only the compressor train, but associated piping. Is easy to introduce pipe stress between shop fabrication/assembly and field.
- Flooded screw compressor discharge should ideally be a straight run sloping towards the coalescing filter.
- The area below the discharge piping mentioned above should be clear and available for pipe supports.

G.6.6 Piping

- All piping, nozzles, supports, clamps must be designed such that mechanical natural frequencies (MNF) have an appropriate separation margin from common excitation frequencies such as Pocket Pass Frequency (PPF). This may result in heavier wall piping, vessel shell wall thickness, nozzles, reinforcement pads, etc. than required for pressure or code compliance only.
- Checks should be made of all blocked-in nozzles such as relief valve or manual bypass lines for acoustic issues (quarter wave)
- Assure pipe stress and thermal growth taken into account during design, fabrication, field erection of all components.
- Minimize or eliminate use of U-bolts for clamps as they don't add any significant stiffness.
- Restraints (support/clamp) should be designed for required dynamic loads, not just static loads.
- The compressor is not a dynamic restraint. Nozzle loads on the compressor must be minimized.
- Easy check is to have a customer witness that includes inspecting all bolting for looseness prior to torquing. If a bolt is moveable in flanges by hand, then it will introduce minimal pipe stress in the cold condition.

Annex H
(Informative)

Packaging Checklist

Oil-flooded screw compressor packages exist across a wide spectrum of application, process, safety, reliability, insurance, client, and other requirements. This results in an incredibly wide range of package scope and specifications. This checklist is intended to help the reader navigate that spectrum and guide the resulting package requirements.

For general purpose air, refrigeration, and other standardized applications, vendor-standard (fit-for-purpose) machines are often acceptable, preferred, and sometimes spared. While the core part of the package may be standardized, the accessories around it are often selected specifically for the site/application. For example, winterized enclosures, suction knock out drums, controls, or air-cooled aftercoolers. These machines traditionally have more limited applications, options, and capabilities.

For special purpose applications, those with high criticality levels and/or for open loop, toxic, flammable, wet, and other challenging applications, API 619 applies. Instead of starting from a vendor-standard package, API 619 compressor packages are typically designed, engineered, and fabricated specifically for a given customer, application, and site. The scope and specifications can be anything the purchaser and vendor agree to.

Table H.1

Packaging Checklist

	Review Considerations	**Yes / No For use at coordination meeting**	**Reference**	**Comments** **Nothing in this column now – for comments during**
1	**Applications:**			
1.1	**Criticality:**			
1.1a	Has the level of criticality for the application been determined?			
1.1.1	**High Criticality Applications:**			
1.1.1a	Have requirements for critical applications been considered, such as:			
1.1.1a1	parallel components • redundancy for comp. package: 3 x 50%, 2 x 100% ,,, • redundancy for accessory equipment: 2 x 100% oil pump ,,,			
1.1.1a2	voting logic for instrumentation (API 614, para. 8.2.3.1) • 2oo3 voting for all instruments. • 2oo3 voting for shut down instrument.			
1.1.1a3	Level of vibration monitoring capability			

	• vibration sensor for compressor & main motor • vibration sensor for compressor only			
1.1.1a4	Redundancy for Control System & instruments. • Redundancy with SIL Level 2/3.			
1.1.2	**Lower Criticality Applications:**			
1.1.2a	Have requirements for less critical applications been considered, such as:			
1.1.2a1	Is there need for parallel components? • redundancy for accessory equipment: 2 x 100% oil pump ,,,			
1.1.2a2	Is there need for voting logic for instrumentation (API 614, para. 8.2.3.1)? • 2oo3 voting for shut down instrument			
1.1.2a3	What level of vibration monitoring is appropriate for the service? • vibration sensor for compressor • vibration sensors for compressor and motor			
1.1.2a4	What level of redundancy for Control System & instruments is appropriate?			
1.2	**Risks & Risk Mitigation/Reliability:**			
1.2a	What philosophy will be used to determine the risks and methods for risk mitigation? • HAZOP • SIL study • Other review meeting			
1.2b	Has the required level of reliability been determined? How will that level be achieved? • SIL level 2/3			
1.3	**Environment:**			
1.3.1	**Outdoor applications:**			
1.3.1a	Have requirements for outdoor applications been considered, such as:			
1.3.1a1	Heat tracing & personnel protection insulation			
1.3.1a2	Cold startup control system associated with oil viscosity management systems			
1.3.1a3	Condensation within inlet piping and vessel sensing instruments for auto drain system.			
1.3.1a4	Requirements for lighting			

1.3.1a5	Electrical code requirements for Hazardous area classification.			
1.3.1a6	Winterization			
1.3.2	**Indoor applications and noise enclosure installation:**			
1.3.2a	Have requirements for indoor applications been considered, such as:			
1.3.2a1	• ventilation systems • electrical code requirements • site conditions • noise limitation • site ambient temperature range			
1.3.2a2	Electrical code requirement for Hazardous Area classification			
1.3.2a3	Maintenance activities • crane capacity and height requirements for lifting components during maintenance • access by mobile cranes, if needed			
1.3.2a3	Lighting • OSHA safety requirements • local ordinances			
1.4	**Auto-Start Applications:**			
1.4.1	Have requirements for auto-start been considered, such as:			
1.4.4.1a	Condensate mitigation			
1.4.4.1b	Additional controls with instruments that indicate safe start confirmation			
1.4.4.1c	Auto switchover controls with instruments if redundant compressor package and/or accessory package equipment (oil pump, package isolation valve,,)			
1.5	**Un-Manned Applications:**			
1.5.1	Have requirements for un-manned applications been considered, such as:			
1.5.1a	Automatic condensate mitigation & liquid drain confirmation.			
1.5.1b	Additional controls with instruments to indicate safe start confirmation			
1.5.1c	Package Isolation Valves open/close confirmation instruments & control.			

2	**Inlet Gas:**			
2.1	**Inlet Gas Properties:**			
2.1a	Have any special conditions/properties of the inlet gas been reviewed? • Should be discussed with purchaser/process engineer.			
2.1b	Does the process data sheet include all process data and gas compositions for situations such as the following? • normal & abnormal conditions • alternate inlet gas • side gas streams • well chemical injection • change of seasons and ambient temperature changes • water (including free liquids) • startup (hot and cold start) • turndown and turndown method • where the gas analysis is taken is important			
2.2	**Liquids:**			
2.2b	Does the inlet gas contain liquids (free or entrained) in normal or abnormal operation?			
2.2b1	If so, what is the amount of liquid in the inlet gas (Kg/h)?			
2.2b2	If so, does the liquid require removal & if so, what will be the method? • Consider superheating, KOD, drying, and other methods. • See Annex E Figure Z01			
2.2c	If a potential for a liquid slug can occur, has the remediation of the liquid slug been determined? • Slugging destroys screw compressors. • Potential for slugging should be discussed with purchaser/system engineer. • Slug should be removed by purchaser's process at upstream of compressor. • See Annex E Figure Z01			
2.2d	What are the water and hydrocarbon dew point margins at the suction and discharge of the compressor under all possible normal and abnormal operating conditions?			
2.3	**Contaminants:**			
2.3a	Does the inlet gas contain contaminants? If so, do these require removal & if so, what will be the method?			

	• Example: tar, waxes, paraffins, polymerizing components, H2S, etc. • See Annex E Figure Z01			
2.4	**Particles:**			
2.4a	Does the inlet gas contain particles? If so, what are the quantities, sizes, and character of these particles? Compressor OEM to confirm maximum particle size and quantity for incoming gas. Please note: Incoming particles which are not removed at suction filter or KOD will be mixed with oil at the compression camber then potentially removed at the oil filter. Oil filters should never be used as process particulate filters. It means, Oil flooded SC package to be work as a wet particle filter. • See Annex E Figure H01			
2.5	**Review of above criteria:**			
	Not all applications are suitable for oil-flooded screw compressors. If issues with particulates, contaminants, liquids, etc. cannot be suitably mitigated, consider an oil-free screw compressor. They are often the best possible choice for wet, polymerizing, reactive, and dirty gases and can be highly reliable even in such challenging services.			
3	**Package:**			
3.1	**Package Simulation:**			
3.1.1	What company is to perform a simulation of the package by process simulation? simulation package or similar system? • Client? • OEM? • Packager? When in the project are the process simulations to be run?			
3.2	**Compressor Arrangement:**			

3.2.1	Are multiple compressors requested? • For 2 stages of compression? • For stand-by/back -up operation such as 2 x 100% or 3 x 50%?			
3.2.2	If multiple compressors, are the compressors packaged as single or multiple packages? • Usually, 1 x comp. per package			
3.2.3	If multiple compressors, is this a series or parallel application? See 3.2.1. as above.			
3.2.4	If multiple compressors with parallel trains, what components, if any, are to be shared? Caution should be applied when sharing components across multiply trains as this will limit availability if the intent is 2x100% compressors. • From suction isolation valve to discharge isolation valve + lube system should be one comp. Pkg. • Inlet KOD may be shared with multiple compressor Packages.			
3.3	**Pulsation Control:**			
3.3a	Has the reduction of pulsations plan been identified? Oil separator vessel to be used as pulsation control vessel.			
3.3b	Has spacing for 1" spacer plates between compressor suction/discharge flanges and process piping been included for potential pulsation dampening devices if needed later?			
3.4	**Package Cleanliness (shop):**			
3.4a	What are the cleanliness requirements of the compressor, piping/tubing, & vessels?			
3.5	**General Arrangement:**			
3.5a	Does the skid layout allow appropriate and safe access to all items which may require adjustment during normal operation and obstruction free access for those items that may need to be removed during normal maintenance, e.g. compressor and its driver, strainers, coolers, control valves, instrumentation, root valves etc?			
3.5b	Does the layout of off-skid components allow appropriate and safe access to all items which may require adjustment during normal operation and obstruction free access for those items that may need to be removed during normal maintenance, e.g. compressor and its			

	driver, strainers, coolers, control valves, instrumentation, root valves etc?			
3.5c	Has the equipment, piping/tubing, sight glasses, gauges, and conduit arrangement been reviewed to ensure that maintenance accessibility exists?			
3.5d	Has the arrangement of the equipment, instrumentation, controls, piping/tubing, conduit, and local start/stop/hand-off-auto switches been reviewed to ensure that operational accessibility exists?			
3.5e	Does the layout of the equipment allow efficient disassembly and/or the removal of equipment?			
3.5f	Has the ability of component draining been reviewed?			
3.5f1	~~Has~~ Have the requirements for automatic or manual control of the package been identified? Have all compressor control interfaces been identified? Have the requirements for compressor safety shutdown system been included?			
3.5g	Will the compressor & driver mounting surfaces be machined to requirements of API 686 after all welding has been completed that could affect the skid flatness? • Comp. & main motor may be installed top of the horizontal 1st oil separator. • Does the skid require stress relieving after welding is completed? Does the ITP include package and equipment mounting surface verification.			
3.5h	Does the skid include provisions for:			
3.5h1	• The grouting of the rails?			
3.5h2	The filling of compressor skid with concrete?			
3.5i	Have the walkways been reviewed to ensure they are practical? • Confirm walkways comply with regulatory requirements. • Are walkways clear of tripping hazards. • Verify that valve handles do not protrude into the walkways in either the open or close position. Verify that there are no head knockers over the walkways.			
3.5j	Have the ladders been reviewed to ensure they are practical?			
3.5k	Have the platform areas been reviewed to ensure they are practical? • Confirm that there are no tripping hazards. • Confirm that work platforms have appropriate handrails.			

3.6	**Reverse Flow & Reverse Compressor Rotation:** • Reverse rotation seldom happens at oil flooded screw comp.			
3.6a	Has the potential of reverse flow through the compressor(s) or other vessels been considered?			
3.6b	• If reverse flow occurs, has the potential for reverse compressor(s) rotation been considered/eliminated?			
3.6c	Has the compressor vendor provided information if reverse flow (reverse rotation) is an issue?			
3.6d	Does reverse compressor rotation require lube oil circulation for the reverse rotation time period?			
3.6e	For two compressors in series (two stage), using two individual compressor casings, has the depressurization of the stages been considered with respect to potential reverse flow and reverse compressor rotation?			
3.6f	For two compressors in series (two stage), using two individual compressor casings, is a check valve position between the two compressors to prevent reverse flow of process gas at shut down?			
3.6g	Review location of discharge check valve and opening time of recycle valve at shut down to prevent or limit potential of reverse rotation.			
3.6h	Where are check valves to be placed in the system? Check valve must be installed at compressor suction & 1st oil separator discharge piping. It prevents the reverse rotation & oil spread to upstream piping.			
3.6i	Has the need/benefit for process check valves been considered?			
	•			
3.7	**Piping/Tubing:**			
3.7.1	**Piping:**			
3.7.1a	Is stainless steel piping specified? • Are there interfaces with carbon steel piping, if so has method of isolation between dissimilar metals been determined? Has Stainless stain bolting been specified.			
3.7.1b	For stainless steel lube oil piping, is stainless steel bolting specified.			
3.7.1c	• For installation in salt laden environments (marine environments) has the potential for chloride stress carrion cracking been addressed.			

3.7.2	**Tubing:**			
3.7.2a	For installation in salt laden environments (marine environments) has the potential for chloride stress carrion cracking, crevice corrosion and pitting been addressed. • Review tubing material selection.			
3.7.2b	Have dual ferrule compression fittings been specified?			
3.7.2c	Is there a preference for tape or paste?			
3.8	**Temporary Strainers:**			
3.8a	Temporary strainers, blinds etc. if used, should have tags reading “temporary” and protruding out of line/ insulation diameter indicating their presence.			
3.8b	Verify that the temporary strainer is sufficiently sized to provide adequate flow area with the fine mesh screen attached.			
4	**Vessels:**			
4.1	**General:**			
4.1a	What vessels are included with the package and what are their arrangement? • 1st oil separator should be included. • KOD (Knock Out Drum) location depends upon package layout for each project design. 1st oil separator vessel design is vertical or horizontal depends upon Compressor , driver sizing, and package layout.			
4.1b	What additional vessels may be required that are not included with the package? For large comp. package KOD, fine oil separator (2nd, 3rd oil separator) and Carbon bed may not be on compressor skid. It depends upon compressor size and package design/layout			
4.1c	What vessels are not provided by the compressor packager? NOTE: For vessels not included in the compressor packagers scope, typically are not included in simulations provided by the compressor packager. • Please see 4.1b as above. Scope of additional vessel depends upon project specification.			
4.1d	What is the arrangement of the system including the vessel locations?			

	It depends upon compressor size, package design, and plant layout.			
4.1e	What are the capabilities for vessel entries, such as cleaning? Usually, shell flange or manhole with hinge per operating condition.			
4.1f	What are the nozzle orientations? (Note: Gas typically exists from the top) Depends upon package design, layout, and operating condition.			
4.1g	Where is the gas stream measured? (Note: The measurement of the gas stream is typically from the top of the separator) Gas stream Flow measurement is done by mainstream flowmeter installed outside compressor package			
4.1h	What is the orientation of the vessel, horizontal or vertical? How does that affect the operational restrictions? • 1st oil separator vessel design is vertical or horizontal. • KOD and 2nd /3rd oil separators are typically vertical design.			
4.1i	If the vessel has a minimal positive pressure with negative pressure and requires draining while in operation, how is the draining accomplished? When KOD is lower or for vacuum pressure condition, drain pump to be installed			
4.1i1	- Is a blow case to be used? - What is the motive gas? - Is the blow case included? - Is the blow case automatic? - Where does the drained liquid go? Usually drain liquid pipe outlet is located at the compressor package skid edge.			
4.2	• **Inlet Filters (for Particles):**			
4.2a	Is an inlet filter required, if so why? • Is it temporally filter? It depends upon fluid condition, inlet piping quality, and others			

4.2b	Has the type, quantity, size, and frequency of particles been identified? It should be advised by purchaser.			
4.2c	• What is the proposed velocity through the filter and what are the optimum velocities by the vendor? • For gas velocity, consult with Filter element OEM. • Besides velocity, filter element capacity should be considered. Filter element capacity Safety factor (SF) should be > x 1.5~2.0 depends upon operation condition and inlet piping condition.			
4.2d	Has the level of filtration (micron) been identified? Better than 200 mesh for compressor suction filter element .			
4.2e	If an inlet filter is provided, what are the expectations (ppm/ppb)? Inlet filter is for particles protection. The particles measurement should be in the basis of diameter size (mm, micro m) with XX kg/h for amount.			
4.2f	What is the type of filtration used? Usually, basket type filter element for particle protection			
4.2g	What is the life of the filter elements? It depends upon inlet gas condition.			
4.2h	Has the arrangement of the inlet filter considered potential liquid entry? Will the filter elements withstand liquid entry? Inlet filter is for particle protection (see Figure H01 & Table H01)			
4.2i	Are there two inlet filter vessels including valves which allow removal /replacement of the filter elements for one of the vessels cleaning while compressor running? For this case, each filter design should be 100% operation condition.			
4.2j	Is a bypass provided without the second parallel inlet filter?			
4.2k	Has the effect of the differential pressure across the filtration system been considered for the compressor's performance and required horsepower?			
4.2l	Is the inlet filter designed/sized for normal and abnormal conditions? Commonly oversized design is considered.			
4.2m	• What alarms are included, typically high and high-high differential pressure.			
4.3	**Separators:**			

4.3.1	**Inlet Separator:**			
4.3.1a	Is an inlet separator required (separation of liquids/gas and/or pulsation control) if so, why and what are the expectations? For Oil-Flooded Screw compressor, pulsation vessel is not used.			
4.3.1b	Is an inlet separator the best choice for this application?			
4.3.1c	What are the expectations of the inlet separator?			
4.3.1d	What are the internal components?			
4.3.1d1	what are the maintenance activities for internal components, if any? • Wire mesh demister and baffle plate are washable. • Chiller/Heater heat exchanger is washable. Coalescer element may be exchangeable.			
4.3.1d2	What is the life of the internal components? Depends upon inlet fluid cleanness			
4.3.1e	Is the inlet separator designed/sized for normal and abnormal conditions?			
4.3.1f	Is the inlet separator to be combined with an inlet scrubber? It depends upon operation condition, particles, and Liquid in process gas.			
4.3.1g	Where and how will liquids be removed from separator? • Drain out from inlet separator. See 4.1i as above			
4.3.1h	What alarms are included, typically low, low-low, high, and high-high levels. *NOTE: Typically, low-low is in case dump valve sticks open and potential of gas flowing from the separator continuously).*			
4.3.2	**Intermediate Separator:** In the case of 2 x separate compressor, it may use 2 x separate compressor package including, oil separator + lubricant system for each stage. In the case of single casing two stage compressor no interstage separator to be used. Low and high stage have common oil separator + lubricant system.			

4.3.2a	For compressors in series, is an intermediate separator included? If so, what is the purpose and what are the expectations? Intermediate separator for 2 x single stage compressor package, brings stable operation.			
4.3.2b	Does the intermediate separator include oil injection to the first stage compressor or does the oil injection come from the 2nd stage discharge separator for both compressor stages? *NOTE: The oil flows and pressures are typically different for the different stages.* Oil injection is managed by each stage compressor not by separator.			
4.3.2c	What are the expectations of the intermediate separator?			
4.3.2d	What are the internal components? Usually, coalescer element for oil separation.			
4.3.2e	If internal components, what are the maintenance activities for internal components? Coalescer element to be exchangeable			
4.3.2f	If internal components, what is the life of the internal components? It should be over 1 year for normal operation.			
4.3.2g	Is the intermediate separator designed/sized for normal and abnormal conditions?			
4.3.2h	Are side streams (inlet or discharge) included in the design of the package?			
4.3.2i	Where and how will liquids be removed from separator? Commonly Interstage separator is designed similar to discharge separator, same as 4.3.3.as below. In the case of side stream contains liquid, separate liquid separation system should be installed.			
4.3.2k	What alarms are included, typically low, low-low, high and high-high levels. *NOTE: Typically, low-low is in case dump valve sticks open and potential of gas flowing from the separator continuously.*			
4.3.3	**Discharge Separator:**			
4.3.3a	What are the expectations of the discharge separator? • Primally expectation of discharge separator is oil separation. • Mechanical oil separation removes oil droplet. Oil vapor is removed by charcoal bed.			

4.3.3b	Should the discharge separator be designed for a 2 phase or 3 phase fluid? Mechanical oil separator is designed for oil /gas separation. Not for oil/(process gas) liquid separation.			
4.3.3c	What are the internal components? Coalescer element is commonly used. It is made by multiple layers of glass wool and other materials.			
4.3.3d	If internal components, what are the maintenance activities for internal components? Coalescer element to be exchangeable.			
4.3.3e	If internal components, what is the life of the internal components? It should be over 1 year at normal operation.			
4.3.3f	Is the discharge separator designed/sized for normal and abnormal conditions?			
4.3.3g	Is oil carryover allowed?			
4.3.3g1	If so, how much oil carryover is allowed?			
4.3.3g2	Has the oil carryover rate been provided for both normal and abnormal conditions?			
4.3.3g3	How is the oil carryover measured?			
4.3.3h	Is a separate, secondary discharge oil separator vessel used for the coalescing elements? Fine grade coalescer element may be used.			
4.3.3i	Is a carbon bed required for additional oil removal? Carbon bed is used in the case of no oil carry over is specified.			
4.3.3j	Retention Time:			
4.3.3j1	What retention time for the oil has been selected?			
4.3.3j2	What is the retention time specified? 2 min per 6th ed. Part 3 para 7.6.14.6 (b)			
4.3.3j3	Is the retention time approved?			
4.3.3k	Is a heater required inside the separator? Heater is designed for oil viscosity control for cold start up preparation.			
4.3.3l	Is a heater installed inside the separator?			

4.3.3m	Where and how will liquids be removed from separator? • During normal operation, liquid removal from oil separator is to keep gas temperature higher than gas dew point. Heater in oil separator is designed for liquid evaporation for start-up preparation not designed for liquid separation during normal operation.			
4.3.3n	What alarms are included, typically low, low-low, high, and high-high levels. *NOTE: Typically, low-low is in case dump valve sticks open and potential of gas flowing from the separator continuously).*			
4.4	**Discharge Gas:**			
4.4.1	Are there requirements for the discharge gas condition?			
4.4.2	What is the allowable amount of liquids/oil allowed in the discharge gas?			
4.5	**Scrubbers:**			
4.5.1	Scrubber tank is not necessary for oil-flooded screw compressor. Oil separator to be used as scrubber function.			
4.5.2	What are the expectations of the scrubber?			
4.6	**Knock Out Drums:**			
4.6.1	Is a knockout drum necessary?			
4.6.2	What are the expectations of the knockout drum? Reduce/minimizing incoming particles and liquids to compressor.			
5.0	**Two Stage Applications and guidance.**			
5.1	**General:**			
5.1.1	Are two stage compressors required? Two stage compressor is considered when pressure ratio (PD/PS) is over 10.			
5.1.2	Are the two stages separate compressors or two stages in one housing?			

	One housing two stage compressor is considered when the operation condition is suitable for the existing compressor. Consult with compressor OEM is recommended.			
5.1.3	Is there an interstage separator? Interstage oil separator with oil system for 1st stage compressor is commonly used for two separate casing two stage compressor design.			
5.1.4	How is the interstage pressure controlled? Interstage pressure is automatically balanced by 1st stage and 2nd stage load and operating condition.			
5.1.5	What are the operational ranges and limitations with respect to pressures are required for the two stages? • At one casing two stage compressor, 20/25~100% flow capacity is controlled by 1st stage compressor slide valve during normal operation. Interstage pressure should be stayed at less than 1st stage maximum discharge pressure and 2nd stage highest suction pressure specified by compressor OEM.			
5.2	• **Two Stage Compressor Controls:**			
	How are the two stages controlled? • At one casing two stage compressor, during normal operation, 2nd stage slide valve should be 100% fixed & capacity control should be handled by 1st stage slide valve. • At two separate compressor packages with each oil system, at start up, both package capacity control is as same as single stage compressor. During normal operation, compressor capacity is controlled by 1st stage compressor. 2nd stage slide valve position should be referring the intermediate pressure. • Consult with compressor OEM is recommended.			
	•			
5.3	• **Two Stage Compressor Oil Systems:**			
5.3.1	How is the lube oil, hydraulic oil, & control oil system oil requirements designed for each stage? • At one compressor casing, one lube oil system provides 1st and 2nd stage. The lubrication and capacity control system design covers both of 1st stage and 2nd stage compressor. 1st stage function and injection oil pressure should be referring intermediate pressure. • At two separate compressor casing, following 2 case should be considered:			

	A) One lube oil system covers both compressor casing case, lubrication and control system design are good for both of 1st stage and 2nd stage compressor. 1st stage function and injection oil pressure to be referring intermediate pressure. • Two separate compressor package with individual lube oil system for each stage case, each lubrication and control system design is good for each compressor.			
5.3.2	Will the proposed lube oil, hydraulic oil, & control oil system for the two stages be able to be easily and well controlled? Commonly, proposed package control system shall be designed for all expected normal and upset operating conditions.			
5.3.3	Has the different lube oil, hydraulic oil, & control oil system pressures for each stage been identified and the methodology provided? • At one compressor casing package and two separate compressor with common lube oil system package, the lube oil system design pressure is good for 2nd stage compressor. At two separate compressor package, each lubrication and control system pressure design is good for each compressor.			
5.3.4	How sensitive will the fluctuation of the interstage pressure be with respect to the two stages for operation? • Interstage pressure should be stayed less than 1st stage maximum discharge pressure and 2nd stage highest suction pressure specified by compressor OEM.			
7.0	**Controls & Instrumentation:**			
	Has vendor been provided with purchaser control, instrument, and electrical specifications applicable to project?			
	B) Has purchaser provided vendor with approved vendor list for controls and instruments?			
	•			
6.0	• **Systems**			
6.1	• **Oil systems**			
6.1.1	**Arrangements:**			
6.1.1a	What is the oil system supplying? • The oil system includes, 1st oil separator, oil pump(s), oil filter(s) & oil temperature /pressure control valves with			

	instruments. Please see typical PID in part -3 & API-614 Fig-110. Duplex oil pumps typically have a pressure regulating valve to control oil pressure (PDCV)-JG Pump may have external or internal pressure relief valves (PRV).			
6.1.1b	Has the oil system process flow drawing been reviewed?			
6.1.1c	Have multiple oil systems been defined? (for two stage compressors either single or two casings) • Please see 6.1.1a as above. Two stage compressors may or may not have separate oil pumps for each stage. It is more common to see oil pumps sized to supply both stages from a single oil system.			
6.1.1d	Has the requirements for two stage compressors been defined?			
6.1.1d1	For multiple stage compressors using a single oil system, have the consequences and difficulties with multiple stages from one oil system been considered? • For a compound compressor made up for more than one stage, has the oil pump system been considered for changes in compressor capacity when in service? For the single casing 2 stage compressor case: at start up the low & high stage are set to the 0% slide valve position. During normal operation: the slide valve in the high stage is 100% fixed & the capacity control is controlled by the low stage slide valve. The 1st stage function oil pressure is to be referring to intermediate pressure.			
6.1.1e	Is there one oil pump or two?			
6.1.1f	Does the oil pump(s) have sufficient margin for flowrate, pressure, temperature, & horsepower? • Note: A PDCV should allow for both.			
6.1.1g	Has the horsepower requirement for cold oil been considered for the oil pump(s)?			
6.1.1h	• Is there one oil filter or two (duplex)?			
6.1.1h1	What is the lube oil filter Micron rating & Beta rating?			
6.1.1h2	• What is the hydraulic oil filter Micron rating & Beta rating? (If a separate hydraulic oil filter has been provided.)			
6.1.1h3	Compare the oil filter flow rating with the oil flow rate.			
6.1.1i	• Is there one oil heater or two (duplex)?			
6.1.1j	Is there one oil cooler or two (duplex)?			
6.1.1k	For duplex components, has consideration been given to prevent the component that is not in service, from plugging or fouling?			

	Recommend using 2-way valves on oil piping. Case of 6-way valve for component switching once it is plugged all system to be stopped.			
6.1.1l	Has the differential pressure for cold oil start-up been considered for all components?			
6.1.1m	Is there an accessible location(s) to sample the oil? • Periodical oil sample & testing is strongly recommended. • Separate locations before and after filtration may provide more information.			
6.1.1n	Is the ability to perform an on-line oil change required? It is possible to add/tap oil during operation. Oil change need to stop the compressor system.			
6.1.2	**Oil Type:**			
6.1.2a	Has the type of oil been determined (mineral oil or synthetic oil) considered? • Please see Oil recommendation table on annex-XX in 6th edition.			
6.1.3	**Oil Viscosity:**			
6.1.3a	How does the oil maintain its required viscosity? • Oil viscosity is depending upon process gas dilution & oil temp. Comp. MFG. specified oil viscosity range shall be maintained all the time.			
6.1.3b	Has the compressor oil and pump oil viscosity been reviewed for:			
6.1.3c	start-up & operational temperatures of unit			
6.1.3d	• potential of oil dilution while compressor setting idle			
6.1.3e	Has the method of ensuring that the oil viscosity is maintained at the desired viscosity for cryogenic applications? At cryogenic operating temperatures, such as lower than -100°C, the lube oil may become frozen. In the case of cryogenic service, oil should not be carried to the cryogenic temperature zone. Commonly multiple oil separators are used. An active charcoal bed is used when very low oil carry over is required.			
6.1.4	• **Oil Circulation Including Pre-Startup & Post Shutdown:**			

6.1.4a	Has the requirements & issues for oil circulation for pre-startup been reviewed:			
6.1.4b	Length of time oil can be circulated during pre-startup? Pre lube oil amount should be limited, infinite pre-lube prior to start-up will be caused of comp. casing internal over flooding.			
6.1.4c	Effect of viscosity during oil circulation during pre-startup? Oil viscosity depends upon process gas dilution & oil temp. The compressor manufacture's specified oil viscosity range shall be maintained at all times.			
6.1.4d	Potential for the compressor being flooded with oil for start-up and if so, potential issues? • See Annex ??? 6.2.			
6.1.4e	Has the requirements & issues for oil circulation for post-shutdown been reviewed? • Usually, no post lube during shutting down is necessary.			
6.1.4f	Length of time oil can be circulated during post-shutdown?			
6.1.4g	If so, how long?			
6.1.4h	Issues with operating the oil systems after the compressor is shut down? • Usually, no post lube during shutting down is necessary.			
6.1.4i	• Issues with operating the oil systems after the compressor is depressurized?			
6.1.4j	Has the control for the oil system(s) been reviewed for start-up conditions, especially if the oil is required to circulate for some time period to provide desired oil temperature at the bearings prior to start up? • See Annex ??? 6.2.			
6.1.4k	Has compressor coast down been determined for oil system operational time after shut down?			
6.1.5	**Oil Flushing Capabilities:**			
6.1.5a	Have oil flushing capabilities been included from the oil filter(s) to the oil entry points for the compressor? • Compressor should be bypassed, during package.			
6.1.5b	Are the connections for the oil piping/tubing readily accessible for field oil flushing of all oil systems?			
6.1.5c	• Have oil draining capabilities been included with the discharge separator(s)?			

6.1.5d	Have provisions been made for the oil to be reclaimed during compressor operation?			
6.1.5e	Are provisions included for complete draining of all oil systems?			
6.1.5f	Has the ability for cleaning vessels been reviewed and are they acceptable?			
6.1.5g	• Is it acceptable to leave debris in the bottom of the discharge separator requiring the oil filter to remove the debris?			
6.2	**Mechanical seals:**			
6.2.1	**Mechanical Seal Requirements:**			
6.2.1a	What seal is proposed?			
6.2.1b	Is the mechanical seal a single, tandem, or double?			
6.2.1c	Are there any limitations with the seal system?			
6.2.2	**Mechanical Seal Flush/Purge Requirements:**			
6.2.2a	What API seal flush plan is proposed?			
6.2.2b	What are the special requirements for the seal flush plan?			
6.2.2c	Has a sketch of the seal flush plan been available for review?			
6.2.2d	Are there provisions for cleaning (flushing) the seal piping/tubing?			
6.2.2e	What instrumentation is proposed for the seal flush plan?			
6.2.2f	What seal flush plan components are included?			
6.2.2g	What are the material details of the seal flush plan components?			
6.3	**Bypass System Around Compressor Casings:**			
6.3a	Should/does a bypass system exist around each stage of compressor casing for rapid depressurization to minimize the chance off compressor reverse rotation? Reverse rotation seldom happens at oil flooded screw comp.			
6.3b	What is the arrangement of the bypass system & what controls are on this system?			
7.1	**Compressor Controls:**			

7.1a	Does the compressor(s) have a mechanism for flow control? • Built-in slide valve to be used for comp. flow control.			
7.1b	Has the flow range been reviewed? • Slide valve control range is from 20/25% to 100% of flow capacity.			
7.1c	How is the flow control achieved? • Internal slide valve and control system • External recycle system with control valve and cooler (cooled bypass from discharge to suction) • Variable speed?			
7.1d	How is bearing/injection oil temperature controlled?			
7.1e	If an aftercooler is supplied, how is gas cooled? • Water cooled exchanger (TEMA R or C) • Fin fan air cooler (adjustable louvers/speed, etc.) How is gas cooling controlled? Where are aftercoolers mounted?		6.4.2	
7.1f	Is a free-standing instrument and control panel required? • Vendor supplied? • Purchaser supplied? Is vendor aware of purchaser control panel specifications/requirements?			
7.1.g	• What is the area classification?		6.4.2	
7.1.g	Do the controls and instruments need to be designed for outdoor installation and operation? What are the requirements? (IP 65, NEMA 4?)			
7.2	• **Instrumentation:**		**6.6**	
7.2a	What instrumentation & type of instrumentation is provided? • Bearing temperatures • Oil temperatures • Process (suction/discharge) temperatures • Bearing and injection oil pressure • Process pressures • Suction strainer delta P • Filter delta P (bearing and injection oil) • Oil viscosity (bearing and injection oil) • Oil level (bearing and separator) • Slide valve position		**6.4.3**	

	• Discharge gas temperature • Input shaft speed Flow indicators in atmospheric drain lines (6.4.4.9)			
7.2b	Where are the instrument values displayed? • PLC • Local instrument panel Remote (DCS)			
7.2c	• Are transmitters such as for pressures and temperatures required vs switches?		**6.4.1.4**	
7.2d	Is voting instrumentation required/proposed? (such as 2oo3) Is 2oo3 voting required for alarms and/or shutdowns?			
7.2e	Does the package include a PLC system? • What does PLC control (oil pumps, seal pressure regulators, startup/shutdown sequence)? • Is PLC supplied by compressor vendor or purchaser?		6.4.4	
7.2f	Have the instrumentation ratings been confirmed?			
7.2.g	Does alarm and shutdown list include the items in Table 9 of API 619 as a minimum? • What additional alarms and shutdowns are required? • Is the alarm system provided with an annunciator? (6.4.5.4) • Is an event recorder included with the alarm system? (6.4.5.3)		6.4.5.5	
	•			
7.3	**Vibration Measurement and Monitoring System:**			
7.3a	Is a vibration measurement and monitoring system proposed? • Casing vibration sensors for antifriction bearings • Proximity probes for sleeve bearings • Rotor axial position •			
7.3b	If a vibration monitoring system has been proposed, has the details of that system been reviewed? • Is the vibration measurement and monitoring system per API 670?		6.4.5	
8	**Reserved**			
	•			
9	**Purchaser's Checklist:**			
9.1	Has a purchaser's checklist been reviewed?			

10	• **Shop Inspection:**			
10.1	Has an inspection plan been developed and agreed:			
10.1a	at manufacturer facility?			
10.1b	at sub-vendors facility?			
10.1c	at packager facility?			
11	**Shop Testing:**			
11.1	Has a shop testing plan been defined and developed?			
11.1a	Purchaser witness requirements defined and agreed.			
11.1b	Acceptance criteria defined and agreed.			
11.2	Compressor mechanical testing.			
11.2a	Is a deceleration test required?			
11.3	Is compressor performance testing required?			
11.4	Is Auxiliary equipment testing required? (Oil systems, gears, control systems)			
11.5	Is complete unit testing required?			
11.5a	Is a tandem test required?		API option	
11.5b	Is a full-pressure/full-load/full-speed test required?		API option	
11.6	Is a sound-level test required?		API option	
11.7	Is a helium test required?		API option	
11.8	Have post-test inspection requirements been defined?		API option	
			API option	
12	**Preparation for Shipment**		API option	
12.1	Is an inspector's checklist required?		API option	
12.2	Are preservation procedures available?		API option	
12.2a	Do preservation procedures address the storage environment and duration?			
12.3	Are packaging and shipping procedures available?			

12.4	Agree components to be removed for shipment. (Bearings, seals, couplings)		API option	
12.5	Agree special shipping unit requirements.			
13	**Installation:**			
13.1	Foundation /support structure checks.			
13.2	Are installation procedures available?			
13.3	Piping alignment tolerances defined.			
13.4	Machinery alignment tolerances defined.			
13.5	Off-skid equipment installation requirements understood (control panels, coolers)			
13.6	Off-skid equipment interconnection requirements.			
13.7	Installation inspection and sign-off sheets are available.			
14	**Commissioning:**			
14.1	Are pre-commissioning procedures available?			
14.2	Oil system flushing requirements understood.			
14.3	Commissioning procedures available.			
14.4	Auxiliary systems commissioning requirements understood.			
14.5	Commissioning inspection and sign-off sheets available.			
14.6	Is a site performance test required?			
14.7	Commissioned package - User acceptance criteria defined.			

Annex I
(Informative)

Background of modified bearing life theory (L_1m)

I.1 Production of rolling element bearings for industrial use began in the early 1900s. Along with production, methods for determination of bearing life were developed. A combination of stress analyses and life testing led to the development of bearing life prediction methods. A factor limiting bearing life was the availability of bearing grade steel, characterized by good hardenability and cleanliness from slag inclusions. The presence of slag under the raceway surface was a critical issue, causing material fatigue and spalling. The bearing life, based on spalling fatigue was statistical in nature, with many early failures. The bearings that did not fail early had much longer and statistically spread life.

I.2 Scientists were working on bearing life prediction methods. A proposal was that the life, in revolutions or hours, that 90% of bearings survived (and 10% failed) should be the criteria for bearing selection. From machinery reliability point of view, 10% may not seem realistic, maybe 1% would make more sense. The reasoning was that if 1% would be used, too many bearings would be oversized. Better to accept that 10% would fail and have to be replaced. Most bearings were anyway replaced at machine overhauls or when the machine was replaced, not because of bearing failure, so 10% was considered a more practical number.

I.3 In a publication in 1943 it was recommended that the requisite L_{10} life for machinery in continuous operation should be 50,000 to 60,000 hours.

I.4 The L10 criteria and analyses behind it became widely accepted and later standardized by both ISO and AFBMA. The requisite L_{10} lives recommended in 1943 are still used today.

I.5 The development of bearing life theory based on subsurface fatigue continued with input from academia. The Weibull statistical theory was included.

I.6 ISO Standard 281:1990

A formula, the Lundberg-Palmgren formula, was published in 1947 and later standardized into ISO 281:1990.

I.7 Further Developments

I.7.1 Improvements in steel quality, heat treatment and manufacturing quality over the years since lead to steady increase in bearing life. Subsurface fatigue became less ubiquitous and replacement of 10% of bearings due to fatigue became less of an issue. The dynamic load capacity C was increased in several steps to account for the improvements.

I.7.2 Beginning in the 1960s, computerized calculation models were developed that could explain how a lubricant film develops in a rolling bearing. Because of the high contact pressure between a rolling element and a bearing race, the viscosity of the lubricating oil increases significantly, and the contact area flattens, enabling a lubricant film to develop. This is referred to as Elasto Hydrodynamic Lubrication. With conventional hydrodynamic lubrication theory, it is not possible to predict the existence of a lubricant film in the contacts of a rolling element bearing." With computerized models it also became possible to calculate the stresses and the stressed volume in the raceways more precisely and account only for the volume of steel that is stressed above a fatigue limit. The surface stresses created by contaminant particles could also be analyzed and accounted for.

I.7.3 There was no mention of the effect of lubrication and contamination, the focus was on subsurface fatigue. It is reasonable to assume that in testing, lubrication was considered “good” and the oil “clean”, but the conditions were not quantified.

I.8 ISO Standard 281:2007

Extensive verification testing of the new theories followed, and a new bearing fatigue calculation method was introduced. In 2007, this became standardized as ISO 281:2007, ISO Modified life.

I.9 In Modified life a reliability parameter a_1 was also introduced, which is 1.0 for 90% reliability and other values for other reliability levels such as 99%. This factor is derived from the Weibull theory. It should be noted that Modified life was not something completely new, it was a refinement of the earlier theory. In Modified life, basic L_{10} is multiplied by the reliability factor a_1 and the modification factor a_{ISO}.

I.10 The modification factor a_{ISO} accounts for the effects of lubrication, contamination, and fatigue limit. In a_{ISO} lubrication quality is defined by κ (see Figure I.1), the ratio between the operating viscosity and a reference viscosity, ν_1, which is the minimum required for adequate lubrication. ν_1 depends on bearing size and speed. Higher speed means a lower ν_1, so high speed improves lubrication conditions, similar to the case for hydrodynamic bearings.

$$\kappa = \frac{\nu}{\nu_1}$$

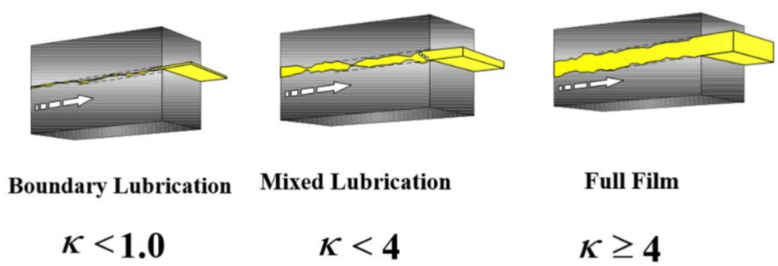


Figure I.1 - Lubrication Quality

I.11 Contamination is quantified by e_c which depends on the cleanliness of the oil as defined in ISO 4406. e_c can be defined by the filter specification if an inline filter is used (see Figure I.2). It also depends on κ and bearing size. The better the κ, the better e_c and the larger the bearing size the better e_c. For more details, see ISO 281:2007.

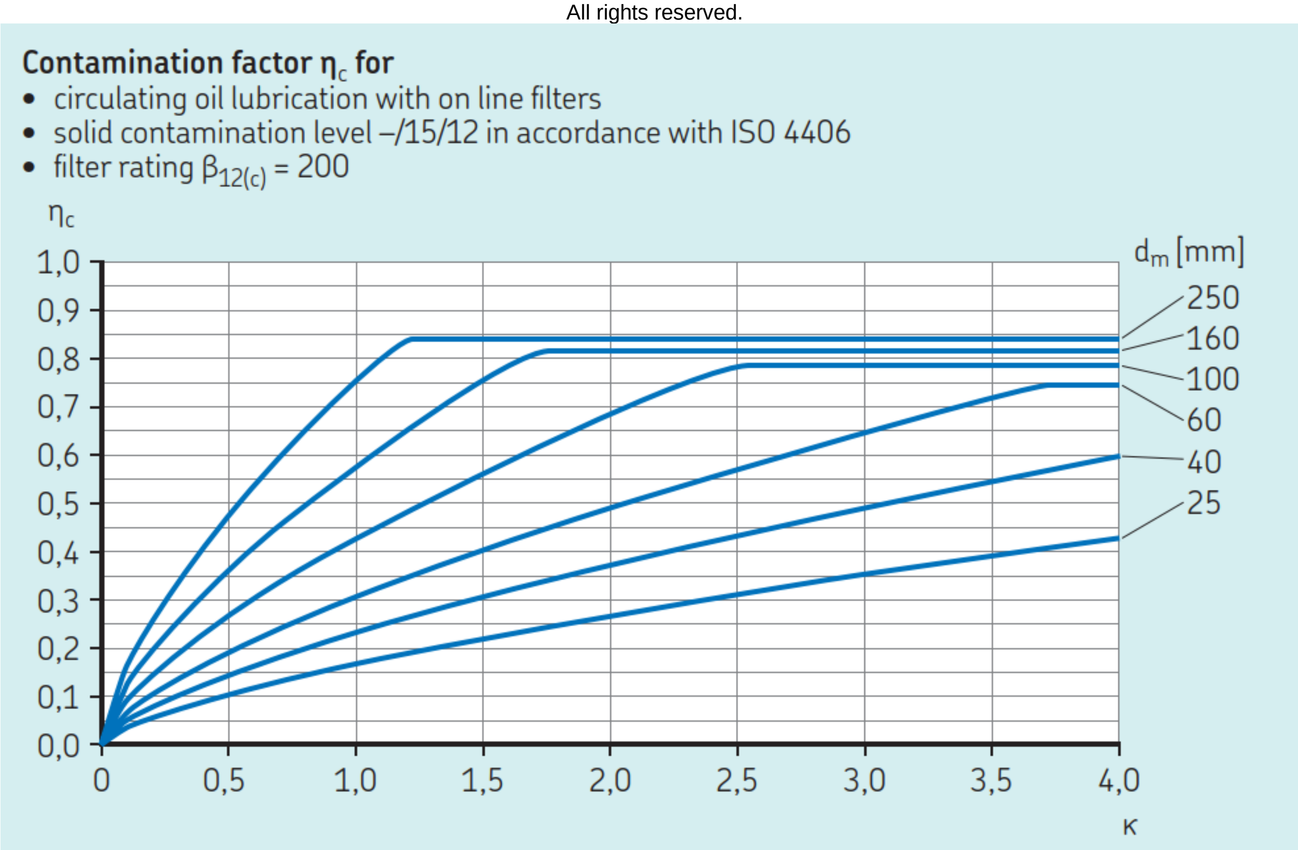


Figure I.2 - Example of e_c diagram, valid for online 12-micron filter, β 200

I.12 With Modified life it is possible to apply actual operating conditions and reliability requirements to rolling bearings. For example, with Modified life, 1% bearing failures from fatigue after 20 years may be acceptable by a user. If the annual operating time is 5000 hours, that means 100,000 hours after 20 years, so L_{1m} would be 20 x 5,000 = 100,000 hours. The a_1 factor for 99% reliability is 0.25, so L_{1m} would be 100,000/0.25 = 400,000 hours, quite different from basic L_{10} 50,000 hours which is specified by API-619. It should be mentioned, that a_{ISO} is very sensitive to the assumed lubrication and contamination conditions.

I.13 Use of Modified Life

Modified life can be used for different purposes and situations:

- By OEMs when selecting bearings for a new machine design
- By consultants and buyers when specifying equipment
- By end users when specifying lubricants, filtration and maintenance requirements
- To identify possibilities to mitigate the effect of dilution by process gas

I.14 Case Studies

I.14.1 In case studies of large oil flooded screw compressors, because of the relatively large bearing sizes and high ndm speeds (rpm x brg mean diameter) of around 650,000, when driven by two pole motors, basic L_{10} 50,000 hours was found to be more restrictive than L_{1m} 100,000 hours (with a 12-micron β 200 filter and 15 cSt operating viscosity). With coarser filtration, the situation reversed.

I.14.2 In case studies of rotary lobe blowers without filters L_{1m} became more restrictive than basic L_{10}, depending on the assumed oil cleanliness level. The ndm speed was much lower in those cases, around 200,000. In blowers with small bearings L_{1m} was more restrictive than for large blowers.

I.14.3 If the lubricating oil is diluted by process gas, it is possible to use Modified life to identify actions that can improve lubrication conditions, to increase *κ.* Those actions are:

- Use a finer filter
- Increase the speed
- Decrease Δ P to reduce bearing load
- Change oil to a higher viscosity grade
- Change the oil to a type that is less prone to dilution
- Increase the bearing size (dm). Only an option for an OEM, space, minimum load and ndm limitations permitting

I.15 It should be noted that Basic life only predicts subsurface fatigue life while Modified life accounts for both subsurface and surface life. Most bearings do not fail at all or fail for other reasons than fatigue. The majority of bearings are either replaced at regular machine overhauls or outlive the machines into which they are installed. By over - specifying fatigue life, there is a risk that too large bearings are selected. Such bearings are not reliable because of potential light load skidding problems or operation at too high speed.

Petroleum, petrochemical and natural gas industries — Rotary-type positive-displacement compressors

Part 4: Rotary lobe blowers

6th Edition Ballot Draft – March 2024

1 Scope

This part of API 619, in conjunction with the requirements of API 619 Part 1, specifies minimum requirements for rotary lobe blowers (see Figure 1) used for vacuum or pressure or both in petroleum, petrochemical, and gas industry services. It is intended for machines in flammable, toxic, hazardous, or uninterrupted services be considered critical by purchaser.

It is not applicable to non-critical services or other types of equipment covered in other standards.

NOTE Standard air compressors are covered in ISO 10440-2.

Figure 1 – Example of Rotary Lobe Blower

2 Normative references

Referenced documents indispensable for the application of this document are listed under Part 1, Section 2.

3 Terms, Definitions, Acronyms, Abbreviations, and Symbols

For the purposes of this document, the terms, definitions, acronyms, abbreviations, and symbols given in Part 1, Section 3 apply.

NOTE See Annex B for a guide to Typical Rotary lobe type blower nomenclature.

4 Dimensions and Units

The dimensional and unit requirements of Part 1, Section 4 shall apply.

5 Requirements

5.1 Statutory Requirements

The statutory requirements in 5.1 of Part 1 shall apply.

5.2 Unit Responsibility

The unit responsibilities in 5.2 of Part 1 shall apply.

5.3 Documentation Requirements

The documentation requirements in 5.3 of Part 1 shall apply.

6 Basic Design

6.1 General

6.1.1 Equipment Reliability

The equipment reliability requirements of Part 1 shall apply.

6.1.2 Performance

6.1.2.1 Performance requirements shall be in accordance with 6.1.2 of Part 1 and the following paragraphs.

6.1.2.2 The equipment (machine, driver, and ancillary equipment) shall perform on the test stand within the specified acceptance criteria of 6.1.2.3 and 6.1.2.4.

6.1.2.3 The blower shall be capable of:

a) providing flow at the certified point with no negative tolerance.

b) required shaft power at the certified point shall not exceed 105 % of the value at this point.

6.1.2.4 After installation, the performance of the equipment shall be the joint responsibility of the purchaser and the vendor who has unit responsibility.

6.1.3 General Requirements

6.1.3.1 General design requirements shall be in accordance with 6.1.3 of Part 1 and the following paragraphs.

6.1.3.2 Two lobe machines shall be applied for process gas services.

6.1.3.3 Three lobe machines may be provided for air and inert gas applications.

6.1.3.4 Use of three lobe machines for services other than air or inert gas requires purchaser approval.

NOTE Gases having the potential to accumulate toxic, hazardous, or corrosive solids or develop condensates during or in between operation are not considered safe for three lobe blowers since by design, one of the three cavities in a three lobe blower may not properly drain.

6.1.3.5 Vendor shall advise filtering requirements for process gas applications.

NOTE This is an excursion in speed and not a continuous operating case.

6.1.4 The equipment shall be designed to withstand a discharge pressure equal to the downstream relief valve set pressure without internal damage.

6.1.5 Speed Requirements

6.1.5.1 Speed requirements shall be in accordance with 6.1.5 of Part 1 and the following paragraph.

6.1.5.2 Maximum continuous speed shall be at least 105% of the rated speed for variable-speed machines and shall be equal to the rated speed for constant-speed applications.

6.1.6 Additional Requirements

Additional requirements in 6.1.6 of Part 1 shall apply.

6.2 Pressure Casings

6.2.1 Casings shall be in accordance with 6.2 of Part 1 and the following paragraphs.

6.2.2 If a relief valve pressure is not specified, the maximum allowable working pressure shall be at least 125% of the maximum specified discharge pressure (gauge).

6.2.3 System pressure protection shall be furnished by the purchaser.

6.3 Casing Appurtenances

Appurtenances shall be in accordance with 6.3 of Part 1.

6.4 Casing Connections

Pressure casing connections shall be in accordance with 6.4 of Part 1.

6.5 External Forces and Moments

6.5.1 Blower shall be designed to withstand external forces and moments on each nozzle as tabulated in Annex C.

6.5.2 Casing and supports shall be designed to have sufficient strength and rigidity to limit distortion of coupling alignment due to pressure, torque and allowable forces and moments per Annex C to 50 µm (0.002 in).

6.5.3 The vendor shall furnish job specific allowable forces and moments for each nozzle in tabular form on outline drawing or in the installation, operation, and maintenance manual.

6.5.4 Expansion joints

6.5.4.1 [●] If specified, expansion joints may be supplied with equipment designed to meet the following:

a) subject to the same design parameters and test requirements as process piping.

b) made of stainless steel 321 or 316Ti.

c) shall be multi-layer type. Each layer shall be designed to handle the full pressure and temperatures expected in the process.

6.5.4.2 [●] Expansion joints shall be designed to owner specified loading and pressure pulsation cycles from atmosphere pressure to rated process pressures.

6.5.4.3 If loading and pressure pulsation cycles are not specified, manufacturer shall advise in proposal design criteria of loading and pressure pulsating cycles from atmosphere pressure to rated process pressures.

6.5.4.4 [●] If specified, dual wall expansion joints shall be supplied.

6.5.4.5 Dual wall expansion joints shall have provisions for pressure sensing instrumentation between walls.

6.5.4.6 Expansion joints can incorporate in service tie rods to prevent over extension during operation or general pipe movement.

6.5.4.7 Tie bars on expansion joints

Tie bars provided shall meet the following:

a) Painted OSHA safety red to prevent them from being inadvertently left in place.

b) Labelled with steel tags stating they are to be removed prior to operation.

c) Made of a compatible material if they are temporarily welded to the expansion joint.

6.6 Rotating Elements

6.6.1 Rotating elements shall be in accordance with 6.6 of Part 1 and the following paragraphs.

6.6.2 Under the most extreme combination of specified operating conditions, lobe rotors shall not contact each other nor the casing.

NOTE This is not applicable to rotor sealing strips, which can wear under extreme conditions.

6.6.3 Rotor bodies not integral with the shaft shall be keyed and shrunk to the shaft as to prevent relative motion under any condition.

NOTE Cast lobes and steel shafts are common on large blowers.

6.6.4 Hollow lobes that are capped shall be gas tight.

NOTE Capped can be through mechanical means such as plugs and O-rings, mechanical fasteners, or welded in place.

6.6.5 Hollow lobes shall be leaked tested.

NOTE: During maintenance, hollow rotors that are closed gastight can be considered to have pressurized process gas inside the rotor cavity, therefore appropriate safety precautions should be taken.

6.6.6 Welds on rotors shall be full-penetration continuous welds.

6.6.7 Welds shall be post-weld heat-treated, using qualified procedures and welder qualifications as per ASME BPVC section IX.

6.6.8 Hollow rotors that are not capped shall be self-draining.

6.7 Shaft Seals

Shaft seals shall be in accordance with 6.7 of Part 1

6.8 Dynamics

6.8.1 General

Dynamics shall be in accordance with 6.8 of Part 1 and the following paragraphs.

6.8.2 Balancing

Major parts of the rotating element, such as the shaft, lobes or their assembly, and timing gears, shall be individually dynamically balanced to ISO 1940-1:2003, grade G2.5.

6.9 Bearings and Bearing Housings

6.9.1 General

Bearing and bearing housing shall be in accordance with 6.9 of Part 1 and the following paragraphs.

6.9.2 Rolling Element Bearings

6.9.2.1 Rolling element bearings shall be provided for rotary lobe blowers.

6.9.2.2 Bearings shall be in accordance with Table 1.

6.9.2.3 Bearings shall be oil lubricated.

Table1 - Bearing Limits for Rotary Lobe Blowers

Limiting Factor	Conditions	
Rolling element bearing speed	Factor [a] $N \cdot d_m$ shall not exceed the following values for pressurized oil-lubricated bearings:	
	Bearing type	$N \cdot d_m$
	Radial:	
	single-row ball bearings cylindrical-roller bearings	500 000
	Radial:	
	tapered roller bearings spherical roller bearings	350 000
	Thrust:	
	single-row ball bearings	350 000
	Thrust:	
	double-row angular-contact tapered roller bearings	300 000 250 000
Rolling element bearing life	Basic rating, L_{10}, in accordance with ISO 281[b] of at least 50 000 h with continuous operation at rated conditions, and at least 32 000 h at maximum radial and axial loads and rated speed. NOTE The calculated bearing life is based on lubrication with clean, filtered oil.	

[a] N is the rotative speed, expressed in revolutions per minute;
d_m is the mean bearing diameter, $(d + D)/2$, expressed in millimetres;
D is the bearing outer diameter, expressed in millimetres;
d is the bearing inner diameter, expressed in millimetres.

[b] For the purpose of this provision, ABMA Standard 9 is equivalent to ISO 281.

6.9.2.4 Rolling element bearing basic rating life

6.9.2.4.1 Rolling element bearing's basic rating life, L10h, shall be at least 50,000 hours with continuous operation at rated conditions, and at least 32,000 hours at maximum radial and axial loads and rated speed.

6.9.2.4.2 The basic rating, L10h life, shall be calculated in accordance with ABMA 9.

NOTE 1 The basic rating life, L10h, is the number of hours, at the operating conditions, that 90 percent of a group of identical bearings, will complete or exceed before the evidence of failure.

NOTE 2 ABMA 9 defines basic rating life L10 in units of millions of revolutions. Industry practice is to convert this to hours and refer to it as L10h.

Where:

L10h = (1,000.000/60N) L10

N=Revolutions per minute

NOTE 3 For the purpose of this provision, ABMA 9 is equivalent to ISO 281 for ball bearings and ABMA 11 is equivalent to ISO 281 for roller bearings.

6.9.2.5 [●] If specified, the L10h life for a system of bearings shall be calculated as given in Equation 1:

$$L10h\ (System) = [(1/L10hA)^{3/2} + (1/L10hB)^{3/2} + \cdots + (1/L10hN)^{3/2}]^{-2/3} \quad (1)$$

Where:

L10hA = Basic rating life, L10h per ISO 281 for bearing A

L10hB = Basic rating life, L10h per ISO 281 for bearing B

L10hN = Basic rating life, L10h per ISO 281 for bearing N

6.9.2.6 [●] If the use of Equation 1 is specified, the purchaser shall specify the system L10h life of the system.

NOTE 1 A machine with two bearings each with an L10h of 50,000 hours has a 0.9 X 0.9 = 0.81 probability of reaching 50,000 Hours

NOTE 2 Based on actual load, and selected bearing, each bearing may not be at the 50,000 limit. The actual bearing L10h may be used.

NOTE 3 The System L10h life will not be greater than the lowest component L10h Life.

6.9.2.7 Supplier to advise in proposal if double-acting axial thrust bearing is combined with radial bearing.

6.9.2.8 Rolling element bearings shall be located, retained, and mounted in accordance with the following:

a) Bearings shall be located on the shaft using shoulders, collars, or other positive locating devices.

b) Snap rings and/or spring-type washers shall not be used to locate or retain bearings.

c) Bearings shall be retained on the shaft with an interference fit and onto the housing with clearance.

d) Bearing shaft and housing fits shall be in accordance with ABMA Standard 7 or other purchaser approved requirements.

e) If bearing manufacturer approves alternative bearing retainment methods, these can be presented for purchaser's review and approval.

6.9.2.9 [●] If specified, no yellow metal is permitted in contact with process fluid.

6.9.3 Bearing housings

6.9.3.1 Sight glasses shall be provided, they may be located on bearing housings or on casing.

6.9.3.2 Sight glasses shall be rated to meet the maximum allowable working pressure and the full vacuum pressure specified.

6.9.3.3 The rise in oil temperature through the bearing and housings shall not exceed 30 K (50 °F) under the most adverse specified operating conditions.

6.9.3.4 The bearing outlet oil temperature shall not exceed 80 °C (180 °F).

6.9.3.5 If the inlet oil temperature exceeds 50 °C (120 °F), special consideration shall be given to bearing design, oil flow and allowable temperature rise.

6.9.3.6 If water cooling is required, either water jackets or cooling coils shall be provided.

6.9.3.7 Rotary lobe blowers shall have bearing-housing-shaft seals and deflectors where the shaft passes through the housing and shall meet the following:

a) The seals and deflectors shall be made of non-sparking materials.

b) Lip-type seals can be used on rotary lobe blowers.

c) The design shall effectively retain oil in the housing and prevent entry of foreign material into the housing.

6.9.3.8 Bearing housings shall have provisions for mounting accelerometers including a milled and tapped surface.

6.9.3.9 Provisions for mounting accelerometers shall be:

a) Located on each bearing housing,

b) Located on plane perpendicular to the axis of rotation,

c) Aligned per in-line axis of bearing, or in between two bearings.

6.10 Lubrication

6.10.1 Oil shall be suitable for the service and full range of operation as indicated on the data sheets, including start-up and shut-down conditions.

6.10.2 Splash oil lubrication is acceptable for rotary lobe blowers if the limits stated in 6.10.6 are not exceeded.

NOTE 1 Splash lubrication effectiveness can be affected by operating speed, vertical height between gears, and oil level.

NOTE 2 On vacuum or oxygen service, oil dilution or condensation can significantly reduce lubricating properties of oil.

NOTE 3 Oil mist lubrication is typically not considered due to the high heat generation of timing gears.

6.10.3 Oil flinger disks or oil rings shall have an operating submergence of 3.0 mm to 6.0 mm (1 /8 in. to 1 /4 in.) above the lower edge of a flinger or above the lower edge of the bore of an oil ring.

6.10.4 Oil flingers shall have mounting hubs to maintain concentricity.

6.10.5 Oil flingers shall be positively secured to the shaft.

6.10.6 A circulating oil system per 6.10.7 shall be supplied when any of the following conditions apply:

a) The starting viscosity (cold start) is above 1000 cSt.

b) The minimum viscosity during any operating conditions is lower than 10 cSt.

NOTE Minimal viscosity conditions can include maximum suction temperature, maximum discharge temperature, or maximum power.

c) Applications using a horizontal flow direction with rotor diameter greater than 500 mm (20 in.).

NOTE Horizontal flow direction implies vertically stacked bearings, making it difficult for splashed oil to reach upper timing gear bearings.

d) The sump oil temperature rise exceeds 40°C (70F) above ambient temperature.

e) Use of PFPE (Perfluoropolyethers) oils in positive pressure service.

f) Average process temperature (T_{inlet} + $T_{discharge}$) / 2 < 10 °C or > 100 °C.

g) Slow roll drive (Turning gear) is applied.

6.10.7 [●] If specified, an oil system consisting of pump and filter shall be furnished per API 614 containing as a minimum, the following oil system identifier: LO-PRS00-R0-H0-BP0-CS0-F1-A0-PV0-TV0-OT0. Refer to Figure B.1 for details.

6.10.8 If the oil inlet temperature of the circulating system exceeds 50 °C (120 °F), a pressurized oil system per 6.10.9 shall be supplied.

6.10.9 When a separate oil system is furnished, it shall comply API 614 and supply pressurized oil at a suitable pressure or pressures, as applicable, to the following items and meet the following requirements:

a) bearings of the driver and of the driven equipment (including any gear);

b) seal-oil system, if combined with the lube-oil system;

c) able to maintain oil outlet temperature below 70 °C (160F)

d) under the most adverse specified operating conditions, the bearing-oil temperature rise shall not exceed 30°C (50 F).

e) furnished per API 614 oil system identifier: LO-PRSA0-R1-H0-BP1-CS1-F2-A0-PV1-TV1-OT0.

f) Refer to Figure D.2 for details.

6.10.10 [●] If specified, a separate oil system shall be furnished per 6.10.9.

6.10.11 Rotary lobe blower manufacturer can provide alternative oil system designs for purchaser's review and approval.

6.11 Materials

Materials shall be in accordance with 6.11 of Part 1.

6.12 Nameplates and rotation arrows

Nameplates and rotation arrows shall be in accordance with 6.12 of Part 1

7 Accessories

7.1 Drivers

Drivers shall be in accordance with 7.1 of Part 1.

7.2 Adjustable Frequency Drives (AFD) and Devices

AFD's shall be in accordance with 7.2 of Part 1.

7.3 Couplings

Couplings shall be in accordance with 7.3 of Part 1.

7.4 Guards

Guards shall be in accordance with 7.4 of Part 1.

7.5 Belt Drives

Belt drives are not permitted.

7.6 Baseplates and Soleplates

7.6.1 Baseplates and Soleplates shall be in accordance with 7.6 of Part 1 and the following paragraphs.

7.6.2 [●] The equipment shall be furnished with soleplates or a baseplate (collectively referred to as mounting plates), as specified.

7.6.3 The upper and lower surfaces of mounting plates and any separate pedestals mounted thereon shall be:

7.6.3.1 Machined parallel to 0.5 mm (0.020 in).

7.6.3.2 Machinery supports shall be designed to limit the relative displacement of the shaft end caused by the worst combination of pressure, torque, thermal expansion, and allowable piping stress, to 50 μm (0.002 in).

NOTE See Annex C for allowable external forces and moments for Rotary Lobe Blowers.

7.6.3.3 Rotary blowers shall be designed to be mounted directly on baseplate or mounting plates, bolted directly on support structure.

7.7 Controls and Instrumentation

Controls and instrumentation shall be in accordance with 7.7 of Part 1 and the following paragraphs.

7.7.1 General

General controls and instrument requirements shall be in accordance with 7.7.1 of Part 1

7.7.2 Control Systems

Control systems shall be in accordance with 7.7.2 of Part 1.

7.7.3 Control Panels

Control panels shall be in accordance with 7.7.3 of Part 1.

7.7.4 Instrumentation

7.7.4.1 General

General instrumentation requirements shall be in accordance with 7.7.4.1 of Part 1

7.7.4.2 Tachometers

Tachometer requirements shall be in accordance with 7.7.4.2 of Part 1.

7.7.4.3 Vibration and position detectors

Vibration and position detectors shall be in accordance with 7.7.4.3 of Part 1 and the following paragraphs.

7.7.4.3.1 One accelerometer per bearing housing shall be supplied.

7.7.4.3.2 Rotor position sensors are not applied on rotary lobe blowers.

7.7.4.4 [●] If specified, vibration monitors shall be supplied and calibrated in accordance with API 670.

7.7.4.5 Bearing temperature detector

7.7.4.5.1 Bearing temperature monitors are not applied on rotary lobe blowers.

7.7.4.5.2 [●] If specified, oil sump temperature sensors shall be provided.

7.7.4.5.3 On vacuum services, a casing metal surface temperature shall be provided.

7.7.4.6 Relief Valves

Relief valves shall be in accordance with 7.7.4.6 of Part 1.

7.7.5 Alarms and Shutdowns

Alarms and shutdowns shall be in accordance with 7.7.5 of Part 1.

7.7.6 Electrical Systems

Electrical systems shall be in accordance with 7.7.6 of Part 1.

7.8 Piping

Piping shall be in accordance with 7.5 of Part 1.

7.9 Special Tools

Special tools shall be in accordance with 7.9 of Part 1.

7.10 Coatings, Insulation, and Jacketing

Insulation shall be in accordance with 7.10 of Part 1.

7.11 Enclosures

Enclosures shall be in accordance with 7.11 of Part 1.

8 Inspection, testing, and preparation for shipment

8.1 General

Inspection, testing, and preparation for shipment shall be in accordance with Section 8 of Part 1 and the following.

8.2 Inspection

Inspection shall be in accordance with 8.2 of Part 1.

8.3 Testing

8.3.1 General

Testing shall be in accordance with 8.3 of Part 1 and the following paragraphs.

8.3.2 Hydrostatic Test

Hydrostatic testing shall be in accordance with 8.3.2 of Part 1.

8.3.3 Mechanical Running Test

8.3.3.1 Requirements prior to the mechanical running test

8.3.3.1.1 For equipment with a separate pressure-lubrication systems, oil flow rates for each bearing housing shall be measured.

NOTE 1 Individual measurements may not be possible for certain blowers.

8.3.3.1.2 If hardware modifications are required to meet test requirements, the test shall be repeated.

8.3.3.2 Speed requirements for the mechanical running test

8.3.3.2.1 Speeds during the mechanical run test shall be in accordance with 8.3.3.2 of Part 1.

8.3.3.2.2 Deceleration testing is not applicable to rotary lobe blowers.

8.3.3.3 Requirements during the mechanical running test

8.3.3.3.1 During the mechanical running test of the machine, assembled with the balanced rotor operating at maximum continuous speed or at any other speed within the specified operating speed range, the casing vibration velocities shall be measured at the locations where the provisions are located.

8.3.3.3.2 Casing velocities shall be within the limits Table 2.

Measurement on bearing housing	Rolling element bearings[a,b]
Vibration at any speed within operating range: — Overall — Increase in allowable vibrations at speeds beyond operating speed but less than trip speed	V_u < 8,0 mm/s RMS (0,3 in/s RMS) 50 %
NOTE The pulsating gas flow through the blower causes increased vibration.	
a V_u is the unfiltered velocity. b RMS is the root mean square.	

Table 2 - Allowable Vibration Levels During Testing

8.3.4 Leak Test

Leak test shall be in accordance with 8.3.4 of Part 1.

8.3.5 Optional tests

8.3.5.1 General

Optional test shall be in accordance with 8.3.5 of Part 1 and the following paragraphs.

8.3.5.2 Performance test

Vibration levels shall be measured and recorded during this test as specified in 8.3.3.3.2

8.3.5.3 Complete unit test

Complete unit testing shall be in accordance with 8.3.5.3 of Part 1.

8.3.5.4 Tandem test

This test is not applicable to blowers.

8.3.5.5 Gear Test

[●] If an external gearbox is provided in the drive train, it shall be tested with the machine unit during the mechanical running test.

8.3.5.6 Helium Test

Helium testing shall be in accordance with 8.3.5.6 of Part 1.

8.3.5.7 Sound Level Test

Sound level testing shall be in accordance with 8.3.5.7 of Part 1.

8.3.5.8 Auxiliary-equipment test

Auxiliary-equipment testing shall be in accordance with 8.3.5.8 of Part 1.

8.3.5.9 Post Test Inspection

Post test inspection shall be in accordance with 8.3.5.9 of Part 1.

8.3.5.10 Inspection of hub/shaft fit for hydraulically mounted couplings

Hub/shaft fit inspection shall be in accordance with 8.3.5.10 of Part 1.

8.3.5.11 Spare-parts test

Hub/shaft fit inspection shall be in accordance with 8.3.5.11 of Part 1.

8.3.6 Test data

Test data shall be in accordance with 8.3.6 of Part 1.

8.3.7 Test report

Test reporting shall be in accordance with 8.3.7 of Part 1.

8.4 Preparation for Shipment

Preparation for shipment shall be in accordance with 8.4 of Part 1.

9 Vendor's data

9.1 Vendor's data shall be in accordance with Section 9 of Part 1 and the following paragraphs.

9.1.1 Vendor shall include a tabular summary of performance data for rotary lobe blowers.

9.1.2 Vendor shall provide complete performance curves to encompass the operating map of the blower.

Annex A
(normative)
Rotary Lobe Blower Datasheets

A representation of the datasheets is enclosed in this annex; however, MS Excel format datasheets have been developed and are available, for purchase from API publications distributors, with this standard. The MS Excel electronic datasheets can have additional functionality over printed hard copies.

ROTARY-TYPE POSITIVE DISPLACEMENT COMPRESSOR ROTARY LOBE BLOWER DATA SHEET SI UNITS

JOB NO. ______ ITEM NO. ______ Rev

PURCHASE ORDER NO. ______ DATE ______

REQUISITION NO. ______

INQUIRY NO. ______

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○ DRAWING UNITS: ○ SI ○ US CUSTOM ○ DUAL

APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ○ AS BUILT DATE ______ REVISION ______

FOR ______ UNIT ______

SITE ______ SERIAL NO. ______

SERVICE ______ NO. REQUIRED ______

MANUFACTURER ______ MODEL ______ DRIVER (6.1) ______

NOTE: ○ INDICATES INFORMATION TO BE COMPLETED BY PURCHASER □ BY MANUFACTURER

OPERATING CONDITIONS

ALL DATA ON PER UNIT BASIS	NORMAL	MAXIMUM	OTHER CONDITIONS A	B	C	D
○ CERTIFIED POINT (X) (5.1.4)						
○ GAS HANDLED (ALSO SEE PAGE 2)						
○ REQUIRED STANDARD VOLUME FLOW Nm^3/h (1.013 bar & 0 °C) (DRY)						
○ REQUIRED STANDARD VOLUME FLOW Nm^3/h (1.013 bar & 0 °C) (WET)						
○ WEIGHT FLOW, kg/hr–(DRY)						
○ WEIGHT FLOW, kg/hr–(WET)						
INLET CONDITIONS: ○ COMPRESSOR INLET FLANGE ○ CUSTOMER CONNECTION						
○ PRESSURE - (bar a)						
○ TEMPERATURE (°C)						
○ RELATIVE HUMIDITY (%)						
○ MOLECULAR WEIGHT						
□ Cp/Cv (K_1)						
□ COMPRESSIBILITY (Z_1)						
□ INLET VOLUME FLOW (m^3/h)						
LIQUID INJECTION						
□ LIQUID INJECTION COMPOSITION						
□ LIQUID INJECTION WEIGHT FLOW, kg/hr						
□ LIQUID PRESSURE						
□ LIQUID TEMPERATURE						
DISCHARGE CONDITIONS: ○ COMPRESSOR DISCHARGE FLANGE ○ CUSTOMER CONNECTION						
○ PRESSURE -(bar a)						
□ TEMPERATURE (°C)						
□ Cp/Cv (K_2)						
□ COMPRESSIBILITY (Z_2)						
□ DEW POINT (°C)						
□ GAS POWER (KW)						
□ BLOWER SHAFT POWER (KW)						
□ POWER REQUIRED AT DRIVER (ALL LOSSES INCL) (KW)						
□ BLOWER INPUT ROTOR SPEED (RPM)						
□ PRESSURE RATIO ACROSS BLOWER (R)						
□ VOLUMETRIC EFFICIENCY (%)						
□ SILENCER Δ P (bar)						
□ SETTLE OUT PRESSURE - absolute (bar)						

PROCESS CONTROL:

CAPACITY CONTROL ______ ______

METHOD: ______

○ COOLED BYPASS FROM ______ TO ______

○ SPEED VARIATION FROM □ RANGE OF SPEED VARIATION ______ % TO ______ %

○ OTHER ______

SIGNAL: ○ SOURCE ______

○ TYPE ○ ELECTRONIC ○ OTHER ______

○ RANGE: ______ mA ______ (bar) ______

○ OTHER ______

DISCHARGE TEMPERATURE CONTROL

METHOD: □ LIQUID INJECTION

SIGNAL: □ SOURCE ______

□ TYPE □ ELECTRONIC □ OTHER ______

SERVICE:

○ CONTINUOUS ○ INTERMITTENT ○ STANDBY

START-UP: ○ NORM AL SUCTION PRESSURE ○ FROM SETTLE OUT CONDITION

REMARKS:

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ROTARY-TYPE POSITIVE DISPLACEMENT COMPRESSOR DATA SHEET SI UNITS

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GAS ANALYSIS		NOR-MAL	MAX-IMUM	OTHER CONDITIONS A	B	C	D	○ REMARKS
○ MOL % ○ ________	M.W.							
AIR	28.966							
OXYGEN	32.000							
NITROGEN	28.016							
WATER VAPOR	18.016							
CARBON MONOXIDE	28.010							
CARBON DIOXIDE	44.010							
HYDROGEN SULFIDE	34.076							
HYDROGEN	2.016							
METHANE	16.042							
ETHYLENE	28.052							
ETHANE	30.068							
PROPYLENE	42.078							
PROPANE	44.094							
I-BUTANE	58.120							
n-BUTANE	58.120							
I-PENTANE	72.146							
n-PENTANE	72.146							
HEXANE PLUS								
○ CORROSIVE AGENTS								
○ SOLID PARTICLE								
○ LIQUID PARTICLE								
○ NACE MATERIALS								
TOTAL								

LOCATION:
○ INDOOR ○ OUTDOOR ○ GRADE
○ HEATED ○ UNDER ROOF ○ MEZZANINE
○ UNHEATED ○ PARTIAL SIDES ○ ________
○ ELEC. AREA CLASSIFICATION ________

SITE DATA:
○ ELEVATION ________ m BAROMETER ________ bara
○ RANGE OF AMBIENT TEMPERATURE:
Normal ________ °C
Maximum ________ °C
Minimum ________ °C

UNUSUAL CONDITIONS: ○ DUST ○ FUMES
○ OTHER ________
○ COPPER AND COPPER ALLOYS PROHIBITED

COATING:
○ ROTATING COMPONENTS
○ STATIONARY COMPONENTS ________

ELECTRICITY

	DRIVERS	CONTROL	SHUTDOWN
VOLTAGE			
HERTZ			
PHASE			

NOISE SPECIFICATIONS:
○ APPLICABLE TO MACHINE: ________
SEE SPECIFICATION ________
○ APPLICABLE TO NEIGHBORHOOD:
SEE SPECIFICATION ________
ACOUSTIC HOUSING: ○ YES ○ NO

APPLICABLE SPECIFICATIONS:
○ API 619-5th Chapter 4
○ VENDOR HAVING UNIT RESPONSIBILITY
____
○ GOVERNING SPECIFICATION (IF DIFFERENT)

○ ELEC AREA CLASS ○ NEC ○ IEC
EQUIPMENT
CLASS ________ GROUP ________ DIV. ________
ZONE ________ GROUP ________ TEMP CALSS ________
CONTROL PANELS ________
CLASS ________ GROUP ________ DIV. ________
ZONE ________ GROUP ________ TEMP CALSS ________
INSTRUMENT AND CONTROLS
STANDARD ○ NEMA ○ IEC

	INDOOR	OUTDOOR
CONTROL ENCLOSURE		
TERMINAL BOX		

SHIPMENT:
○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQ'D
○ OUTDOOR STORAGE MORE THAN 6 MONTH ________ MONTHS
○ LIFTING TOOLS

SPARE ROTOR ASSEMBLY PACKAGE
○ METAL STORAGE CONTAINER
○ N2 PURGE ○ OTHER ________

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SPEEDS:

MAX. CONT. ________ RPM TRIP ________ RPM

MAX. TIP SPEEDS: ________ m/s @ MAX. OPER. SPEED

MIN. ALLOW ________ RPM

LATERAL CRITICAL SPEEDS:

FIRST CRITICAL ________ RPM

DAMPED **UNDAMPED** ________

MODE SHAPE ________

LATERAL CRITICAL SPEED - BASIS:

DAMPED UNBALANCE RESPONSE ANALYSIS

OTHER TYPE ANALYSIS: ________

POCKET PASSING FREQUENCY AT RATED SPEED: ________ Hz

TORSIONAL CRITICAL SPEEDS:

FIRST CRITICAL ________ RPM

SECOND CRITICAL ________ RPM

VIBRATION: (5.7.3.6) ________

HOUSING ________ mm/s RMS

ROTATION, LOOKING AT COMPRESSOR DRIVEN END: CW CCW

CASING:

MODEL ________

CASING SPLIT ________

MATERIAL ________ CLADDING ________

OPERATION: PROVISIONS FOR LIQUID INJECTION

________ CORR. ALLOW (mm.) ________

MAX. ALLOWABLE WORK PRESS. ________ (bar)

RELIEF VALVE SETTING ________ (bar)

MARGIN FOR ACCUMULATION ________ (bar)

LEAK TEST GAS: ________

LEAK TEST PRESSURE

WITH SEALS ________ (barg)

WITHOUT SEALS ________ (barg)

TEST PRESS. (barg) ________ HYDRO ________

MAX. ALLOW. TEMP. ________ °C MIN. OPER. TEMP. ________ °C

MIN DESIGN METAL TEMP ________ °C

AT CONCURRENT PRESSURE ________ bar (G)

COOLING JACKET YES NO

ROTORS:

DIAMETER (mm.): ________

NO. LOBES: ________

ROTOR LENGTH TO DIAMETER RATIO (L/D) ________

ROTOR CLEARANCE (mm) ________

TYPE: ________

SINGLE PIECE FORGED

SINGLE PIECE CAST

FABRICATED

WELDED MECH ATTACHED

MATERIAL ________

MAX. YIELD STRENGTH (N/mm^2) ________

BRINELL HARDNESS. MAX. ________ MIN. ________

REMARKS: ________

SHAFT:

MATERIAL ________

DIA @ ROTORS (mm) ________ DIA @ COUPLING (mm) ________

SHAFT END. TAPERED CYLINDRICAL

SHAFT SLEEVES:

AT SHAFT SEALS ________ MATL. ________

TIMING GEARS:

PITCH LINE DIAMETER (mm) MALE: ________ FEMALE: ________

MATERIAL TYPE

SEALS

PROCESS GAS TO BE ISOLATED FROM OIL

PURGE GAS: ________

PURGE LEAKAGE ALLOWABLE INTO PROCESS

INNER SEPARATION SEALS:

SEAL SYSTEM TYPE ________

LIP SEAL

LABYRINTHS

LABYRINTH MATERIAL

RESTRICTIVE RING

RING MATERIAL

MECHANICAL CONTACT TYPE SEAL:

SINGLE / DOUBLE: ________

BUFFER LIQUID: ________

FLUID LEAKAGE (CC/MIN/SEAL)

DRY GAS SEALS

DRY GAS SEAL TYPE

TYPE OF SEAL GAS ________

SEAL GAS FLOW (PER SEAL)

NORMAL: ________ kg/hr. @ ________ (bar)

MAX.: ________ kg/hr. @ ________ (bar)

TYPE BUFFER GAS ________

BUFFER GAS FLOW (PER SEAL)

NORMAL: ________ kg/hr. @ ________ (bar)

MAX.: ________ kg/hr. @ ________ (bar)

SEE SEAL DATASHEET

OUTER SHAFT SEAL:

SEAL SYSTEM TYPE ________

LIP SEAL

SINGLE / DOUBLE:

GAS TIGHT

LABYRINTHS

LABYRINTH MATERIAL

RESTRICTIVE RING

RING MATERIAL

MAGNETIC COUPLING

MECHANICAL CONTACT TYPE SEAL:

SINGLE / DOUBLE: ________

BUFFER LIQUID: ________

FLUID LEAKAGE (CC/MIN/SEAL)

DRY GAS SEALS

DRY GAS SEAL TYPE

TYPE OF SEAL GAS

BEARINGS

ROLLING ELEMENT RADIAL BEARING

Yellow metal not permitted in contact with process

TYPE: ________ , Ndm: ________ mm/min

Min L10 Bearing life ________

Cage material ________ Ball bearing material ________

ROLLING ELEMENT THRUST BEARING

TYPE: ________ , Separate Combined

Ndm: ________ mm/min

Cage material ________ Ball bearing material ________

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PROCESS CONNECTIONS - COMPRESSOR CASING (Annex C):

	SIZE	RATING	FACING	ORIENTATION
INLET				
DISCHARGE				
OTHER				

PROCESS CONNECTIONS - CUSTOMER INTERFACE:

INLET				
DISCHARGE				

CASING - ALLOWABLE PIPING FORCES AND MOMENTS:

		INLET		DISCHARGE		OTHER	
		FORCE N	MOMT N-m	FORCE N	MOMT N-m	FORCE N	MOMT N-m
AXIAL	X						
VERTICAL	Y						
HORIZ. 90°	Z						
AXIAL	X						
VERTICAL	Y						
HORIZ. 90°	Z						

OTHER CONNECTIONS:

SERVICE:	NO	SIZE	TYPE/RATING
LUBE OIL INLET			
LUBE OIL OUTLET			
SEAL INLET			
SEAL OUTLET			
CASING DRAINS (5.3.4)			
VENTS			
COOLING WATER INLET			
COOLING WATER OUTLET			
LIQUID INJECTION			
PURGE FOR:			
BRG. HOUSING			
BETWEEN BRG. & SEAL			
BETWEEN SEAL & GAS			
OTHER			

Note:

VIBRATION DETECTORS:

ACCELEROMETER PROVISIONS IN ACCORDANCE WITH: API670
SEE ATTACHED API 670 DATASHEET
MFR. ______
MODEL ______
NO. AT BRG HOUSING ______ TOTAL NO. ______
OSCILLATOR-DETECTORS SUPPLIED BY ______
MFR. ______ MODEL ______
MONITOR SUPPLIED BY ______
LOCATION ______ ENCLOSURE ______
MFR. ______ MODEL ______
SCALE RANGE ______
SHUTDN: SET @ ______ TIME DLY. ______ SEC
ALARM. SET @ ______ TIME DLY. ______ SEC

AXIAL POSITION DETECTOR:

IN ACCORDANCE WITH: API 670 ______
SEE ATTACHED API 670 DATASHEET
TYPE ______ MODEL ______
MFR. ______ NO. REQ'D per Shaft/Total ______ / ______
OSCILLATOR-DETECTORS SUPPLIED BY ______
MFR. ______ MODEL ______
MONITOR SUPPLIED BY ______
LOCATION ______ ENCLOSURE ______
MFR. ______ MODEL ______
SCALE RANGE ______ ALARM: SET @ ______
SHUTDOWN: SET @ ______ TIME DELAY ______

COUPLINGS:

APPLICABLE SPECIFICATION ______
IN ACCORDANCE WITH: API 671 ______
SEE ATTACHED API 671 DATASHEET ______
COUPLING FURNISHED BY ______ MOUNTED BY ______
COUPLING GUARD FURNISHED BY ______
MAGNETIC COUPLING APPLIED

	DRIVER-COMP	GEAR-COMP OR DRIVER-GEAR
MANUFACTURER		
MODEL		
COUPLING TYPE		
MOUNT CPLG. HALVES		
-DBSE mm		
LIMITED END FLOAT REQ'D		
MOMENT SIMULATOR REQUIRED		
CPLG. RATING (kW/100 RPM)		
KEYED (1) OR (2) OR HYDR. FIT		
COUPLING GUARD TYPE		

BASEPLATE & SOLEPLATES:

SOLE PLATES FOR: BLOWER GEAR DRIVER
BASEPLATE:
COMON FOR COMPRESSOR AND DRIVER
EXTENDED UNDER OTHER EQUIPMENT ______
DECKED WITH NON-SKID DECK PLATE OPEN CONSTR.
DRIP RIM WITH OPEN DRAIN SUBPLATE
HORIZONTAL ADJUSTING SCREWS FOR EQUIPMENT
MINIMUM OVERSIZED DISTANCE AROUND EQUIPMENT: ______
SUITABLE FOR PERIMETER SUPPORT
EPOXY GROUT/EPOXY PRIMER GROUNDING LUGS REQ'D.

LUBE OIL SYSTEM

SEE ATTACHED API 614 DATASHEET
API 614 OIL SYSTEM CONFIGURATION TYPE
Splash lubrication
Recirculation system: LO-PRS00-R0-H0-BP0-CS0-F1-A0-PV0-TV0-OT0
Pressurized system: LO-PRSA0-R1-H0-BP1-CS1-F2-A0-PV1-TV1-OT0
COMMON WITH DRIVER

LUBRICANT TYPE ______ GRADE (ISO 3448) ______

ROTARY-TYPE BLOWER

DATA SHEET
SI UNITS

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1 **UTILITY CONDITIONS: (ALL UNITS ARE GAUGE)**

			DRIVERS	HEATING
2	STEAM			
3	INLET	MIN.	___ kPa (bar) ___ °C	___ kPa (bar) ___ °C
4		NORM	___ kPa (bar) ___ °C	___ kPa (bar) ___ °C
5		MAX.	___ kPa (bar) ___ °C	___ kPa (bar) ___ °C
6	EXHAUST	MIN.	___ kPa (bar) ___ °C	___ kPa (bar) ___ °C
7		NORM	___ kPa (bar) ___ °C	___ kPa (bar) ___ °C
8		MAX.	___ kPa (bar) ___ °C	___ kPa (bar) ___ °C

9 **ELECTRICITY:**

10	DRIVERS	HEATING	CONTROL	SHUT-DOWN
11 VOLTAGE				
12 HERTZ				
13 PHASE				

14 **COOLING WATER**
15 TEMP. INLET ______ °C MAX. RETURN ______ °C
16 PRESS. NORM ______ kPa (bar) DESIGN ______ kPa (bar)
17 MIN. RETURN ______ kPa (bar) MAX. ALLOW Δ P ______ kPa (bar)
18 WATER SOURCE ______
19 **INSTRUMENT AIR/GAS:**
20 GAS USED: ○ AIR ○ GAS: ______
21 MAX PRESS ______ kPa (bar) MIN. ______ kPa (bar)
22 **TOTAL UTILITY CONSUMPTION:**
23 COOLING WATER ______ m^3/h
24 STEAM, NORMAL ______ kg/h
25 STEAM, MAX ______ kg/h
26 INSTRUMENT AIR ______ Nm^3/h
27 NITROGEN ______ Nm^3/h
28 HP (DRIVER) ______ kW
29

MASSES (KG):
BLOWER ______ GEAR ______ DRIVER ______ BASE ______
ROTORS: BLOWER ______ DRIVER ______ GEAR ______
COMPR. UPPER CASE ______
L.O. CONSOLE ______ S.O. CONSOLE ______
MAX. FOR MAINTENANCE (IDENTIFY) ______
TOTAL SHIPPING MASS ______

SPACE REQUIREMENTS (mm):
COMPLETE UNIT L ______ W ______ H ______
L.O. CONSOLE L ______ W ______ H ______

MISCELLANEOUS:
□ RECOMMEND STRAIGHT RUN OF PIPE DIA. BEFORE SUCTION
○ VENDOR'S REVIEW & COMMENTS ON PURCHASER'S PIPING & FOUNDATION
○ PROVIDE RATES FOR VENDOR REPRESENTATIVE FIELD SUPPORT
○ OPTICAL ALIGNMENT FLATS REQUIRED
○ LATERAL ANALYSIS REPORT REQUIRED
○ TORSIONAL ANALYSIS REPORT REQUIRED
○ CASING MOUNTED TORSIONAL SHAFT VIBRATION PICKUP
COORDINATION MEETING

30 **SHOP INSPECTION AND TESTS:**	REQ'D	OBSERVED	WITNESSED	REMARKS:
31 SHOP INSPECTION				
32 HYDROSTATIC				
33 HELIUM LEAK				
34 MECHANICAL RUN				
35 REAL TIME VIBRATION DATA PROVIED				
36 LUBE OIL AND SEAL OIL PRESSURE VARIED				
37 USE SHOP LUBE & SEAL SYSTEM				
38 USE JOB LUBE & SEAL SYSTEM				
39 USE SHOP MONITORING EQUIPMENT				
40 USE JOB MONITORING EQUIPMENT				
41 MECHANICAL RUN SPARE ROTORS				
42 CASING LEAK TEST				
43 PERFORMANCE TEST (GAS) (AIR)				
44 COMPLETE UNIT TEST				
45 PRESSURE COMP. TO FULL OPER. PRESSURE				
46 POST-TEST INSPECTION				
47 SOUND-LEVEL TEST				
48 AUX.-EQUIPMENT TEST				
49 FULL-LOAD TEST				
50 BASEPLATE FLATNESS & LEVEL				
51 OTHER:				
52				
53				
54				
55				
56				
57				

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ROTARY-TYPE BLOWER

DATA SHEET
SI UNITS

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VENDOR MUST FURNISH ALL PERTINENT DATA FOR THIS SPECIFICATION SHEET BEFORE RETURNING.
ITEM NO. ______ SERVICE ______ JOB NO. ______
MANUFACTURER ______

CONTROL PANEL:
FURNISHED BY: ☐ VENDOR ☐ PURCHASER ☐ OTHERS ______
☐ LOCAL ______ ☐ REMOTE ______
☐ FREE STANDING ☐ WEATHERPROOF ☐ TOTALLY ENCLOSED ☐
☐ VIBRATION ISOLATORS ☐ CABINET HEATERS ☐ PURGE CONNECTIONS
☐ ANNUNCIATOR: FURNISHED BY: ☐ VENDOR ☐ PURCHASER ☐ OTHERS ______
ANNUNCIATOR LOCATED ON ☐ CONTROL PANEL ☐ MAIN CONTROL BOARD

INSTRUMENT SUPPLIERS:

○ PRESSURE GAUGES:	MFR. ______	SIZE & TYPE:	______
○ TEMPERATURE GAUGES:	MFR. ______	SIZE & TYPE:	______
○ LEVEL GAUGES:	MFR. ______	SIZE & TYPE:	______
○ DIFF. PRESSURE GAUGES:	MFR. ______	SIZE & TYPE:	______
○ PRESSURE TRANSMITTERS :	MFR. ______	SIZE & TYPE:	______
○ DIFF. PRESSURE TRANSMITTERS :	MFR. ______	SIZE & TYPE:	______
○ TEMPERATURE TRANSMITTERS :	MFR. ______	SIZE & TYPE:	______
○ LEVEL TRANSMITTERS :	MFR. ______	SIZE & TYPE:	______
○ CONTROL VALVES:	MFR. ______	SIZE & TYPE:	______
○ PRESSURE RELIEF VALVES:	MFR. ______	SIZE & TYPE:	______
○ THERMAL RELIEF VALVES:	MFR. ______	SIZE & TYPE:	______
○ FLOW INDICATORS:	MFR. ______	SIZE & TYPE:	______
○ GAS FLOW INDICATOR:	MFR. ______	SIZE & TYPE:	______
○ VIBRATION EQUIPMENT:	MFR. ______	SIZE & TYPE:	______
○ TACHOMETER:	MFR. ______	RANGE & TYPE:	______
○ SOLENOID VALVES	MFR. ______	SIZE & TYPE:	______
○ ANNUNCIATOR:	MFR. ______	MODEL & NO. POINTS	______
○ DEPRESSURIZATION VALVE	MFR. ______	SIZE & TYPE:	______
○ THERMOCOUPLES	MFR. ______	SIZE & TYPE:	______
○ RESISTANCE TEMPERATURE DETECTOR (RTD)	MFR. ______	SIZE & TYPE:	______
○ THERMOWELLS	MFR. ______	SIZE & TYPE:	______
○ TACHOMETER:	MFR. ______	SIZE & TYPE:	______
○ ______	MFR. ______	SIZE & TYPE:	______

☐ CUSTOMER CONNECTIONS BROUGHT OUT TO TERMINAL BOXES BY VENDOR
NOTE: ☐ SUPPLIED BY VENDOR ○ SUPPLIED BY PURCHASER

PRESSURE GAUGE REQUIREMENTS

FUNCTION	LOCALLY MOUNTED	LOCAL PANEL
COMPRESSOR SUCTION ______	☐ ○	☐ ○
COMPRESSOR DISCHARGE ______	☐ ○	☐ ○
______	☐ ○	☐ ○
______	☐ ○	☐ ○

TEMPERATURE GAUGE REQUIREMENTS:

COMPRESSOR SUCTION ______	☐ ○	☐ ○
COMPRESSOR DISCHARGE ______	☐ ○	☐ ○
______	☐ ○	☐ ○
______	☐ ○	☐ ○

MISCELLANEOUS INSTRUMENTATION:
☐ ○ DRIVER START/STOP ☐ UNIT CONTROL PANEL ☐ SEPARATE PANEL ☐ MAIN BOARD ☐ ______

☐ ○ VIBRATION AND SHAFT POSITION PROBES & PROXIMITORS
☐ ○ VIBRATION AND SHAFT POSITION READOUT EQUIPMENT
☐ ○ VIBRATION READOUT LOCATED ON: ☐ UNIT CONTROL PANEL ☐ SEPARATE PANEL ☐ MAIN BOARD ☐ ______

ALARM & SHUTDOWN: (6.4.5.2)

FUNCTION	ALARM	TRIP
☐ ○ HI LUBE OIL SUPPLY TEMPERATURE	______	______
☐ ○ COMPRESSOR HI DISCH. TEMP.	______	______
☐ ○ COMPRESSOR HI DISCH. PRESS.	______	______
☐ ○ COMPRESSOR Δ P	______	______
☐ ○ LOW SUCTION PRESSURE	______	______
☐ ○ SHAFT RADIAL VIBRATION	______	______
☐ ○ SHAFT AXIAL POSITION	______	______
☐ ○ CASING VIBRATION	______	______
☐ ○	______	______
☐ ○	______	______
☐ ○	______	______
☐ ○	______	______
☐ ○	______	______

FUNCTION	PRE-ALARM	TRIP
☐ ○ DRIVER SHAFT RADIAL VIBRATION	______	______
☐ ○ DRIVER FRAME VIBRATION	______	______
☐ ○ DRIVER SHAFT AXIAL POSITION	______	______
☐ ○ GEARBOX SHAFT RADIAL VIBRATION	______	______
☐ ○ GEARBOX CASING VIBRATION	______	______
☐ ○ GEARBOX SHAFT AXIAL POSITION	______	______
☐ ○ HI COMPR. THRUST BRG. TEMP.	______	______
☐ ○ HI COMPR. JOURNAL BRG. TEMP.	______	______
☐ ○ HI DRIVER THRUST BRG. TEMP.	______	______
☐ ○ HI DRIVER JOURNAL BRG. TEMP.	______	______
☐ ○ HI GEARBOX THRUST BRG. TEMP.	______	______
☐ ○ HI GEARBOX JOURNAL BRG. TEMP.	______	______
☐ ○	______	______

CONTACTS:
ALARM CONTACTS SHALL: ☐ OPEN ☐ CLOSE TO SOUND ALARM AND BE NORMALLY ☐ ENERGIZED ☐ DE-ENERGIZED
SHUTDOWN CONTACTS SHALL: ☐ OPEN ☐ CLOSE TO TRIP AND BE NORMALLY ☐ ENERGIZED ☐ DE-ENERGIZED
NOTE: NORMAL CONDITION IS WHEN COMPRESSOR IS IN OPERATION.

MISCELLANEOUS:
○ INSTRUMENT TAGGING REQUIRED.
○ ALARM AND SHUTDOWN DEVICES SHALL BE SEPARATE.
PURCHASERS ELECTRICAL AND INSTRUMENT CONNECTIONS WITHIN THE CONFINES OF THE BASEPLATE AND CONSOLE SHALL BE: ☐ BROUGHT OUT TO TERMINAL BOXES. ☐ MADE DIRECTLY BY THE PURCHASER.
COMMENTS REGARDING INSTRUMENTATION: ______

NOTE: FOR INSTRUMENTS IN LUBE OIL AND SEAL OIL SERVICES, REFER TO API 614 DATASHEET.
NOTE: FOR INSTRUMENTS IN SEAL GAS SERVICES, REFER TO API 692 DATASHEET.

Annex B
(informative)
Typical Rotary Lobe Type Blower Nomenclature

Figure B.1 shows typical rotary lobe blower nomenclature.

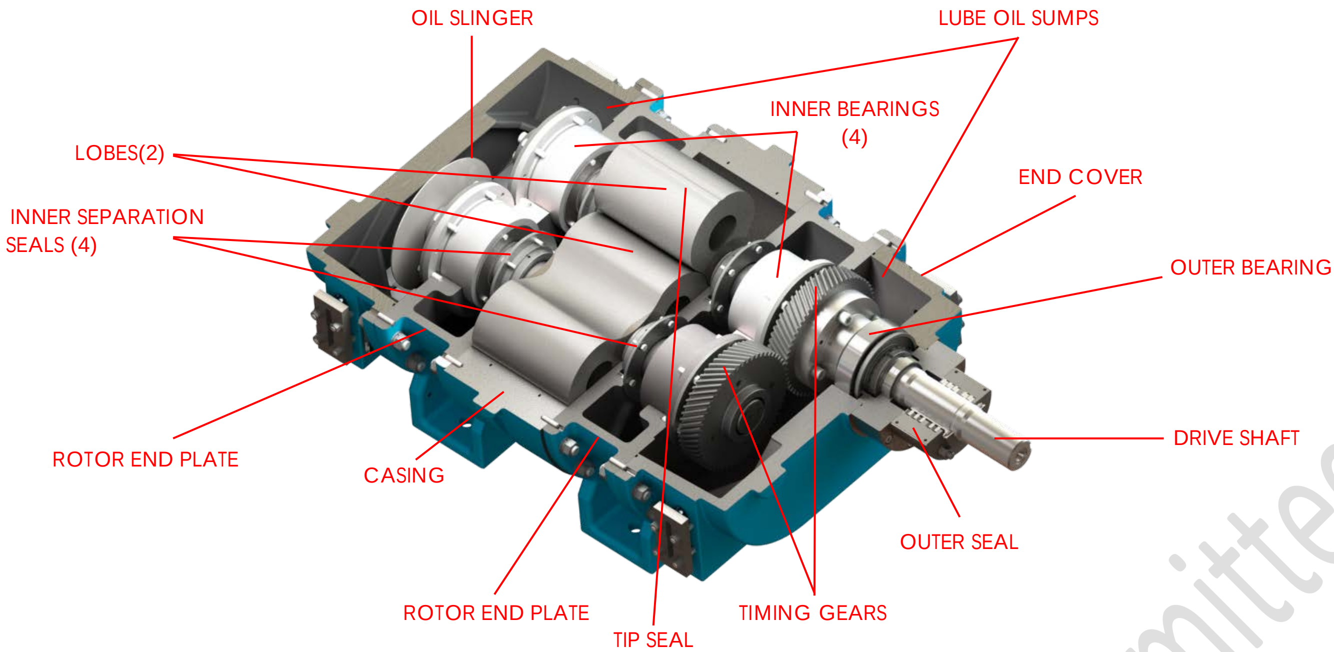

Figure – B.1

Annex C
(normative)
Allowable External Forces and Moments for Rotary Lobe Blowers

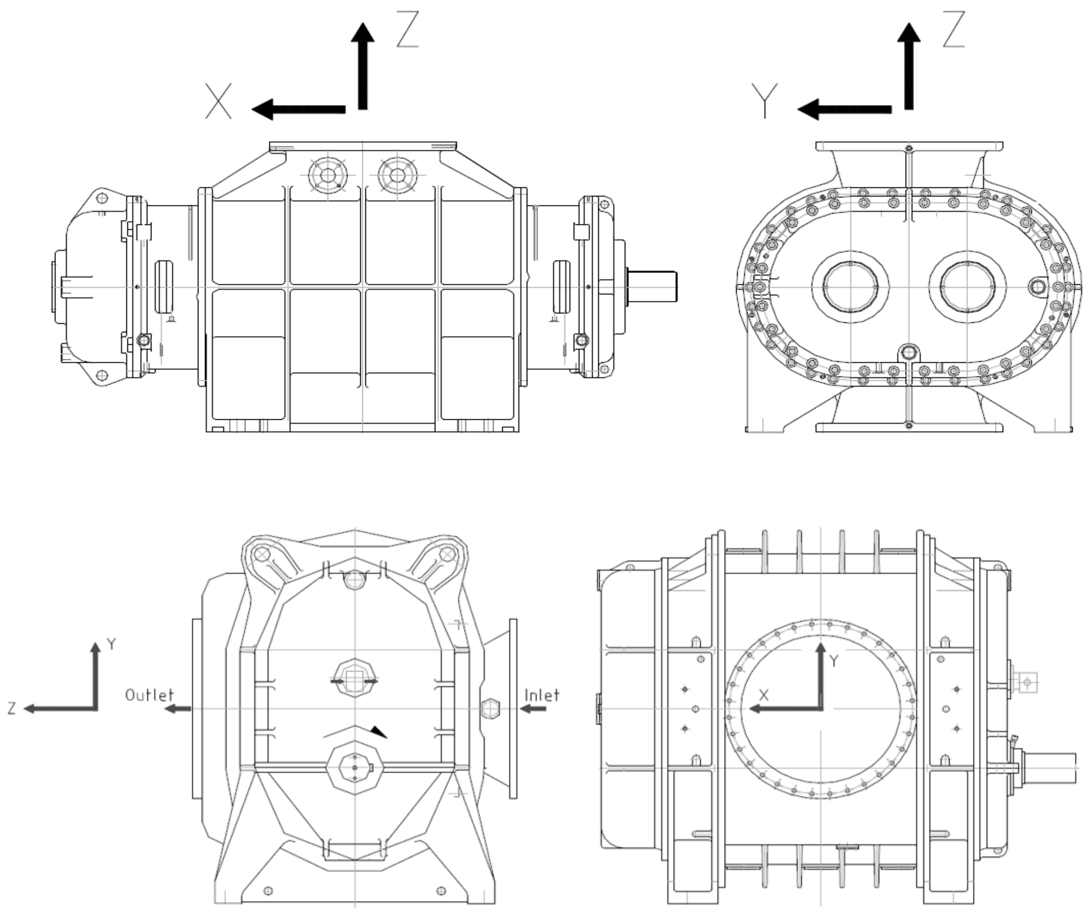

Figure C.1 – Vector Orientations

Maximum resultant vector forces and moments in flanges for varying flange diameters are shown in Table C.1. Vector orientations for use with Table C.1 are shown in Figure C.1.

Table C.1 – Allowable Forces and Moments

Flange Diameter	Allowable forces and moments			
ANSI	Fx,y	Fz	Mx,y	Mz
[in]	[lbf]	[lbf]	[ft-lbf]	[ft-lbf]
2	31	3190	470	160
3	43	1650	290	100

Flange Diameter	Allowable forces and moments			
DN	Fx,y	Fz	Mx,y	Mz
[mm]	[N]	[N]	[Nm]	[Nm]
50	140	14200	640	213
80	190	7360	390	130

4	47	1330	290	100	100	210	5900	390	130
6	56	880	250	83	150	250	3900	340	113
8	65	550	290	100	200	290	2450	390	130
10	76	440	210	72	250	340	1960	290	97
12	83	550	250	83	300	370	2450	340	113
14	110	440	250	130	350	490	1960	340	180
16	110	440	250	130	400	490	1960	340	173
20	140	440	250	160	500	610	1960	340	220
24	1390	990	810	270	600	6200	4400	1100	367
28	1390	1240	1220	410	700	6200	5500	1650	550
36	1390	1570	1620	540	900	6200	7000	2200	733
40	1390	1570	1620	540	1000	6200	7000	2200	733
48	1390	1570	1620	540	1200	6200	7000	2200	733

Table C.1 – Allowable Forces and Moments

Annex D
(informative)
Schematics for Lube-oil Systems

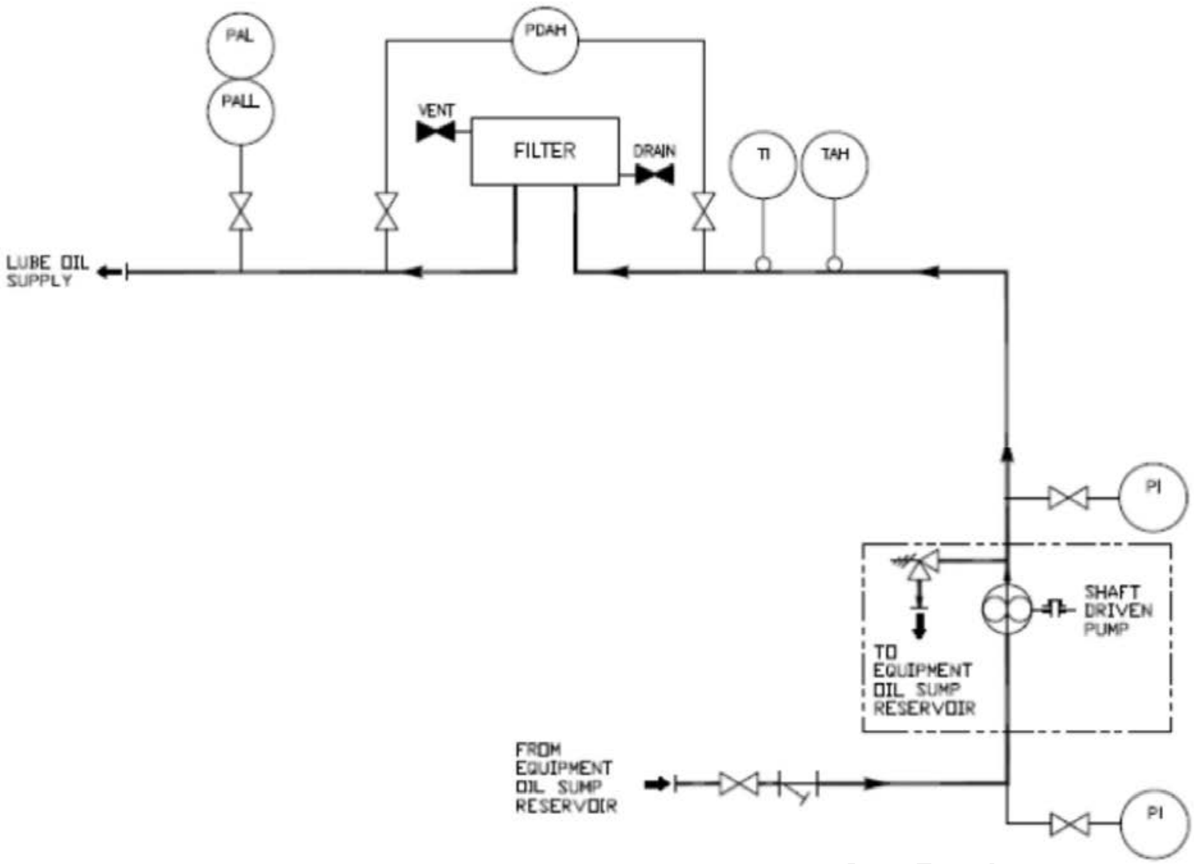

Figure D.1 - Oil circulation system

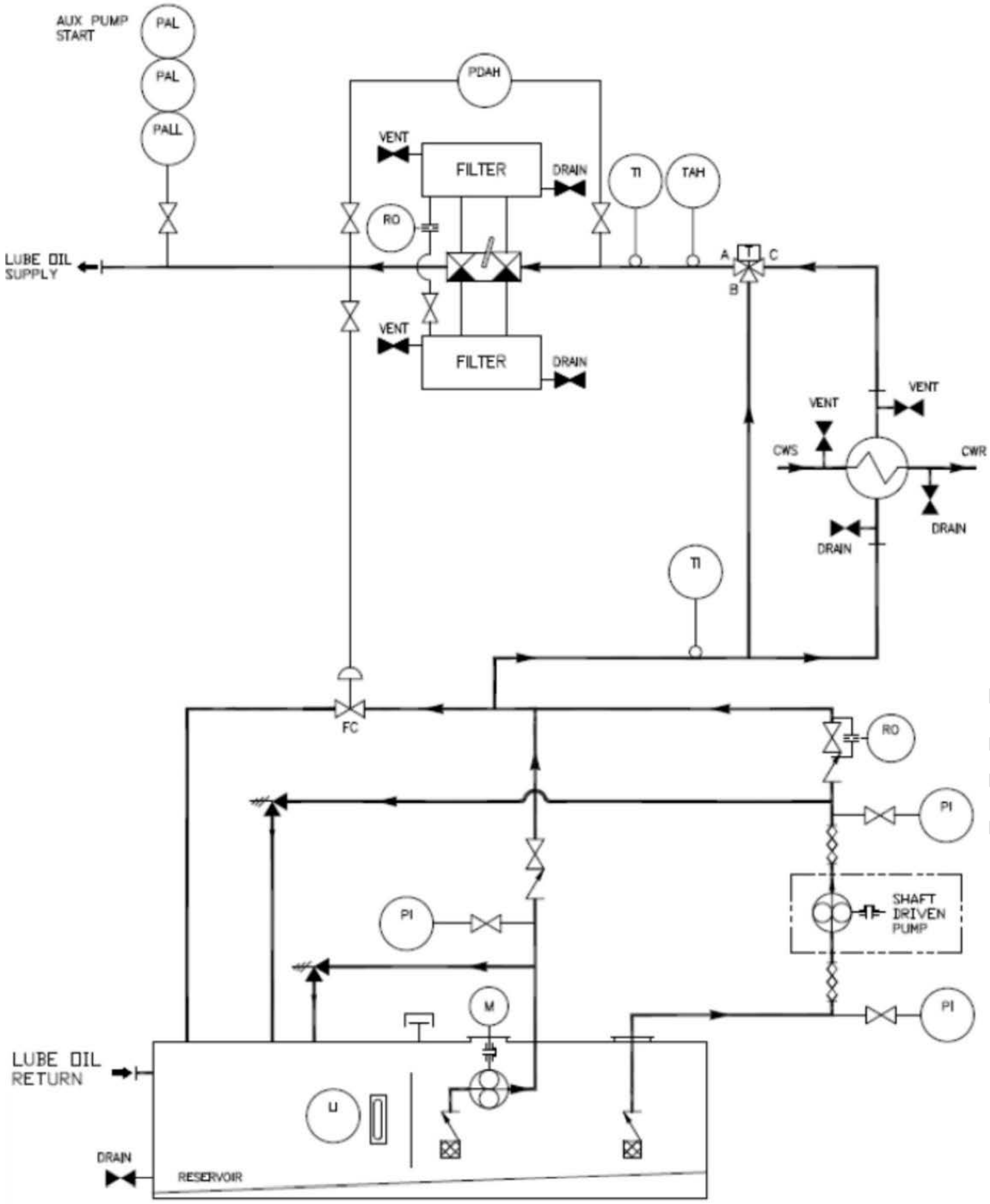

Figure D.2 - Separate oil system