Rotary-type Positive Displacement Compressors for Petroleum, Petrochemical and Natural Gas Industries

ANSI/API STANDARD 619
FIFTH EDITION, DECEMBER 2010

ISO 10440-1:2007 (Identical), Petroleum, petrochemical and natural gas industries—Rotary-type positive displacement compressors—Part 1: Process compressors

energy API

AMERICAN PETROLEUM INSTITUTE

ISO

Approved American National Standard ANSI

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Downstream Segment

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Foreword

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

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

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

ISO 10440-1 was prepared by Technical Committee ISO/TC 118, *Compressors and pneumatic tools, machines and equipment,* Subcommittee SC 1, *Process compressors*.

This second edition cancels and replaces the first edition (ISO 10440-1:2000), which has been technically revised.

ISO 10440 consists of the following parts, under the general title *Petroleum, petrochemical and natural gas industries — Rotary-type positive-displacement compressors*:

— *Part 1: Process compressors*

— *Part 2: Packaged air compressors (oil-free)*

Introduction

This part of ISO 10440 is based on API 619, 4th edition, December 2004, with the intent that the 5th edition of API 619 will be identical to this part of ISO 10440.

Users of this part of ISO 10440 should be aware that further or differing requirements may be needed for individual applications. This part of ISO 10440 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 part of ISO 10440 and provide details.

A bullet (•) at the beginning of a subclause or paragraph indicates that either a decision is required or further information is to be provided by the purchaser. This information should be indicated on the datasheet(s), otherwise it should be stated in the quotation request or in the order.

In this part of ISO 10440, where practical, US Customary (USC) units are included in brackets for information. Dedicated datasheets for SI units and for USC units are provided in Annex A.

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

Part 1: **Process compressors**

1 Scope

This part of ISO 10440 specifies requirements for dry and oil-flooded, helical-lobe rotary compressors (see Figure 1) used for vacuum or pressure or both in petroleum, petrochemical, and gas industry services. It is intended for compressors that are in special-purpose applications.

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.

2 Normative references

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

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

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

ISO 262, *ISO general-purpose metric screw threads — Selected sizes for screws, bolts and nuts*

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

ISO 724, *ISO general-purpose metric screw threads — Basic dimensions*

ISO 945 [1)], *Cast iron — Designation of microstructure of graphite*

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

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*

1) Under revision as ISO 945-1, *Designation of microstructure of cast irons — Part 1: Graphite classification by visual analysis.*

ISO 1940-1:2003, *Mechanical vibration — Balance quality requirements for rotors in a constant (rigid) state — Part 1: Specification and verification of balance tolerances*

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

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 5753:1991, *Rolling bearings — Radial internal clearance*

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

ISO 7005-1, *Pipe flanges — Part 1: Steel flanges for industrial and general service piping systems*

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

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

ISO 10437, *Petroleum, petrochemical and natural gas industries — Steam turbines — Special-purpose applications*

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

ISO 10441, *Petroleum, petrochemical and natural gas industries — Flexible couplings for mechanical power transmission — Special-purpose applications*

ISO 13691, *Petroleum and natural gas industries — High-speed special-purpose gear units*

ISO 13706, *Petroleum, petrochemical and natural gas industries — Air-cooled heat exchangers*

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

ISO 16812, *Petroleum, petrochemical and natural gas industries — Shell-and-tube heat exchangers*

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

ANSI/ABMA Standard 7, *Shaft and Housing Fits for Metric Radial Ball and Roller Bearings (Except Tapered Roller Bearings) Conforming to Basic Boundary Plan* [2)]

ANSI/ABMA Standard 20, *Radial Bearings of Ball, Cylindrical Roller and Spherical Roller Types — Metric Design*

API RP 500, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class 1, Division 1 and Division 2* [3)]

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

ANSI/API 526, *Flanged Steel Pressure Relief Valves*

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

ANSI/API 613, *Special Purpose Gear Units for Petroleum, Chemical and Gas Industry Services*

ANSI/API 670, *Machinery Protection Systems*

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

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

ANSI/API 671, *Special Purpose Couplings for Petroleum, Chemical, and Gas Industry Services*

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

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

ASME B1.1, *Unified Inch Screw Threads, UN and UNR Thread Form* [4)]

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

ASME Boiler and Pressure Vessel Code: Section IX, *Welding and Brazing Qualifications*

ASTM A247, *Standard Test Method for Evaluating the Microstructure of Graphite in Iron Castings* [5)]

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

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

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

ASTM A536, *Standard Specification for Ductile Iron Castings*

ASTM E94, *Standard Guide for Radiographic Examination*

ASTM E709, *Standard Guide for Magnetic Particle Examination*

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

ANSI/AWS D1.1/D1.1M, *Structural Welding Code — Steel* [6)]

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)* [7)]

NACE MR0103, *Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments* [8)]

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

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

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

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

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

NEMA 250, *Enclosures for Electrical Equipment (1 000 Volts Maximum)* [9)]

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

NFPA (Fire) 30, *Flammable and Combustible Liquids Code* [10)]

NFPA (Fire) 70-05, *2005 National Electrical Code*

TEMA Standard Class C [11)]

TEMA Standard Class R

3 Terms and definitions

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

NOTE See Annex B for a guide to rotary-type positive-displacement compressor nomenclature.

3.1
alarm point
preset value of a measured parameter at which an alarm is actuated to warn of a condition that requires corrective action

3.2
anchor bolts
bolts used to attach the mounting plate to the support structure (concrete foundation or steel structure)

NOTE Refer to 3.14 for definition of hold-down bolts.

3.3
axially split
split with the principal joint parallel to the shaft centreline

3.4
baseplate
structure providing support and mounting surfaces for one or more pieces of equipment

3.5
certified point
point at which the vendor certifies that the performance is within the tolerances stated in the standard, usually the normal operating point

3.6
critical speed
shaft rotational speed at which the rotor-bearing support system is in a state of resonance

3.7
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

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

10) National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101, USA.

11) Tubular Exchanger Manufacturers Association, Inc., 25 North Broadway, Tarrytown, NY 10591, USA.

3.8
dry screw compressor
helical-lobe rotary 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.

3.9
fail-safe
system that causes the equipment to revert to a permanently safe condition (shutdown and/or depressurized) in the event of a component failure or failure of the energy supply to the system

3.10
flooded screw compressor
helical-lobe rotary 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 and establishes an oil film between the rotors. One rotor drives the other in the absence of a timing gear.

3.11
gas/oil separator
pressure-containing device, usually a vessel, used to separate entrained oil from the process gas

3.12
gauge board
bracket or plate used to support and display gauges, switches and other instruments

NOTE 1 A gauge board is open and not enclosed

NOTE 2 A gauge board is not a panel. A panel is an enclosure. Refer to 3.31 for the definition of a panel.

3.13
general-purpose application
application that is usually spared or is in non-critical service

3.14
hold-down bolts
mounting bolts
bolts holding the equipment to the mounting plate

3.15
hydrodynamic bearings
bearings that use the principles of hydrodynamic lubrication, where bearing surfaces are oriented such that relative motion forms an oil wedge or wedges to support the load without shaft-to-bearing contact

3.16
inlet volume flow
flow rate expressed in volume 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 particular location such as interstage or compressor discharge. Actual volume flow should not be used interchangeably with inlet volume flow.

3.17
inlet separator
device, usually a filter or vessel, used to separate entrained solid and liquid contaminants from the process gas inlet steam

3.18
maximum allowable differential pressure
highest differential pressure that can be permitted in the compressor under the most severe operating conditions of minimum suction pressure and discharge pressure equal to the relief-valve setting

3.19
maximum allowable speed
highest rotational speed of the power-input rotor at which the manufacturer’s design permits continuous operation

3.20
maximum allowable temperature
maximum continuous temperature for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified maximum operating pressure

3.21
maximum allowable working pressure
MAWP
maximum continuous pressure for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified maximum operating temperature

3.22
maximum continuous speed
highest rotational speed of the power-input rotor at which the machine, as built and tested, is capable of continuous operation with the specified fluid at any of the specified operating conditions

3.23
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 Deviations from the specified conditions, such as relief-valve set pressure, are excluded from maximum power.

3.24
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

3.25
minimum allowable speed
lowest rotational speed of the power-input rotor at which the manufacturer's design permits continuous operation

3.26
minimum allowable temperature
lowest temperature for which the manufacturer has designed the equipment or part thereof

3.27
mounting plate
device used to attach equipment to concrete foundations

NOTE A mounting plate can be a soleplate, a baseplate or a combination of both.

3.28
normal operating point
point at which usual operation is expected and optimum efficiency is desired, usually the certified point

3.29
observed inspection
observed test
inspection or test where the purchaser is notified of the timing of the inspection or test and the inspection or test is performed as scheduled if the purchaser or his representative is not present

NOTE Refer to 3.58 for the definition of a witnessed test.

3.30
owner
final recipient of the equipment who may delegate another agent as the purchaser of the equipment

3.31
panel
enclosure used to mount, display and protect gauges, switches and other instruments

NOTE A panel is not a gauge board. A panel is enclosed and not open. Refer to 3.12 for the definition of a gauge board.

3.32
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.

3.33
pressure casing
composite of all stationary pressure-containing parts of the unit, including all nozzles and other attached parts

3.34
pressure design code
recognized pressure vessel standard specified or agreed by the purchaser

3.35
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.

3.36
radially split
split with the principal joint perpendicular to the shaft centreline

3.37
rated speed
100 % speed
highest rotational speed of the power input rotor required to meet any of the specified operating conditions

3.38
relief-valve set pressure
pressure at which a relief valve starts to lift

3.39
remote
located away from the equipment or the console, typically in a control house

3.40
required capacity
largest inlet volume required by the specified operating conditions

3.41
rotor
rotating male or female assembly, including rotor body, shaft and shrunk-on sleeves (if furnished)

NOTE See Figure 1.

3.42
rotor body
helical profile section on or integral with the shaft

3.43
rotor set
set consisting of both male and female rotors and, for dry screw compressors, including timing gears and thrust collars

3.44
seal barrier gas
clean gas supplied to the area between the seals of a dual seal arrangement at a pressure higher than the process pressure

3.45
seal buffer gas
clean gas supplied to the process (inboard) side of a seal

3.46
separation seal gas
supply of inert gas or air fed into the region between the seal and the shaft bearing or between the bearing housing and atmosphere

3.47
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.

3.48
shutdown point
preset value of a measured parameter at which automatic or manual shutdown of the system or equipment is required

3.49
slide valve
device integral to the compression chamber for varying the volumetric flow through a rotary screw compressor

NOTE See Figure B.2, item 8.

3.50
soleplate
plate grouted to the foundation, with a mounting surface for equipment or for a baseplate

3.51
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

3.52
special tool
tool which is not a commercially available catalogue item

3.53
standby
normally idle or idling piece of equipment that is capable of immediate automatic or manual start-up and continuous operation

3.54
thermal relief valve
valve for relieving pressure caused by thermal expansion of liquid within a closed volume

3.55
trip speed
rotational speed of the power-input rotor at which the independent emergency overspeed system operates to shut down a prime mover

NOTE For the purposes of this part of ISO 10440, the trip speed of alternating-current electric motors, except variable-frequency drives, is the speed corresponding to the synchronous speed of the motor at maximum supply frequency.

3.56
unit responsibility
responsibility for coordinating the technical aspects of the equipment and all auxiliary systems included in the scope of the order, including responsibility for reviewing such factors as the power requirements, speed, rotation, general arrangement, couplings, dynamics, noise, lubrication, sealing system, material test reports, instrumentation, piping, conformance to specifications and testing of components

3.57
vendor
supplier
agency that supplies the equipment

NOTE The vendor can be the manufacturer of the equipment or the manufacturer's agent and normally is responsible for service support.

3.58
witnessed inspection
witnessed test
inspection or test where the purchaser is notified of the timing of the inspection or test and a hold is placed on the inspection or test until the purchaser or his representative is in attendance

4 General

4.1 Pressure design code

- The pressure design code shall be specified or agreed by the purchaser. Pressure components shall comply with the pressure design code and the supplemental requirements in this part of ISO 10440.

4.2 Unit responsibility

The vendor who has unit responsibility shall ensure that all subvendors comply with the requirements of this part of ISO 10440.

4.3 Units of measurement

- The purchaser shall specify whether data, drawings, hardware (including fasteners) and equipment supplied for this part of ISO 10440 shall use the SI or USC units.

NOTE Dedicated datasheets for SI units and for USC units are provided in Annex A.

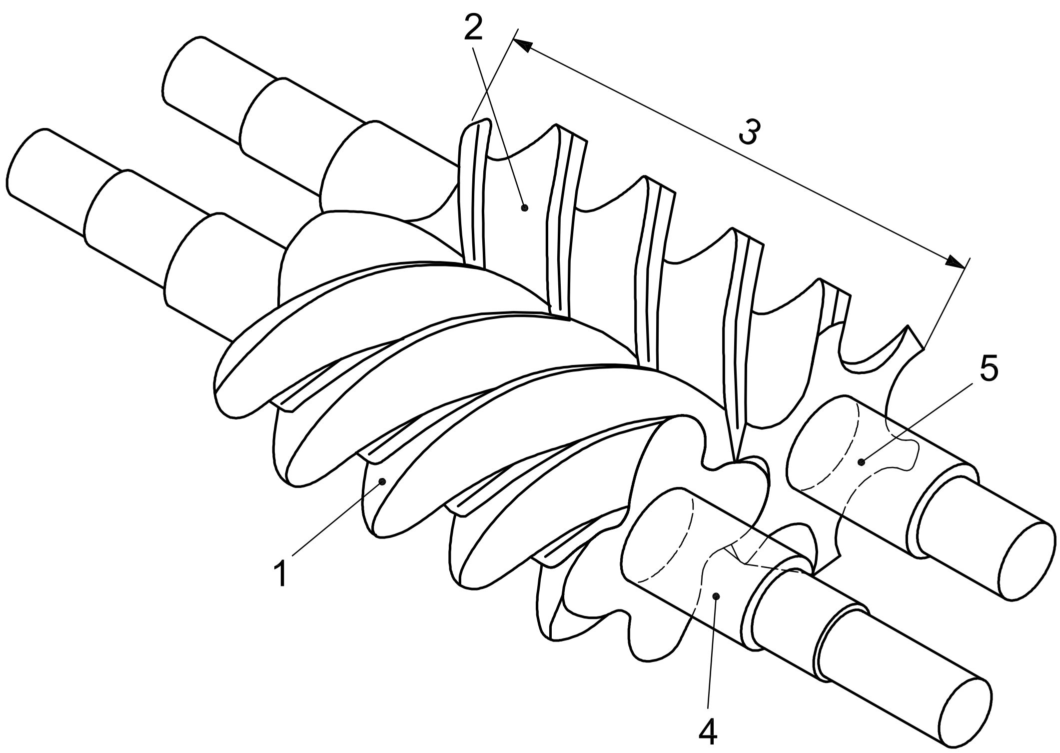
4.4 Statutory requirements

The purchaser and the vendor shall mutually determine the measures to be taken to comply with any governmental codes, regulations, ordinances or rules that are applicable to the equipment.

5 Basic design

5.1 General

5.1.1 Typical helical-lobe compressor rotors are shown in Figure 1.



Key

1 male rotor
2 female rotor
3 rotor body
4 shaft extension – male rotor
5 shaft extension – female rotor

Figure 1 — Helical-lobe compressor rotors

The equipment (including auxiliaries) covered by this part of ISO 10440 shall be designed and constructed for a minimum service life of 20 years and at least 3 years of uninterrupted operation.

It is recognized that this is a design criterion.

The term "design" shall apply solely to parameters or features of the equipment supplied by the manufacturer. The term "design" should not be used in the purchaser's enquiry or specifications because it can create confusion in understanding the order.

5.1.2 The vendor shall assume unit responsibility for all equipment and all auxiliary systems included in the scope of the order.

● **5.1.3** The purchaser shall specify the equipment's normal operating point.

● **5.1.4** The purchaser shall specify all other operating points, including start-up conditions, and shall indicate the certified operating point.

● **5.1.5** The purchaser shall specify the settle-out pressure. In the event that 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, relief valves and piping system can be adversely affected.

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

5.1.7 Equipment shall be designed to run, without damage, at the relief-valve set pressure, specified maximum differential pressure and trip speed (see 5.1.12) simultaneously.

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

For machines operating with variable suction and discharge-pressure levels, maximum allowable temperature can occur before maximum allowable pressure or maximum allowable differential pressure occurs. In such cases, the manufacturer and the purchaser should jointly consider and apply suitable safeguarding controls to avoid any damage. Controls may include but are not limited to discharge temperature or differential pressure.

5.1.8 Unless otherwise specified, cooling-water systems shall be designed for the conditions given in Table 1:

Table 1 — Conditions for cooling-water systems

Water velocity over heat-exchange surfaces	1,5 m/s to 2,5 m/s	5 ft/s to 8 ft/s
Maximum allowable working pressure (MAWP)	> 700 kPa (7,0 bar)[a]	> 100 psi[a]
Test pressure (1,5 times MAWP)	> 1 050 kPa (10,5 bar)[a]	> 150 psi[a]
Maximum pressure drop	100 kPa (1 bar)	15 psi
Maximum inlet temperature	32 °C	90 °F
Maximum outlet temperature	50 °C	120 °F
Maximum temperature rise	17 K	30 R[b]
Minimum temperature rise	10 K	20 R[b]
Fouling factor on water side	0,35 m^2 K/kW	0,002 h·ft^2·R/Btu
Shell-corrosion allowance	3,0 mm	0,125 in

[a] Gauge pressure.

[b] Rankin is a deprecated unit.

The vendor shall notify the purchaser if the criteria for minimum temperature rise and velocity over heat-exchange surfaces result in a conflict. The criterion for velocity over heat-exchange surfaces is intended to minimize water-side fouling; the criterion for minimum temperature rise is intended to minimize the use of cooling water. If such a conflict exists, the purchaser shall approve the final selection.

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

5.1.10 All equipment shall be designed to permit rapid and economical maintenance. Major parts, such as casing components and bearing housings, shall be designed and manufactured to ensure accurate alignment on reassembly. This can be accomplished by the use of shouldering, cylindrical dowels or keys.

5.1.11 The equipment's maximum continuous speed shall be not less than 105 % of the rated speed for variable-speed machines and shall be equal to the rated speed for constant-speed motor drives.

5.1.12 The equipment's trip speed shall not be less than the values in Table 2.

Table 2 — 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
Gas turbine	105
Variable-speed motor	110
Constant-speed motor	100
Reciprocating engine	110

[a] Indicates governor class as specified in NEMA SM 23.

5.1.13 Spare and replacement parts for the machine and all furnished auxiliaries shall meet all the criteria of this part of ISO 10440.

5.1.14 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.

5.1.15 The equipment (machine, driver and ancillary equipment) shall perform on the test stand and on their permanent foundation within the specified acceptance criteria. After installation, the performance of the combined units shall be the joint responsibility of the purchaser and the vendor who has unit responsibility. The performance of the machine shall also take into account the following.

a) The power at the certified point shall not exceed 104 % of the quoted value with no negative tolerance on required capacity.

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

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

● d) The purchaser shall specify gas composition(s). The purchaser may also specify relative molecular mass, ratio of specific heats (C_p/C_v) and compressibility factor (Z).

e) Unless otherwise specified, the vendor shall use the specified values of flow, the specified gas composition and the gas conditions to calculate relative molecular mass, ratio of specific heats (C_p/C_v) and compressibility factor (Z). The compressor vendor shall indicate his values on the datasheets with the proposal and use them to calculate performance data.

● **5.1.16** If specified, the vendor shall review and comment on the purchaser's piping and foundation drawings.

● **5.1.17** If specified, in order to verify compliance with agreed criteria (e.g. API RP 686 or vendor's standard), 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,

c) shaft alignment at operating temperature.

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.

5.1.18 Motors, electrical components and electrical installations shall be suitable for the area classification (class, group and division or zone) specified by the purchaser and shall meet the requirements of the applicable sections of IEC 60079 (all parts) or NFPA 70-05, Articles 500, 501, 502 and 504, as well as any local codes specified and furnished on request of the purchaser.

● **5.1.19** 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. The equipment furnished by the vendor shall conform to the maximum allowable sound pressure level specified. In order to determine compliance, the vendor shall provide both maximum sound pressure and sound power level data per octave band for the equipment.

NOTE The sound power level of a source can be treated as a property of that source under a given set of operating conditions. The sound pressure level, however, varies depending on the environment in which the source is located as well as the distance from the source. Vendors routinely take exception to guaranteeing a purchaser's maximum allowable sound pressure level requirement due to the argument that the vendor has no control over the environment in which the equipment will be located. The vendor has control, however, over the sound power level of the equipment.

● **5.1.20** If specified, the vendor shall supply acoustical treatment. The type of treatment and safety requirements shall be agreed by the vendor and the purchaser.

These compressors tend to be very noisy. The compressor can require an acoustical enclosure to achieve acceptable noise levels. Such factors as accessibility for operation and maintenance, purge requirements when handling flammable or toxic gas, noise levels within the enclosure, explosion-proof doors, and see-through window requirements for machine monitoring should be considered in the design and construction of acoustical enclosures.

5.1.21 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 flooded screw compressors (see 5.10.3.1.1) and may be required for dry screw compressors if liquid injection is utilized.

● **5.1.22** The equipment, including all auxiliaries, shall be suitable for operation under the environmental conditions specified by the purchaser. This statement of conditions shall include whether the installation is indoors (heated or unheated) or outdoors (with or without a roof), maximum and minimum temperatures, unusual humidity and dusty or corrosive conditions.

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

5.1.24 Bolting shall be furnished as follows.

a) The details of threading shall conform either to ISO 261, ISO 262, ISO 724 and ISO 965 (all parts) or to ASME B1.1.

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

c) Internal socket-type, slotted-nut or spanner-type bolting shall not be used unless specifically approved by the purchaser.

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

d) The manufacturer's marking shall be located on all fasteners 6 mm (0,25 in) and larger (excluding washers and headless set screws). For studs, the marking shall be on the nut end of the exposed stud end.

NOTE A set screw is a headless screw with an internal hex opening on one end.

● **5.1.25** The purchaser should indicate the presence of solid or liquid particles in the gas stream and their amount, size and composition.

5.2 Pressure casing

5.2.1 The pressure casing shall be designed in accordance with 5.2.2 or 5.2.3, as selected by the vendor and the casing-joint bolting shall be in accordance with 5.2.4. In addition, 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.

5.2.2 The allowable tensile stress used in the design of the pressure casing (excluding bolting) for any material shall not exceed 0,25 times the minimum ultimate tensile strength for the material at the maximum specified operating temperature. For cast materials, the allowable tensile stress shall be multiplied by the appropriate casting factor as shown in Table 3.

Table 3 — Casting factors

Type of NDE	Casting factor
Visual, magnetic particle and/or liquid penetrant	0,8
Spot radiography	0,9
Ultrasonic	0,9
Full radiography	1,0

5.2.3 Pressure-containing components may be designed with the aid of finite-element analysis, provided that the design limits comply with the pressure design code (e.g. Section VIII, division 2, of the ASME pressure vessel code) and with the maximum allowable stress intensity, Σ_{max}, expressed in kilopascals (pounds per square inch), as given in the modified Equation (1). Manufacturing data-report forms, third-party inspections and stamping as specified in the pressure design code are not required.

$$\Sigma_{\text{max}} = \Sigma_{\text{c}} \left(P_{\text{c}} / 150 \right) \quad (1)$$

where

Σ_{c} is the ASME Code stress intensity, expressed in kilopascals (pounds per square inch);

P_{c} is the ASME Code hydrotest pressure, expressed in percent of MAWP.

The manufacturer shall state the source of the material properties, such as ASTM, as well as the casting factors applied in his proposal.

5.2.4 For casing-joint bolting, the allowable tensile stress, as determined in 5.2.2, shall be used to determine the total bolting area based on hydrostatic load and gasket preload as applicable. The preload stress shall not exceed 0,75 times the bolting material minimum yield.

NOTE 1 In general, deflection is the determining consideration in the design of casings. Ultimate tensile or yield strength is seldom the limiting factor.

NOTE 2 Preloading the bolting is required to prevent unloading the bolted joint due to cyclic operation.

5.2.5 The maximum allowable working pressure of the 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, it shall be specified by the vendor. (See 5.1.7.)

5.2.6 Unless otherwise specified, for dry screw compressors, system pressure protection shall be furnished by the purchaser.

5.2.7 For 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.

5.2.8 Casings shall be made of steel if

a) the rated discharge gauge pressure is over 2 750 kPa (27,5 bar; 400 psi),

b) the discharge temperature is over 260 °C (500 °F);

c) the gas is flammable or toxic.

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

5.2.9 Casings designed for more than one maximum allowable working pressure shall not be used. If a cooling jacket is utilized, this jacket shall have only external connections between the upper and lower housings.

5.2.10 The main joint of axially split casings shall use a metal-to-metal joint that is tightly maintained by bolting. The joint shall be sealed with a compound that is compatible with the fluids to be handled. Gaskets (including string-type) shall not be used. The main joints of radially split casings may incorporate a gasket. Such gaskets shall be fully confined.

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

5.2.12 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).

5.2.13 Supports and alignment bolts shall be rigid enough to permit the machine to be moved by the use of its lateral and axial jackscrews.

5.2.14 Jackscrews, guide rods, casing-alignment dowels and/or other appropriate devices shall be provided to facilitate disassembly and reassembly. Guide rods shall be of sufficient length to prevent damage to the internals or casing studs by the casing during disassembly and reassembly. Lifting lugs or eyebolts shall be provided for lifting only the top half of the casing. Methods of lifting the assembled machine shall be specified by the vendor.

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.

● **5.2.15** If specified for dry screw compressor corrosion resistance, overlay cladding or plating 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 lined similarly or have compatible stainless steel end plates provided.

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

5.2.16 In addition to the requirements of 5.1.24, pressure-casing bolting shall be furnished as specified in 5.2.17 and 5.2.18.

5.2.17 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.

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.

● **5.2.18** 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.

5.2.19 The use of threaded holes in pressure parts shall be minimized. 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. The depth of the threaded holes shall be at least 1,5 times the stud diameter.

5.2.20 Mounting surfaces shall meet the following criteria.

a) They shall be machined to a finish of 6,3 µm (250 µin) Ra (arithmetic average roughness) or better.

b) To prevent a soft foot, they shall be in the same horizontal plane within 25 µm (0,001 in).

c) Each mounting surface shall be machined within a flatness of 13 µm/330 linear mm (0,000 5 in/linear ft) of mounting surface.

d) Different mounting planes shall be parallel to each other within 50 µm (0,002 in).

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

Hold-down bolt holes shall be drilled perpendicular to the mounting surface or surfaces and, to allow for equipment alignment, be 13 mm (0,5 in) larger in diameter than the hold-down bolt. If spot-faced, its diameter shall be three times that of the bolt hole.

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

5.3 Casing connections

5.3.1 All openings or nozzles for piping connections on pressure casings shall be DN 20 (NPS $^3/_4$) or larger and shall be in accordance with ISO 6708. Sizes DN 32, DN 65, DN 90, DN 125, DN 175 and DN 225 (NPS 1-$^1/_4$, 2-$^1/_2$, 3-$^1/_2$, 5, 7, and 9) shall not be used.

5.3.2 All connections shall be flanged or machined and studded, except where threaded connections are permitted by 5.3.6. All connections shall be suitable for the maximum allowable working pressure of the casing. Main inlet and outlet process connections shall be oriented as specified. 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.

5.3.3 Connections welded to the casing shall meet the material requirements of the casing, including impact values, rather than the requirements of the connected piping (see 5.11.4.5). All welding of connections shall be completed before the casing is hydrostatically tested (see 7.3.2).

5.3.4 A casing drain shall be provided.

5.3.5 Butt-welded connections, size DN 40 (NPS 1-$^1/_2$) and smaller, shall be reinforced by using forged welding inserts or gussets.

5.3.6 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.

5.3.7 Pipe nipples screwed or welded to the casing should 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-$^1/_2$).

5.3.8 The pipe nipple shall be provided with a welding-neck or socket-weld flange.

5.3.9 The nipple and flange material shall meet the requirements of 5.3.3.

5.3.10 Threaded openings and bosses for pipe threads shall conform to ISO 7-1 and ISO 7-2 or ASME B1.20.1-1983.

5.3.11 Threaded openings not required to be connected to piping shall be plugged with solid, steel plugs in accordance with ASME B16.11. As a minimum, these plugs shall meet the material requirements of the pressure casing. Plugs that may later require removal shall be of a corrosion-resistant material. Plastic plugs are not permitted. A process-compatible thread lubricant of proper temperature specification shall be used on all threaded connections. Thread tape or thread sealant shall not be used.

5.3.12 Flanges shall conform to ISO 7005-1 or ISO 7005-2, or ASME B16.1, ASME B16.5 or ASME B16.42 or ASME B16.47, series A or B, as applicable, except as specified in 5.3.13 to 5.3.16.

5.3.13 Cast iron flanges shall be flat-faced and conform to the dimensional requirements of ISO 7005-2 or ASME B16.1 or ASME B16.42. Class 125 flanges shall have a minimum thickness equal to class 250 for sizes DN 200 (NPS 8) and smaller.

NOTE For general-purpose equipment, relaxation of the class 250 thickness requirement may be considered. Bolting dimensions are equivalent for class 125 and class 250 flanges. The added thickness is preferred for most machinery applications.

5.3.14 Flanges other than cast iron shall conform to the dimensional requirements of ISO 7005-1 or ASME B16.5 or ASME B16.47.

5.3.15 Flat face flanges with full raised face thickness are acceptable on casings of all materials. Flanges in all materials that are thicker or have a larger outside diameter than required by ISO or ASME are acceptable. Non-standard (oversized) flanges shall be completely dimensioned on the arrangement drawing.

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

5.3.17 Machined and studded connections shall conform to the facing and drilling requirements of ISO 7005-1 or ISO 7005-2, or ASME B16.1, ASME B16.5, ASME B16.42 or ASME B16.47, series A or B. Studs and nuts shall be furnished installed, the first 1,5 threads at both ends of each stud shall be removed.

5.3.18 Machined and studded connections and flanges not in accordance with ISO 7005-1 or ISO 7005-2, or ASME B16.1, ASME B16.5, ASME B16.42 or ASME B16.47 require purchaser's approval. Unless otherwise specified, the vendor shall supply mating flanges, studs and nuts for these non-standard connections.

5.3.19 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°. Studs or bolt holes shall straddle centrelines parallel to the main axes of the equipment.

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

5.4 External forces and moments

5.4.1 As a minimum, the compressor shall be designed to withstand external forces and moments on each nozzle as tabulated in Annex C. The vendor shall furnish the allowable forces and moments for each nozzle in tabular form.

Silencers can require additional support.

5.4.2 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 to 50 µm (0,002 in).

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 unless specifically approved by the purchaser.

5.5 Rotating elements

5.5.1 Rotors

5.5.1.1 Rotor stiffness shall be adequate to prevent contact between the rotor bodies and the casing and between gear-timed rotor bodies at the most unfavourable specified conditions. Rotor bodies not integral with the shaft shall be permanently attached to the shaft to prevent relative motion under any condition. Structural welds on rotors shall be full-penetration continuous welds and shall be post-weld heat-treated, using qualified procedures and welders.

NOTE Only dry screw compressors are furnished with gear-timed rotor bodies.

5.5.1.2 Shafts shall be forged steel unless otherwise approved by the purchaser.

● **5.5.1.3** If specified or if vibration and/or axial-position probes are furnished, the rotor shaft-sensing areas (both radial vibration and axial position) that are observed by radial-vibration probes shall

a) be concentric with the bearing journals;

b) be free from stencil and scribe marks or any other surface discontinuity, such as an oil hole or a keyway, for a minimum of one probe-tip diameter on each side of the probe;

c) not be metallized, sleeved or plated;

d) have a final surface finish of a maximum of 0,8 µm (32 µin) Ra, preferably obtained by honing or burnishing;

e) be properly demagnetized to the levels specified in API 670 or otherwise treated so that the combined total electrical and mechanical runout does not exceed 25 % of the maximum allowed peak-to-peak vibration amplitude or the following value, whichever is greater:

   1) for areas to be observed by radial-vibration probes, 6 µm (0,25 mil),

   2) for areas to be observed by axial-position probes, 13 µm (0,5 mil).

5.5.1.4 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.

5.5.1.5 Shaft ends shall conform to the requirements of ISO 10441 or API 671.

5.5.1.6 All shaft keyways shall have fillet radii conforming to ASME B17.1.

5.5.2 Timing gears — Dry screw compressors

5.5.2.1 Timing gears shall be made of forged steel and shall be a minimum of ISO 1328-1:1995, accuracy grade 5. Timing gears shall be of the helical type; see Figure B.1. The ISO service factor shall be a minimum of 3,0.

NOTE For the purposes of this provision, AGMA 1328-1 is equivalent to ISO 1328-1.

5.5.2.2 The meshing relationship between gear-timed rotors shall be adjustable and the adjustment shall be arranged for positive locking. The adjustment and locking provisions shall be accessible with the rotors in their bearings. The gear enclosing chamber shall not be subject to contact with the gas.

5.5.2.3 Where timing gears have to be removed for seal replacement, it shall be possible to retime the rotors without further disassembly of radially split casings.

5.5.2.4 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.

5.5.2.5 Inspection ports or other means shall be provided on the housing covers, such that timing gears may be inspected without disassembly of the unit.

5.6 Shaft seals

5.6.1 General

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

5.6.1.2 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.

● **5.6.1.3** The purchaser may specify a sealing pressure provided it meets the requirements of 5.6.1.2 as a minimum.

5.6.1.4 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.

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

5.6.1.6 Shaft seals should 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 seals on some designs.

● **5.6.1.7** Shaft seals may be one of, or a combination of, the types described in 5.6.3 and 5.6.4 as specified by the purchaser or other types as mutually agreed. Materials of component parts shall be suitable for the service.

5.6.1.8 If either the process or seal-support fluid are toxic or flammable, a separation seal is required in addition to the primary seal to prevent leakage to the atmosphere or to the bearing housing. This separation seal shall be capable of acting as a temporary, emergency 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 the separation seal. Flammable liquids shall be as defined in NFPA 30. See Figures 2 and 3 for typical arrangements of separation seals.

5.6.1.9 Dry screw compressors with self-acting dry-gas seals and, unless otherwise agreed by the purchaser, other shaft seal types, shall have provisions for buffer gas injection to each seal.

5.6.2 Seal support systems

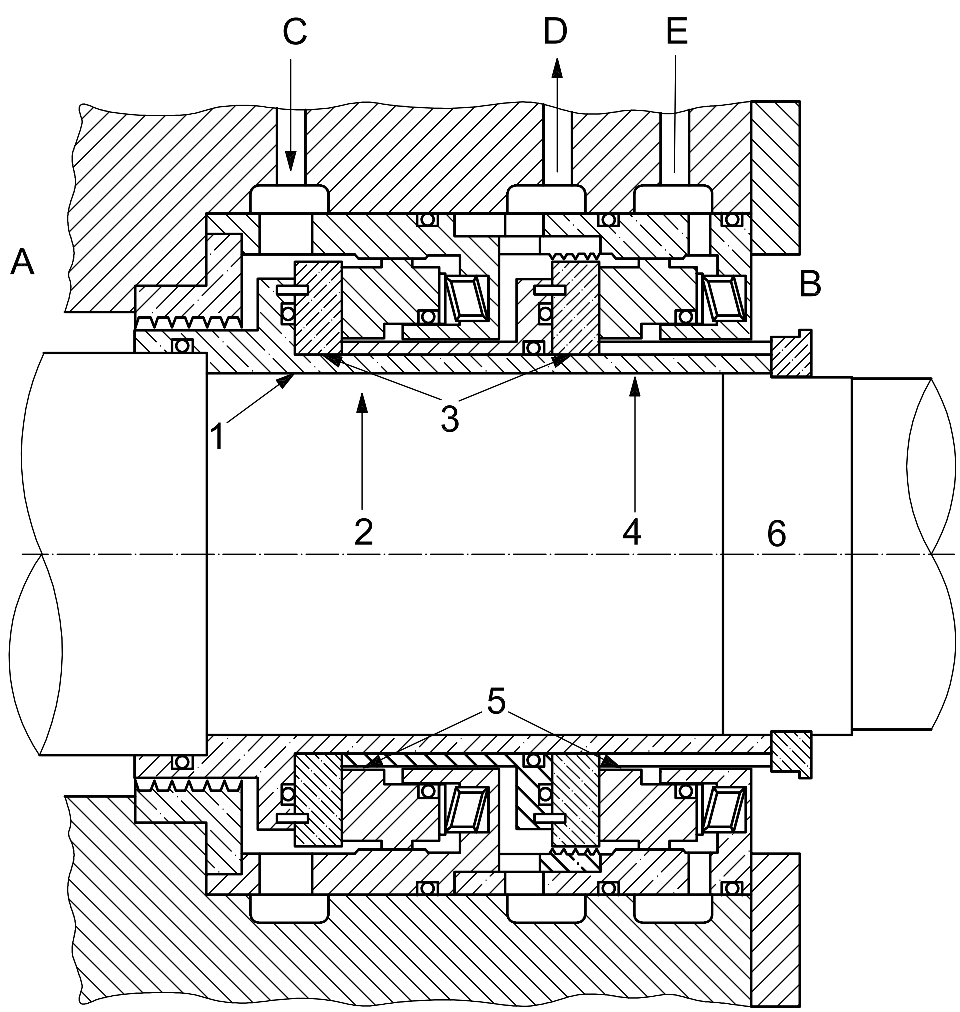
● **5.6.2.1** The purchaser should specify whether any of the following seal-support systems is required:

a) seal barrier gas;

b) seal buffer gas;

c) separation seal gas.

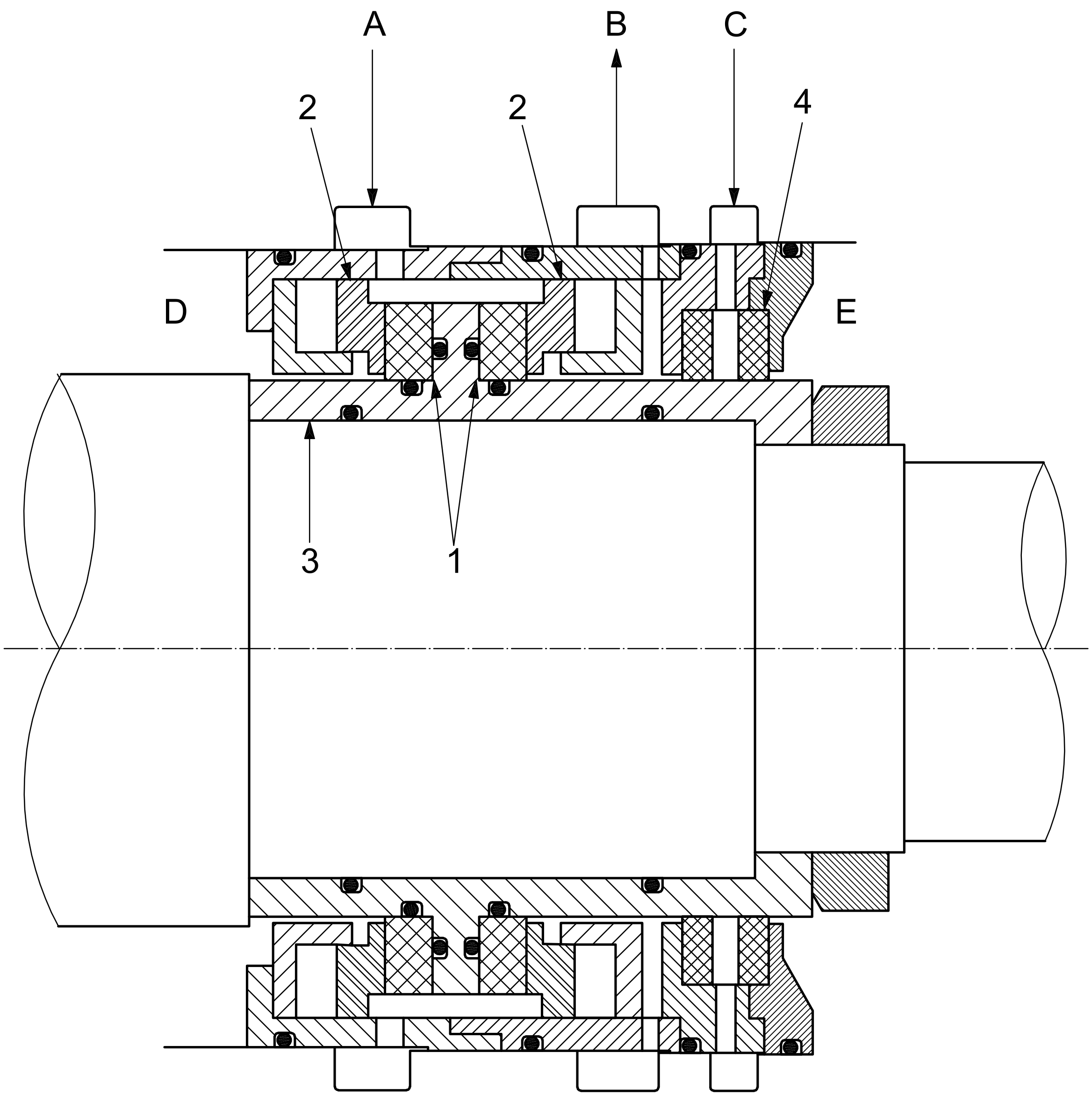
In addition, the vendor shall state whether seal fluid is required for any specified operating conditions.



Key

A	gas side	1	shaft sleeve
B	atmosphere side	2	main primary seal
C	filtered seal gas inlet	3	rotating seat
D	gas leakage out	4	backup seal or isolating seal
E	isolation seal (inert buffer-injection gas)	5	stationary seat
		6	compressor rotor centreline

Figure 2 — Self-acting gas seal — Tandem arrangement



Key

A filtered seal gas inlet
B gas leakage out
C barrier/isolation seal; clean, dry gas supply
D gas side
E atmosphere side

1 rotating seat
2 stationary seat
3 rotor sleeve
4 barrier/isolation seal

Figure 3 — Self-acting gas seal — Double arrangement

5.6.2.2 If buffer-gas injection is provided, the vendor shall state the gas requirements including pressures, flow rates, dew points and filtration.

● **5.6.2.3** If specified, the vendor shall furnish the complete seal-support system, including schematic and bill of materials. The method of control, design, materials and scope of supply is mutually agreed by the purchaser and the vendor.

5.6.2.4 If a barrier or buffer gas is required, the gas shall be filtered and shall be dry and free of any contaminants that form residues. The seal-gas source may be taken from the compressor discharge or intermediate point. An alternative seal-gas source may be used and can be required during start-up or shutdown and for the separation seal.

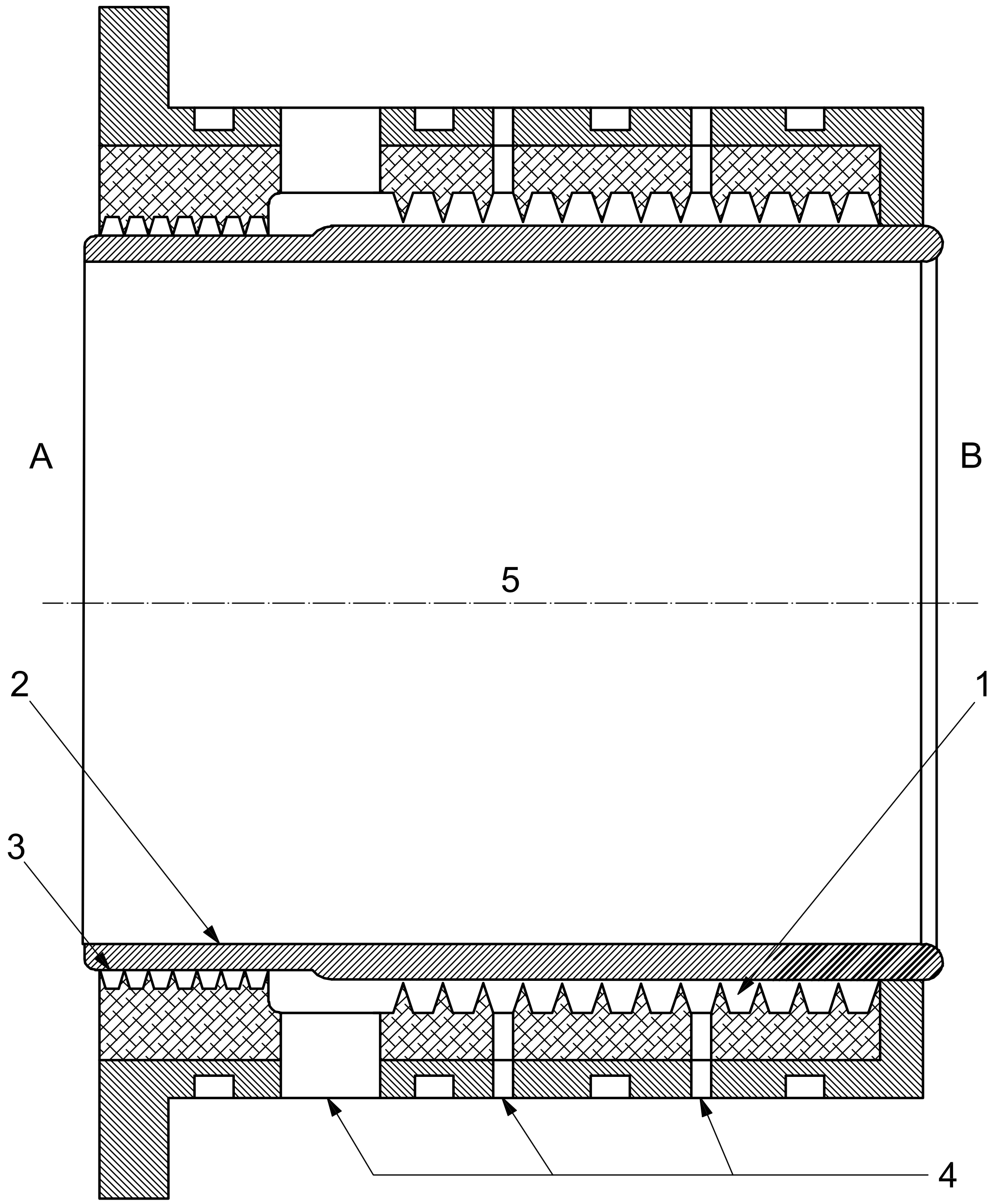
5.6.2.5 Support systems for self-acting dry-gas seals shall be in accordance with ISO 10438-1 and ISO 10438-4.

NOTE For the purposes of this provision, API 614-99, Chapters 1 and 4, are equivalent to ISO 10438-1 and ISO 10438-4, respectively.

5.6.3 Shaft seals for dry screw compressors

5.6.3.1 Labyrinth type

The labyrinth seal (a typical seal is shown in Figure 4) may include restrictive-ring type in addition to the labyrinths if approved by the purchaser. Labyrinths may be stationary or rotating.



Key

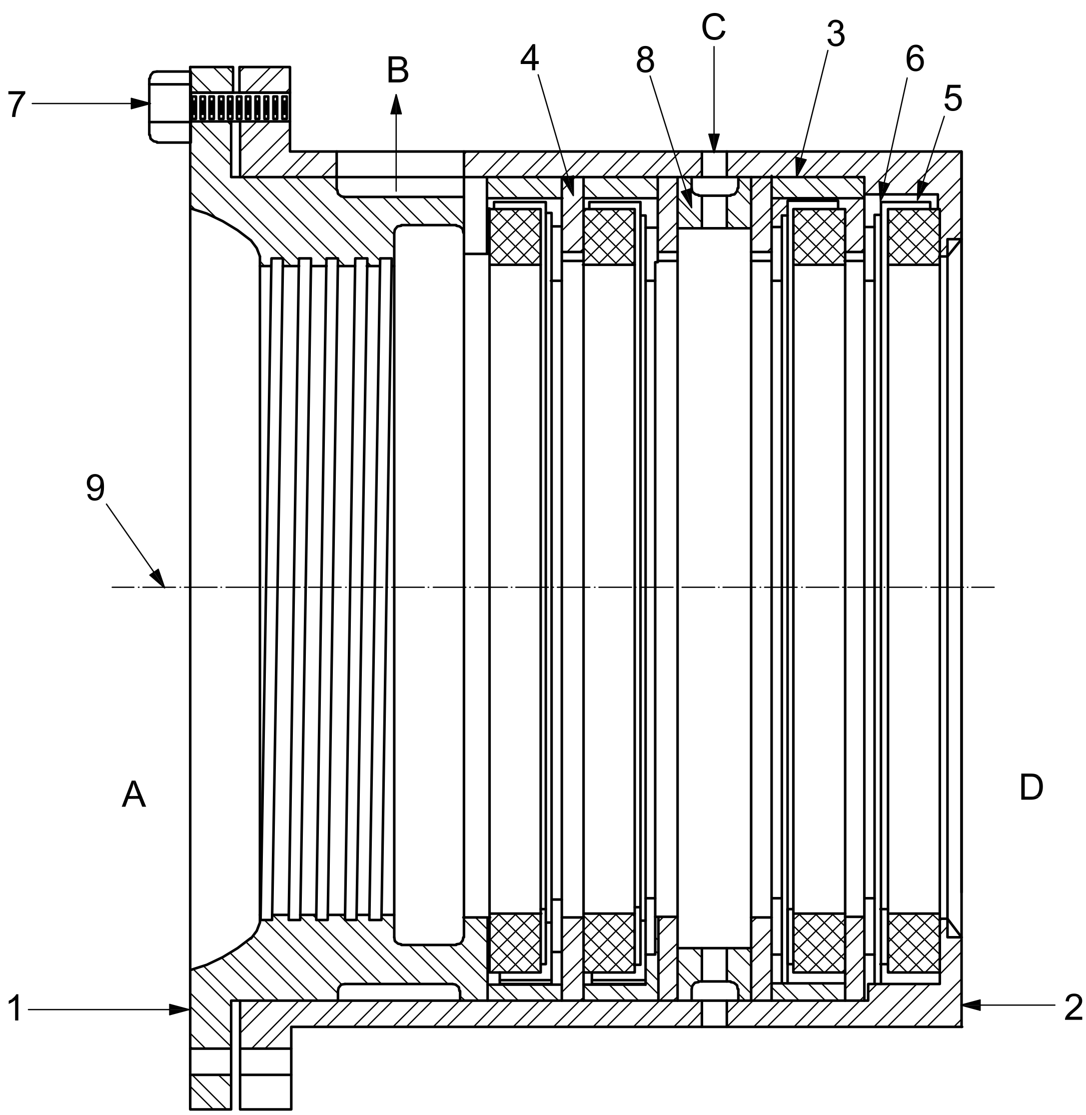
A atmosphere side
B gas side

1 labyrinth
2 shaft sleeve
3 wind-back oil seal
4 ports for venting, purging or scavenging as required
5 compressor rotor centreline

Figure 4 — Labyrinth shaft seal

5.6.3.2 Restrictive-ring type

Restrictive-ring-type seals (a typical seal is shown in Figure 5) shall include rings of carbon or other suitable material mounted in retainers or spacers. The seals may be operated dry or with a sealing liquid.



Key

A atmosphere side
B vent to atmosphere
C purge
D gas side

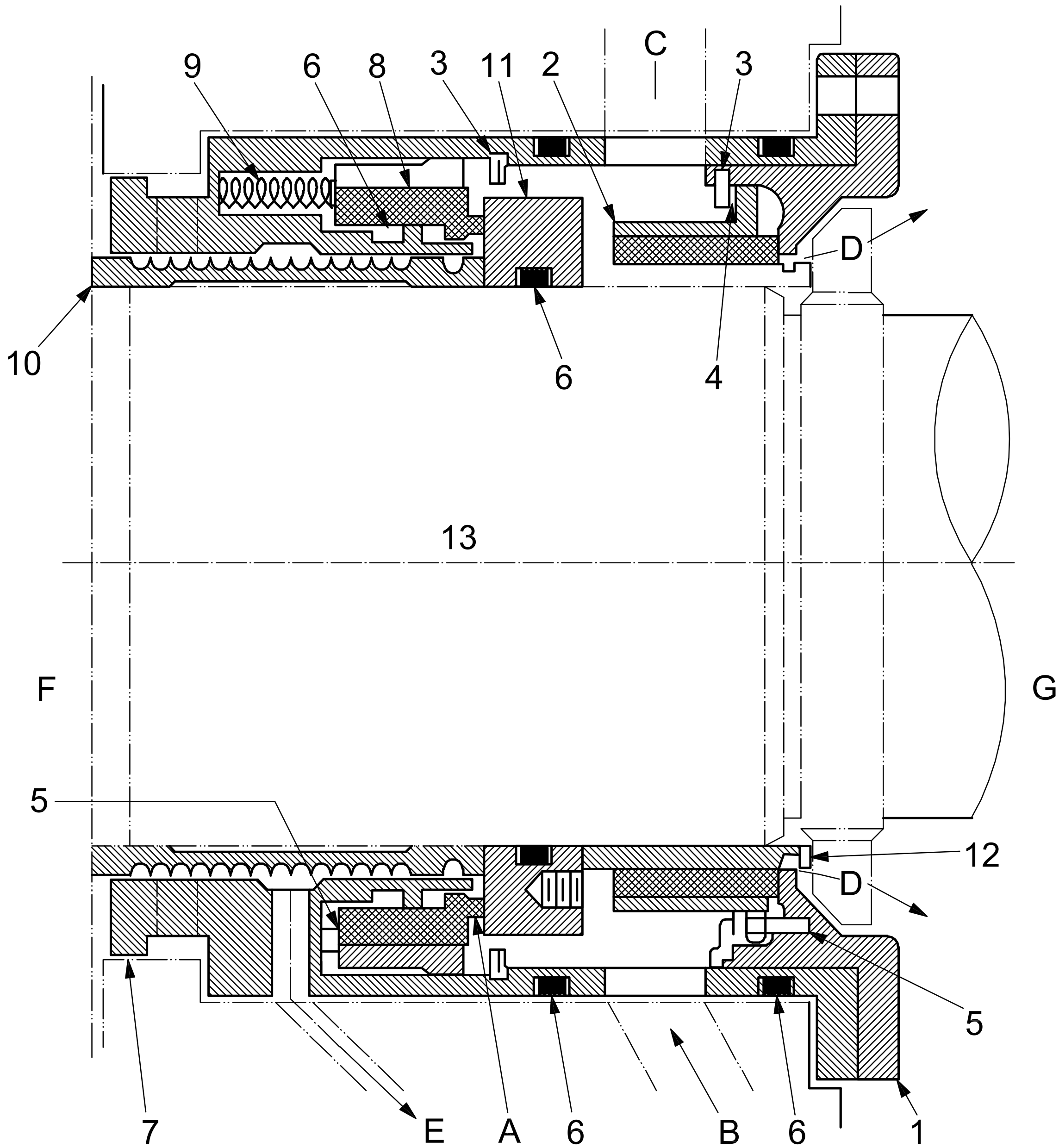
1 windback labyrinth
2 seal cage
3 spacer ring
4 spacer washer
5 seal assembly
6 washer spring
7 capscrew
8 spacer ring
9 compressor rotor centreline

Figure 5 — Restrictive-ring-type seal (purged)

5.6.3.3 Mechanical-(contact-)type seal

5.6.3.3.1 Single mechanical-(contact-)type seals (a typical seal is shown in Figure 6) shall be provided with labyrinths and slingers or restrictive rings to minimize oil leakage to the atmosphere or into the compressor. Oil or other suitable liquid furnished under pressure to the rotating faces may be supplied from the lube-oil system or from an independent system in accordance with 5.10.

5.6.3.3.2 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	1	bushing retainer	8	stationary seal ring
B	seal oil inlet	2	bushing seal ring	9	compression spring
C	seal oil return	3	snap ring	10	sleeve
D	seal oil return	4	wave washer spring	11	rotating face
E	leakage oil drain	5	rotation lock pin	12	runner
F	gas side	6	o-ring	13	compressor rotor centreline
G	atmosphere side	7	seal housing		

Figure 6 — Oil-cooled mechanical-(contact-)seal assembly

5.6.3.4 Self-acting dry-gas seal

● **5.6.3.4.1** Seal arrangement shall be single, double or tandem as specified.

5.6.3.4.2 A typical tandem arrangement is shown in Figure 2 and double arrangement with separation seal in Figure 3.

NOTE 1 Other variations are commonly used, depending on the particular application.

NOTE 2 There is the possibility of the seal being unidirectional in rotation.

NOTE 3 The seal leaks a small amount of seal gas.

5.6.4 Shaft seals for oil-flooded screw compressors

5.6.4.1 Mechanical-(contact-)type seals (a typical seal is shown in Figure 6) shall be provided with 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 5.10.

● **5.6.4.2** If specified that gas leakage to atmosphere is not permissible, oil-flooded screws require dual seal designs with an independent seal-fluid system. For refrigeration services, consideration shall also be given to introduction of inert gases into the system.

5.6.4.3 The arrangement of self-acting dry-gas seals shall be single, tandem or double.

5.7 Dynamics

5.7.1 General

5.7.1.1 In the design of rotor-bearing systems, consideration shall be given to all potential sources of periodic forcing phenomena (excitation) that shall include, but are 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;

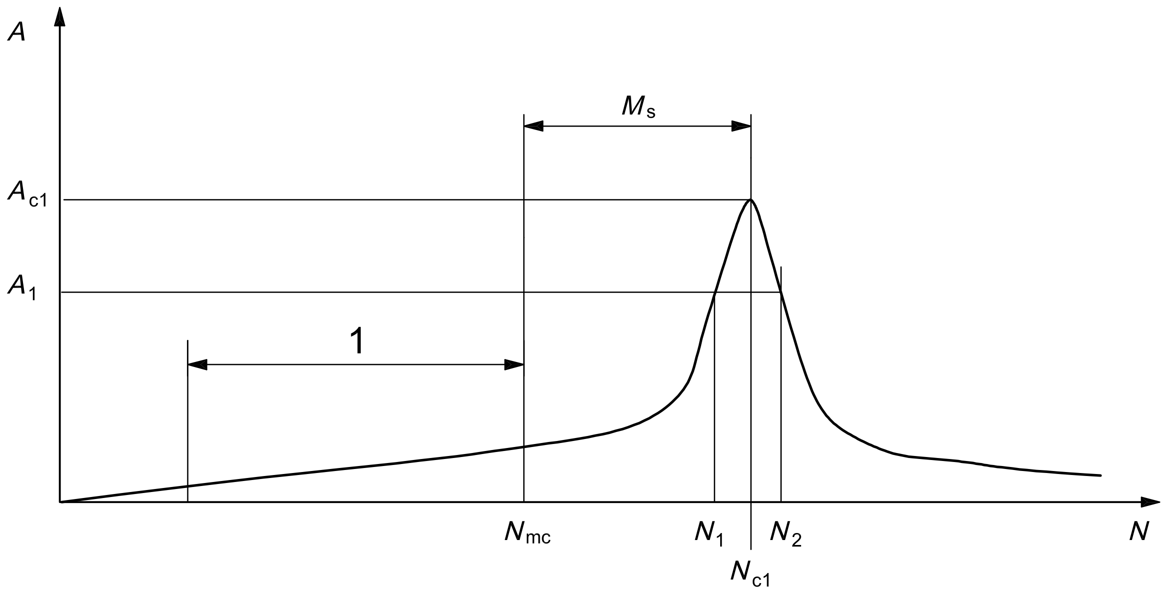
j) ball and race frequencies of rolling element bearings;

k) electrical line frequency.

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.

5.7.1.2 If the rotor-amplification factor (see Figure 7) 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 ISO 10440, 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, centre 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 7 — Rotor-response plot

5.7.1.3 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 specified separation margin (see 5.7.1.4). The effective stiffness 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.

5.7.1.4 Rotors shall be of a stiff-shaft construction with the first actual lateral critical speed at least 120 % of the maximum allowable speed. Unless otherwise specified, a lateral critical analysis is not required.

NOTE In most cases based on historical data, the vendor is able to demonstrate that the machine has a stiff-shaft design.

5.7.2 Torsional analysis

● **5.7.2.1** For motor-driven units and units including gears, units comprising three or more coupled machines (excluding any gears) or when 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 5.7.2.2 through 5.7.2.5.

5.7.2.2 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) cyclic process impulses;

c) torsional transients such as start-up of synchronous electric motors and generator phase-to-phase or phase-to-ground faults;

d) torsional excitation resulting from electric motors, reciprocating engines and rotary-type positive-displacement machines;

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

f) one- and two-times line frequency;

g) running speed or speeds of all rotating elements;

h) pocket passing frequency;

i) harmonic frequencies from variable frequency drives.

5.7.2.3 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).

5.7.2.4 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 affect. 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. Identification of these frequencies shall be the mutual responsibility of the purchaser and the vendor.

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.

5.7.2.5 If torsional resonances are calculated to fall within the margin specified in 5.7.2.3 (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. The assumptions made in this analysis regarding the magnitude of excitation and the degree of damping shall be clearly stated. The acceptance criteria for this analysis shall be mutually agreed upon by the purchaser and the vendor.

5.7.2.6 In addition to the torsional analysis required in 5.7.2.2 to 5.7.2.5, the vendor shall perform a transient torsional vibration analysis for synchronous driven units and/or variable speed motors. The acceptance criteria for this analysis shall be mutually agreed upon by the purchaser and the vendor.

5.7.3 Vibration and balance

5.7.3.1 Major parts of the rotating element, such as the shaft and timing gears, shall be individually dynamically balanced to ISO 1940-1:2003, grade G2,5 or less. 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 8821. Keyways 180° apart, but not in the same transverse plane, shall also be filled. The initial balance correction to the bare shaft shall be recorded. The components to be mounted on the shaft shall also be balanced in accordance with the "half-key convention" as described in ISO 8821.

NOTE For the purposes of this provision, ANSI S2.19 is equivalent to ISO 1940-1.

5.7.3.2 The rotors and timing gears shall be match-marked or keyed. This assembly shall be check-balanced (including keys). There shall be no exposed keys or unfilled keyways. The maximum unbalance shall be in accordance with ISO 1940-1:2003, grade G2,5.

NOTE For the purposes of this provision, ANSI S2.19 is equivalent to ISO 1940-1.

● **5.7.3.3** If specified, balance grade ISO 1940-1:2003, grade G1 shall be provided, or the maximum allowable residual unbalance, U_{max}, expressed in gram·millimetres (ounce·inches), for each plane (journal) shall be calculated as given in Equations (1) and (2):

In SI units $$U_{max} = 6\,350\ W/N \quad (1)$$

In USC units $$U_{max} = 4\ W/N \quad (2)$$

where

W is the component mass (for components), expressed in kilograms (pounds); or load per balancing machine journal (for rotors), expressed in kilograms (pounds);

N is the maximum continuous speed, expressed in revolutions per minute.

NOTE 1 For the purposes of this provision, ANSI S2.19 is equivalent to ISO 1940-1.

NOTE 2 For this equipment, the gas forces and variations in gas forces are orders of magnitude higher than the forces resulting from unbalance.

5.7.3.4 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.

● **5.7.3.5** If specified, a residual unbalance check shall be performed in accordance with Annex D.

5.7.3.6 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 or, if specified for dry screw compressors, the shaft vibrations shall be measured in accordance with API 670. Unless otherwise specified, the limits in Table 4 shall apply to dry screw compressors and the limits in Table 5 shall apply to oil-flooded screw compressors.

5.7.3.7 If shaft vibration probes are supplied, electrical and mechanical runout shall be determined and recorded by rolling the rotor in the V-blocks at the journal centreline while measuring runout with a non-contacting vibration probe and a dial indicator at the centreline of the probe location and one probe-tip diameter to either side.

5.7.3.8 Accurate records of electrical and mechanical runout for the full 360° at each probe location shall be included in the mechanical test report.

5.7.3.9 If the vendor can demonstrate that electrical or mechanical runout is present, a maximum of 25 % of the test level calculated from Table 4 or 6,5 µm (0,25 mil), whichever is greater, may be vectorially subtracted from the vibration signal measured during the factory test.

Table 4 — 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 $\left(\sqrt{(16\,000/n)}\text{ mils}\right)$ — 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).

Table 5 — 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 %

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.

5.8 Bearings

5.8.1 General

5.8.1.1 Bearings shall be one of the following arrangements: rolling element radial and thrust, hydrodynamic radial and rolling element thrust or hydrodynamic radial and thrust. 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. Unless otherwise specified, the bearing type and arrangement shall be selected in accordance with the limitations in Tables 6 and 7.

Table 6 — Bearing selection

Condition	Bearing type and arrangement
Radial and thrust bearing speed and life within limits for rolling element bearings and Machine energy density below limit	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 and Machine energy density below limit	Hydrodynamic radial and rolling element thrust or Hydrodynamic radial and thrust
Radial and thrust bearing speed or life outside limits for rolling element bearings or Machine energy density above limit	Hydrodynamic radial and thrust

Table 7 — Bearing limits

Limiting Factor	Conditions
Rolling element bearing speed	Factor [a] $N \cdot d_m$ shall not exceed the following values for pressurized oil-lubricated bearings[b]: 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 — 300 000 tapered roller bearings — 250 000
Rolling element bearing life	Basic rating, L_{10}, in accordance with ISO 281[c] 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. In oil-flooded screw compressors, aggressive and/or contaminated process gases can significantly shorten the actual bearing life.
Energy density	When the product of machine-rated power, expressed in kW (hp), and rated speed, expressed in rev/min, is $4{,}0 \times 10^6$ kW/min ($5{,}4 \times 10^6$ hp/min) or greater, hydrodynamic radial and thrust bearings are required.

[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 flooded screw compressors with special directed (jet) lubrication arrangement, the acceptable $N \cdot d_m$ factor for radial and thrust ball bearings may be increased according to the bearing manufacturer's recommendation.

[c] For the purpose of this provision, ABMA Standard 9 is equivalent to ISO 281.

5.8.1.2 Thrust bearings shall be sized for continuous operation through the full operating range including the most adverse specified operating conditions. 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 5.8.1.3 and 5.8.1.4;

e) highest transient load.

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

5.8.1.4 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).

● **5.8.1.5** If specified, for dry screw compressors, hydrodynamic thrust and radial bearings shall be fitted with bearing-metal temperature sensors installed in accordance with API 670. See Figures B.5 and B.6.

NOTE For flooded screw compressors, bearing-temperature measurement is often not practical.

5.8.2 Rolling element bearings

5.8.2.1 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 ABMA Standard 7.

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

5.8.2.2 Single-row, deep-groove ball bearings shall have greater than normal internal clearance according to ISO 5753:1991, group 3 or ABMA Symbol 3, as defined in ABMA Standard 20.

5.8.2.3 Rolling element bearings shall be selected in accordance with the following.

a) A rolling element thrust bearing may be a single-row, deep-groove ball bearing provided the combined axial thrust and radial load is within the capability of such a bearing and the requirements of 5.8.1 are satisfied.

b) If the loads exceed the capability of a single-row, deep-groove bearing, a matched pair of single-row, angular-contact-type bearings shall be used.

c) Unless otherwise specified, 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 7.

d) Rolling element thrust bearings shall be secured to the shaft with a nut and an appropriate locking method.

e) Four-point contact (split race) ball bearings shall not be used for radial loads. Bearings with filling slots shall not be used.

5.8.3 Hydrodynamic bearings

5.8.3.1 Hydrodynamic radial bearings shall be in accordance with 5.8.3.1.1 to 5.8.3.1.3.

5.8.3.1.1 Hydrodynamic radial bearings shall be precision-bored and of the sleeve or pad type, with steel-backed, babbitted, replaceable liners, pads or shells. The bearings shall be equipped with anti-rotation pins and shall be positively secured in the axial direction.

5.8.3.1.2 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 Tables 4 and 5) while the unit is operating loaded or unloaded at specified operating speeds including operation at any resonant condition.

5.8.3.1.3 Bearings shall be designed to prevent incorrect positioning.

5.8.3.2 Hydrodynamic thrust bearings shall be in accordance with 5.8.3.2.1 to 5.8.3.2.4.

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

5.8.3.2.2 Unless otherwise specified, replaceable thrust collars shall be furnished and shall be positively locked to the shaft to prevent fretting.

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

5.8.3.2.4 Hydrodynamic thrust bearings shall be selected at no more than 50 % of the bearing manufacturer's ultimate load rating. The ultimate load rating is the load that produces the minimum acceptable oil-film thickness without inducing failure during continuous service or the load that does not exceed the creep-initiation or yield strength of the babbitt at the location of maximum temperature on the pad, whichever load is less. 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) deflection of the bearing pad;

d) minimum oil-film thickness;

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

f) design configuration of the bearing;

g) babbitt alloy;

h) turbulence of the oil film.

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

5.9 Bearing housings

5.9.1 Bearing housings for pressure-lubricated hydrodynamic bearings shall be arranged to minimize foaming. The drain system shall be adequate to maintain the oil foam level below shaft end seals. 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.

5.9.2 Oil connections on bearing housings shall be in accordance with 5.3.

5.9.3 The rise in oil temperature through the bearing and housings shall not exceed 30 K (50 °F) under the most adverse specified operating conditions. The bearing outlet oil temperature shall not exceed 80 °C (180 °F). If the inlet oil temperature exceeds 50 °C (120 °F), special consideration shall be given to bearing design, oil flow and allowable temperature rise. In this case, outlet oil temperature may exceed 80 °C (180 °F).

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.

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

5.9.5 Compressors shall have bearing-housing-shaft seals and deflectors where the shaft passes through the housing; lip-type seals shall not be used. The seals and deflectors shall be made of non-sparking materials. The design of the seals shall effectively retain oil in the housing and prevent entry of foreign material into the housing.

● **5.9.6** If specified, for dry screw compressors, provision shall be made for mounting two radial-vibration probes on each bearing, one axial position probe on each rotor and a one-event-per-revolution probe; see Figures B.3 and B.4. The probe installation shall be as specified in API 670.

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

● **5.9.7** 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.

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

5.10 Lube-oil and seal-oil systems

5.10.1 General

5.10.1.1 Unless otherwise specified, 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 (including any gear);

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.

● **5.10.1.2** Relief valves whose sole purpose is to protect blocked-in equipment (e.g. coolers or filters) from thermal expansion shall be supplied if specified by the purchaser. The purchaser shall mark THERM outside the relief-valve symbol on the schematic if the relief valve is for protection from thermal expansion only.

5.10.2 Dry screw compressors

5.10.2.1 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. Compatibility of lube-oil requirements shall be mutually agreed among the user and all vendors supplying equipment served by the common system. In some cases, there can be significant differences in individual component needs.

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.

5.10.2.2 Unless otherwise specified, bearings and bearing housings shall be arranged for oil lubrication using a mineral oil in accordance with ISO 3448.

5.10.2.3 Unless otherwise specified, pressurized oil systems for dry screw compressors shall conform to the requirements of ISO 10438-1 and ISO 10438-2.

NOTE For the purposes of this provision, API 614-99, Chapters 1 and 2, are equivalent to ISO 10438-1 and ISO 10438-2, respectively.

● **5.10.2.4** If specified, an oil reservoir integral to the base frame shall be provided in accordance with the requirements of ISO 10438-3.

NOTE For the purposes of this provision, API 614-99, Chapter 3, is equivalent to ISO 10438-3.

● **5.10.2.5** If specified, a full-capacity, shaft-driven oil pump shall be provided in accordance with the requirements of ISO 10438 (all parts).

NOTE 1 This pump is typically driven by the low-speed shaft of the gear box.

NOTE 2 For the purposes of this provision, API 614 is equivalent to ISO 10438 (all parts).

5.10.3 Flooded screw compressors

5.10.3.1 General

5.10.3.1.1 Flooded screw compressors shall utilize a pressurized reservoir and separation vessels.

Oil systems for flooded screw compressors are designed with consideration of the following features.

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).

Typical systems are described in Annex E.

5.10.3.1.2 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.

5.10.3.1.3 If any optional lube-oil components are required, this shall be specified by the purchaser.

NOTE Refer to Annex E for examples of typical lube-oil systems and their arrangements.

5.10.3.1.4 The discharge temperature in any specified operating condition shall be maintained at least 10 K (18 °F) higher than the dew point of the process-gas components and water vapour.

5.10.3.1.5 The gas pipe between the compressor discharge nozzle and the first oil separator shall be sized to withstand pulsation, high-volume mixed-phase flow and vibration loads.

5.10.3.1.6 Lube- and seal-oil-system components listed below shall conform to the requirements of ISO 10438-1 and ISO 10438-2:

a) transfer valves;

b) gauges;

c) heaters.

For piping and tubing, see 6.5.1 and 6.5.2.

NOTE For the purposes of this provision, API 614-99, Chapters 1 and 2, are equivalent to ISO 10438-1 and ISO 10438-2, respectively.

5.10.3.2 Oil filters

Oil filters shall conform to the requirements of ISO 10438-2 and to the following.

a) Oil filters for bearing-, seal- and control-oil supply shall provide a minimum particle removal efficiency of 99,5 % for 10 µm particles (b > 200).

b) Particle removal by oil filters for rotor-supply (injection) oil shall be agreed by the supplier and the purchaser.

NOTE For the purposes of this provision, API 614-99, Chapter 2, is equivalent to ISO 10438-2.

5.10.3.3 Coolers

● **5.10.3.3.1** A single oil cooler shall be provided in accordance with ISO 10438-1 and ISO 10438-3. The cooler shall be liquid-cooled shell-and-tube or plate type, or air-cooled type, as specified. Internal oil coolers are not acceptable.

NOTE For the purposes of this provision, API 614-99, Chapters 1 and 3, are equivalent to ISO 10438-1 and ISO 10438-3, respectively.

The vendor shall include in the proposal complete details of any proposed shell-and-tube-type, plate-type or air-cooled-type cooler.

● **5.10.3.3.2** If specified, dual coolers shall be provided. Each cooler shall be sized for the full heat load.

5.10.3.3.3 Unless otherwise specified, the cooler shall be sized to handle the full heat load of any specified operating condition and the unloaded condition.

5.10.3.4 Pumps

5.10.3.4.1 Unless otherwise specified, dual pumps shall be furnished in accordance with ISO 10438-3. At least one pump shall be motor-driven.

NOTE For the purposes of this provision, API 614-99, Chapter 3, is equivalent to ISO 10438-3.

● **5.10.3.4.2** If specified or agreed, a single pump may be furnished.

NOTE On some systems, the pump is required for start-up only.

5.10.3.4.3 A strainer shall be provided upstream of the pump(s).

5.10.3.5 Oil separators

5.10.3.5.1 For flooded screw compressors, an oil-separation vessel or vessels shall be supplied as specified in 5.10.3.5.2 to 5.10.3.5.5.

● **5.10.3.5.2** 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.

● **5.10.3.5.3** Separators shall be designed in accordance with the specified pressure design code.

5.10.3.5.4 Unless otherwise specified, separators shall be constructed of carbon steel with a 3 mm (1/8 in) corrosion allowance.

Austenitic stainless steel should be specified for corrosive services or applications where the vessel interior is frequently exposed to the atmosphere.

● **5.10.3.5.5** Separators shall be equipped with the following characteristics and appendages:

a) capacity to avoid frequent filling and to provide adequate allowance for system rundown. A minimum 2-min retention time shall be provided. 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 E.4;

NOTE Oil retention time is required for sufficient degassing to maintain the required oil characteristics.

b) internal coalescing filtration and impingement baffles, as necessary to achieve the specified allowable oil-carryover concentration;

c) unless otherwise specified, a flanged, safety relief valve in accordance with 6.4.4.6;

d) flanged opening [152,4 mm (6,0 in) minimum] for servicing and cleaning of the separator internals;

e) separate flanged vent, filter drain (if applicable), oil-return, oil-fill and drain connections;

f) flanged, armoured level gauge;

g) baffle by the gas inlet opening to help direct gas upward and oil downward;

h) stilling tubes on oil-fill and return connections to direct oil to a level below the minimum operating level;

i) vortex breaker upstream of the oil-outlet connection;

j) if specified, separate, flanged connections for level switch, pressure differential indicator, pressure indicator, oil-conditioner inlet, oil-conditioner outlet and electric heater;

k) if specified, separate austenitic stainless steel thermowell connections for a temperature gauge and/or switch(es);

l) if specified, electric heater with temperature control.

5.11 Materials

5.11.1 General

5.11.1.1 The manufacturer shall select the materials of construction to be suitable for the specified operating and site environmental conditions (see 5.11.1.7) and shall comply with the requirements of this part of ISO 10440 and the purchaser.

See 6.5 for requirements for auxiliary piping materials. The material(s) selected by the manufacturer should be reviewed and agreed to by the purchaser.

5.11.1.2 The materials of construction of all major components shall be clearly stated in the vendor's proposal. Materials shall be identified by reference to applicable international standards, including the material grade; see Table F.1. If no such designation is available, the vendor’s material specification, giving physical properties, chemical composition and test requirements, shall be included in the proposal.

If International Standards are not available, internationally recognized national or other standards may be used.

- **5.11.1.3** 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.

5.11.1.4 The vendor shall specify the optional tests and inspection procedures that can be necessary to ensure that materials are satisfactory for service (see 5.11.1.2). Such tests and inspections shall be listed in the proposal.

The purchaser may specify additional optional tests and inspections, especially for materials used for critical components or in critical services.

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

5.11.1.6 Minor parts, such as nuts, springs, washers, gaskets and keys, shall have corrosion resistance at least equal to that of specified parts in the same environment.

- **5.11.1.7** The purchaser shall specify any corrosive agents (including trace quantities) present in the motive and process fluids and in the site environment, including constituents that may cause stress-corrosion cracking.

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

5.11.1.8 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.

5.11.1.9 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.

5.11.1.10 If the purchaser has specified the presence of hydrogen sulfide in any fluid, materials exposed to that fluid shall be selected in accordance with the requirements of NACE MR0103. Ferrous materials not covered by NACE MR0103 shall be limited to a yield strength not exceeding 620 N/mm^2 (90 000 psi) and a hardness not exceeding Rockwell C 22 (240 HRB). Components that are fabricated by welding shall be post-weld heat treated, if required, so that both the welds and the heat-affected zones meet the yield strength and hardness requirements.

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

In many applications, small amounts of wet H_2S are sufficient to require materials resistant to sulfide stress-corrosion cracking. If trace quantities of wet H_2S are known to be present or if there is any uncertainty about the amount of wet H_2S that can be present, the purchaser should automatically note on the datasheets that materials resistant to sulfide stress-corrosion cracking are required.

5.11.1.11 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.

5.11.1.12 Where applicable, materials and casting factors 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 5.11.5.

5.11.1.13 Low-carbon steels can be notch-sensitive and susceptible to brittle fracture at ambient or low temperatures. Steel made to a coarse austenitic grain-size practice (such as ASTM A 515) shall not be used. Only fully killed or normalized steels made to fine-grain practice shall be used.

5.11.1.14 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 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.

5.11.1.15 The minimum quality bolting material for pressure joints shall be carbon steel (e.g. ASTM A307-04, grade B) for cast iron casings and high-temperature alloy steel (e.g. ASTM A193/A193M-06, grade B7) for steel casings. Carbon steel nuts (e.g. ASTM A194/A194M-06, 2H) shall be used. Where space is limited, case-hardened carbon steel nuts (e.g. ASTM A563-04, grade A) shall be used. For temperatures below – 30 °C (– 20 °F), low-temperature bolting material in accordance with ASTM A320/A320M shall be used.

5.11.2 Castings

5.11.2.1 General

5.11.2.1.1 Castings shall be sound and free from porosity, hot tears, shrink holes, blow holes, cracks, scale, blisters and similar injurious defects. Surfaces of castings shall be cleaned by sandblasting, shotblasting, chemical cleaning or any other standard method. Mould-parting fins and remains of gates and risers shall be chipped, filed or ground flush.

5.11.2.1.2 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 is permitted) and of a composition compatible with the casting.

5.11.2.1.3 All repairs that are not covered by ASTM or other internationally recognized material specifications shall be subject to the purchaser's approval.

5.11.2.1.4 There shall be no fully enclosed, cored voids that can become fully enclosed due to plugging, welding or assembly.

5.11.2.2 Repairs to pressure-containing ferrous castings

5.11.2.2.1 Pressure-containing ferrous castings shall not be repaired except as permitted by 5.11.2.2.2, 5.11.2.2.3 and 5.11.2.2.4.

5.11.2.2.2 Weldable grades of steel castings shall be repaired by welding, using a qualified welding procedure based on the requirements of the specified pressure design code. 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.

5.11.2.2.3 Cast grey iron may be repaired by plugging within the limits specified in ASTM A278. The holes drilled for plugs shall be carefully examined using liquid penetrant to ensure that all defective material has been removed.

5.11.2.2.4 Ductile iron may be repaired by plugging within the limits specified in ASTM A395 or ASTM A536. The holes drilled for plugs shall be carefully examined using liquid penetrant to ensure that all defective material has been removed.

5.11.2.3 Ductile iron castings

5.11.2.3.1 Ductile iron castings shall be produced in accordance with an internationally recognized standard such as ASTM A395 or ASTM A536.

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

5.11.2.3.2 The keel or Y-block cast at the end of the pour shall be at least as thick as the thickest section of the main casting. This test block shall be tested for tensile strength and hardness and shall be microscopically examined. Classification of graphite nodules under microscopic examination shall be in accordance with ISO 945 or ASTM A247.

Critical sections are typically heavy sections, section changes, high-stress points such as drilled lubrication points, the rotor bores 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 may be selected in accordance with ASTM A395 or other internationally recognized material specifications. Minimum quality levels should be agreed upon between the purchaser and the vendor.

5.11.2.3.3 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. All three specimens shall have an impact value not less than 11 J (8,1 ft-lb_f) and the mean of the three specimens shall not be less than 14 J (10 ft-lb_f) at room temperature.

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

5.11.2.3.5 Brinell hardness tests shall be made on the actual casting at feasible critical sections, such as section changes, flanges and other accessible locations, such as the casing bore. Sufficient surface material shall be removed before hardness tests are made to eliminate any skin effect. Tests shall also be made at the extremities of the casting at locations that represent the sections poured first and last. These shall be made in addition to the hardness test on keel or Y-blocks in accordance with 5.11.2.3.2.

5.11.3 Forgings

5.11.3.1 Unless otherwise agreed upon by the purchaser and the vendor, the forging material shall be selected from those listed in Annex F.

5.11.3.2 All repairs that are not covered by ASTM or other specified internationally recognized material specifications shall be subject to the purchaser's approval.

5.11.4 Welding

● **5.11.4.1** Table 8 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 8 — 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	ANSI/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)

5.11.4.2 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. Repair welds shall be non-destructively tested by the same method used to detect the original flaw; however, the minimum level of inspection after the repair shall be by the magnetic-particle method in accordance with 7.2.2.4 for magnetic material and by the liquid-penetrant method in accordance with 7.2.2.5 for non-magnetic material. Unless otherwise specified, procedures for major repairs shall be subject to review by the purchaser before any repair is made.

5.11.4.3 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.

5.11.4.4 All accessible areas of welds on built-up rotors shall be inspected by means of magnetic-particle or dye-penetrant examination.

5.11.4.5 Pressure-containing casings made from wrought materials or combinations of wrought and cast materials shall conform to the conditions specified in 5.11.4.6 to 5.11.4.9.

5.11.4.6 Plate edges shall be inspected by magnetic-particle or liquid-penetrant examination as required by 5.11.4.1 and Table 8.

5.11.4.7 Accessible surfaces of welds shall be inspected by magnetic-particle or liquid-penetrant examination after back-chipping or gouging and again after post-weld heat treatment.

5.11.4.8 Pressure-containing welds, including welds of the case to axial- and radial-joint flanges, shall be full-penetration welds.

5.11.4.9 Casings fabricated from materials that, according to the specified pressure design code, require post-weld heat treatment shall be heat-treated regardless of thickness.

5.11.4.10 Connections welded to pressure casings shall be installed as specified in 5.11.4.11 to 5.11.4.15.

● **5.11.4.11** In addition to the requirements in 5.11.4.1, specific welds shall be subjected to 100 % radiography, magnetic-particle inspection, ultrasonic inspection, or liquid-penetrant inspection, if specified.

● **5.11.4.12** 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.

5.11.4.13 All welds shall be heat-treated in accordance with 5.11.4.1 and Table 8.

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

5.11.4.15 Auxiliary piping welded to alloy 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.

5.11.5 Low-temperature service

● **5.11.5.1** The purchaser shall specify the minimum design metal temperature and concurrent pressure used to establish impact test and other material requirements.

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

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

Care should be taken in 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.

The published design-allowable stresses for many materials in internationally recognized standards such as the ASME Code and ANSI standards are based on minimum tensile properties. Some standards do not differentiate between rimmed, semi-killed, fully-killed, hot-rolled and normalized material, nor do they take into account whether materials were produced under fine- or coarse-grain practices. The vendor should exercise caution in the selection of materials intended for service between – 30 °C (– 20 °F) and 40 °C (100 °F).

5.11.5.3 All carbon, low-alloy and high-alloy steel, pressure-containing components, including nozzles, flanges and weldments, shall be impact-tested in accordance with the requirements of the specified pressure design code. For materials and thicknesses not covered by the specified pressure design code, the purchaser should specify requirements.

NOTE Impact testing of a material might not be required depending on the minimum design metal temperature, thermal, mechanical and cyclic loading and the governing thickness. Refer to requirements of the pressure design code (e.g. Section VIII, Division l, Section UG-20F of the ASME Code).

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).

The results of the impact testing shall meet the minimum impact energy requirements of the specified pressure design code.

5.12 Nameplates and rotation arrows

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

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

5.12.3 Nameplates and rotation arrows (if attached) shall be of austenitic stainless steel or of nickel-copper (UNS N04400) alloy. Attachment pins shall be of the same material. Welding is not permitted.

5.12.4 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.

5.13 Quality

Refer to API 683 for guidelines on a quality-assurance programme for the equipment.

6 Accessories

6.1 Drivers

6.1.1 General

6.1.1.1 The driver shall be of the type specified, shall be sized to meet the maximum specified operating conditions, including external gear and coupling losses, and shall be in accordance with applicable specifications, as stated in the inquiry and order. The driver shall operate under the utility and site conditions specified in the inquiry.

6.1.1.2 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.

6.1.1.3 The driver shall be capable of starting under the conditions specified, and the starting method shall be agreed by the purchaser and the vendor. The driver's starting-torque capabilities shall exceed the speed-torque requirements of the driven equipment.

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

6.1.2 Motors

● **6.1.2.1** 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 variable-frequency drive applications.

6.1.2.2 Motor drives shall conform to internationally recognized standards (e.g. API 541 or API 546), as applicable. Motors that are below the power scope of API 541 or API 546 shall be in accordance with IEEE 841. Electric motor drivers shall be rated with a 1,0 service factor. The motor rating shall be at least 110 % of the greatest 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.

6.1.2.3 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.

6.1.3 Steam turbines

● Steam turbine drivers shall conform to ISO 10437 or API 611 as specified by the purchaser. 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. 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 1 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.

NOTE 2 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.

NOTE 3 For the purposes of this provision, ANSI/API 612 is equivalent to ISO 10437.

6.1.4 Gear units

● Gear units shall either conform to ISO 13691 or ANSI/API 613, or conform to API 677, as specified.

6.2 Couplings and guards

6.2.1 Unless otherwise specified, flexible couplings and guards between drivers and driven equipment shall be supplied by the manufacturer of the driven equipment.

6.2.2 Couplings and guards shall conform to ISO 10441 or ANSI/API 671. The make, type, and mounting arrangement of couplings shall be agreed upon by the purchaser and the vendors of the driver and driven equipment.

6.2.3 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.

6.2.4 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.

6.2.5 The purchaser of the coupling shall provide or include a moment simulator, if required for the mechanical running test (see 7.3.3).

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

6.3 Mounting plates

6.3.1 General

● **6.3.1.1** The equipment shall be furnished with soleplates or a baseplate (collectively referred to as mounting plates), as specified.

NOTE Refer to Annex G for typical mounting plate drawings.

6.3.1.2 The upper and lower surfaces of mounting plates 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.

6.3.1.3 If an item of equipment being supported has a mass in excess of 225 kg (500 lb), the mounting plate or plates shall be furnished with horizontal (axial and lateral) jackscrews, the same size or larger than the vertical jackscrews. The lugs holding these jackscrews shall be attached to the mounting plates in such a manner that they do not interfere with the installation of the equipment, jackscrews or shims. Precautions shall be taken to prevent vertical jackscrews in the equipment feet from marring the shimming surfaces. 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. Such arrangements should be proposed for equipment that is too heavy to be lifted or moved horizontally using jackscrews. Jackscrews shall be plated for rust resistance.

6.3.1.4 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 Annex C for allowable piping loads.

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

6.3.1.6 Unless otherwise specified, epoxy grout shall be used for machines mounted on concrete foundations. Grouting preparation and installation shall be in accordance with API RP 686-96, Chapter 5.

6.3.1.7 The anchor bolts shall not be used to fasten equipment to the mounting plates.

6.3.1.8 Mounting plates shall conform to the following.

a) Mounting plates shall not be drilled for equipment to be mounted by others.

b) Mounting plates shall be supplied with leveling screws. Tapered blocks for leveling may be supplied instead of leveling screws if approved by the purchaser.

c) Outside corners of mounting plates 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) Mounting plates shall extend at least 25 mm (1 in) beyond the outer three sides of equipment feet.

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

6.3.1.9 The alignment shims shall be in accordance with API RP 686-96, Chapter 7, and shall straddle the hold-down bolts and vertical jackscrews and be at least 5 mm (0,25 in) larger on all sides than the equipment feet.

6.3.1.10 Unless otherwise specified, anchor bolts shall be furnished by the purchaser.

6.3.1.11 Hold-down bolts used to attach the equipment to the mounting plates and all jackscrews shall be supplied by the vendor.

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

6.3.2 Baseplates

6.3.2.1 If a baseplate is specified, the purchaser shall indicate the major equipment to be mounted on it. 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. 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) might need to be fabricated in multiple sections because of shipping restrictions.

6.3.2.2 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.

● **6.3.2.3** If specified, the baseplate shall be designed to facilitate the use of optical, laser-based or other instruments for accurate leveling in the field. The details of such facilities shall be agreed by the purchaser and vendor. 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. Removable protective covers shall be provided. For column-mounted baseplates (see 6.3.2.4), leveling pads or targets shall be located close to the support points. For non-column-mounted baseplates, a pad or target should be located at each corner. If required for long units, additional pads shall be located at intermediate points.

● **6.3.2.4** 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. The baseplate design shall be mutually agreed upon by the purchaser and the vendor.

6.3.2.5 The baseplate shall be provided with lifting lugs for at least a four-point lift. Lifting the baseplate complete with all equipment mounted shall not permanently distort or otherwise damage the baseplate or the equipment mounted on it.

6.3.2.6 The bottom of the baseplate between structural members shall be open except if an oil reservoir integral with the base plate is supplied. 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. These 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. 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. Vent holes at least 13 mm (0,5 in) in diameter shall be provided at the highest point in each bulkhead section of the baseplate.

6.3.2.7 Unless otherwise specified, non-skid metal decking covering all walk and work areas shall be provided on the top of the baseplate.

6.3.2.8 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.

6.3.2.9 All upper baseplate mounting surfaces shall be

a) machined after the baseplate is fabricated,

b) machined within a flatness of 4,2 µm/100 mm (0,000 5 in/ft) of mounting surface,

c) parallel to each other within 50 µm (0,002 in).

Each group of mounting surfaces required to be in the same horizontal plane for a single machine casing shall be so within 25 µm (0,001 in) to prevent a soft foot.

6.3.3 Soleplates and sub-soleplates

● **6.3.3.1** If soleplates are specified, they shall meet the requirements of 6.3.3.2 and 6.3.3.3 in addition to those of 6.3.1.

6.3.3.2 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.

6.3.3.3 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.

● **6.3.3.4** If specified, sub-soleplates shall be provided by the vendor.

6.3.3.5 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 6.3.1.2).

6.4 Controls and instrumentation

6.4.1 General

● **6.4.1.1** The vendor shall provide sufficient compressor-performance data to enable the purchaser to properly design a control system for start-up and for all specified operating conditions. If requested by the purchaser, the vendor shall review the purchaser’s overall compressor control system for compatibility with vendor-furnished control equipment.

6.4.1.2 Instrumentation and installation shall conform to the purchaser’s specifications, and, unless otherwise specified, instrumentation and installation shall conform to the requirements of ISO 10438.

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

● **6.4.1.3** The purchaser shall specify controls, instruments, and control panel requirements. The typical datasheets in Annex A may be used to specify the requirements.

6.4.1.4 Unless otherwise specified, controls and instrumentation shall be designed for outdoor installation and shall meet the requirements of IP65 as detailed in IEC 60079 (all parts) or NEMA 250, classification 4.

6.4.1.5 Instrumentation and controls shall be designed and manufactured for use in the area classification (class, group and division or zone) specified.

6.4.1.6 All conduit, armoured 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.

6.4.2 Control systems

● **6.4.2.1** The compressor may be controlled on the basis of 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. 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. The purchaser shall specify 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.

6.4.2.2 For a variable-speed drive, the control signal shall act to adjust the set point of the driver's speed-control system. The speed of the machine shall vary linearly and directly with the control signal. Unless otherwise specified, the control and operating speed 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.

● **6.4.2.3** 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.

● **6.4.2.4** 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.

6.4.2.5 The full range of the specified control signal corresponds to the required operating range of the driven equipment. Unless otherwise specified, the maximum control signal shall correspond to the maximum continuous speed or the maximum flow.

6.4.3 Instrument and control panels

● **6.4.3.1** If specified, a panel shall be provided and shall include all panel-mounted instruments for the driven equipment and the driver. Such panels shall be designed and fabricated in accordance with the purchaser's description. The panel is to be freestanding, located on the base of the unit or in another location, as specified. The instruments on the panel shall be clearly visible to the operator from the driver control point. A lamp-test push button shall be provided. The instruments to be mounted on the panel shall be specified.

● **6.4.3.2** Unless otherwise specified, panels shall be made of steel plate at least 3 mm (1/8 in) thick, reinforced, self-supporting and closed on the top and sides. If specified, the backs of panels shall be closed to minimize electrical hazards, to prevent tampering or to allow purging for safety or corrosion protection. All instruments shall be flush-mounted on the front of the panel and all fasteners shall be of corrosion-resistant material.

6.4.3.3 Panels shall be completely assembled, piped and wired, requiring only connection to the purchaser's external piping and wiring circuits. If more than one wiring point is required on a unit for control or instrumentation, the wiring to each switch or instrument shall be provided from a single terminal box with terminal posts. Each box shall be mounted on the unit or its base, if any. All leads and posts on terminal strips, switches and instruments shall be tagged for identification. Wiring inside panels shall be neatly run in conduits or supported on cable trays.

6.4.3.4 Interconnecting piping, tubing or wiring for controls and instrumentation furnished by the vendor shall be disassembled only to the extent necessary for shipment.

6.4.4 Instrumentation

6.4.4.1 General

- For all instrument types, the purchaser shall specify the hardware connection from the measurement point through to the instrument.

6.4.4.2 Tachometers

- If specified, a tachometer shall be provided for variable-speed units. The type, range and indicator provisions shall be as specified. Unless otherwise agreed, 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.

6.4.4.3 Vibration and position detectors

- **6.4.4.3.1** If specified, non-contacting vibration and axial-position transducers shall be supplied, installed, and calibrated in accordance with ANSI/API 670. See Figures B.3 and B.4.

- **6.4.4.3.2** If specified, seismic-vibration transducers shall be supplied, installed and calibrated in accordance with ANSI/API 670.

- **6.4.4.3.3** If specified, vibration, axial position and seismic monitors shall be supplied and calibrated in accordance with ANSI/API 670.

6.4.4.4 Bearing temperature monitor

- If specified, a bearing-temperature monitor shall be supplied and calibrated in accordance with ANSI/API 670. See Figures B.5 and B.6.

NOTE Due to size restrictions, there is the possibility of not being able to incorporate bearing-temperature monitoring on smaller models of compressors. On oil-flooded screw compressors, bearing-temperature monitoring might not be practical.

6.4.4.5 Slide-valve position indicator

If slide valves are supplied, instrumentation shall be provided to indicate the position of the slide valve.

6.4.4.6 Relief valves

6.4.4.6.1 The vendor shall furnish the relief valves for installation on equipment or piping that the vendor is supplying. Other relief valves related to equipment or piping outside the system that the vendor is supplying should be furnished by the purchaser. The vendor's quotation shall list all relief valves and shall clearly state that these valves shall be furnished by the vendor.

6.4.4.6.2 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. The vendor shall determine the size and set pressure of all relief valves within his scope of supply and recommend the size and setting of relief valves supplied by others required to protect the equipment he supplies. Relief-valve sizes and settings shall take into account all possible modes of equipment failure.

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

● **6.4.4.6.4** If specified, thermal relief valves shall be provided for accessories or cooling jackets that can be blocked in by isolation valves.

6.4.4.7 Compressor depressurization valve

● If specified, the vendor shall supply a depressurization valve installed in the piping system.

6.4.4.8 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.

6.4.4.9 Flow indicators

6.4.4.9.1 Flow indicators shall be furnished in each atmospheric oil-drain return line.

6.4.4.9.2 Unless otherwise specified, the flow indicator shall be

a) flanged,

b) of bulls-eye type with glass on both sides,

c) of steel body construction,

d) of diameter not less than one half the inside diameter of the oil pipe,

e) capable of clearly showing the minimum oil flow.

To facilitate viewing of the flow of oil through the line, each flow indicator should be installed with its bulls-eye glass in a vertical plane.

6.4.5 Alarms and shutdowns

6.4.5.1 General

6.4.5.1.1 An alarm/shutdown system shall be provided that shall initiate an alarm if any one of the specified parameters reaches an alarm point and shall initiate shutdown of the equipment if any one of the specified parameters reaches the shutdown point.

● **6.4.5.1.2** The purchaser should specify the alarms and trips required, which may include those listed in Table 9.

Table 9 — Conditions requiring 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

6.4.5.1.3 The vendor shall advise the purchaser of any additional alarms and/or shutdowns considered essential to safeguard the equipment.

● **6.4.5.1.4** The purchaser shall specify the extent to which this alarm/shutdown system is to be supplied by the equipment vendor.

6.4.5.1.5 Unless otherwise specified, the necessary valving and switches or bridging links shall be provided to enable all instruments and other components, except shutdown-sensing devices, to be replaced with the equipment in operation. If isolation valves are specified for shutdown-sensing devices, the vendor shall provide a means of locking the valves in the open position.

6.4.5.2 Alarms

6.4.5.2.1 It is accepted that with some systems, particularly those based on conventional direct-acting instruments, complete compliance with the requirements of 6.4.5.2.2 to 6.4.5.2.9 might not be achievable.

6.4.5.2.2 For every shutdown parameter, an alarm shall be provided with the alarm point set at a lesser deviation from the normal condition than the associated shutdown point.

● **6.4.5.2.3** Any alarm parameter reaching the alarm point shall initiate an audible warning or flashing light or both, as specified. It shall be possible to determine which parameter initiated the alarm.

● **6.4.5.2.4** Any shutdown parameter reaching the shutdown point shall cause the equipment to shut down and shall initiate an audible warning or a flashing light or both, as specified, which shall be distinguishable from those associated with an alarm. It shall be possible to determine which parameter initiated the shutdown.

6.4.5.2.5 If any component of the alarm/shutdown system malfunctions, an alarm shall be initiated and shall be distinguishable from alarms resulting from malfunction of the equipment.

NOTE To accomplish this, redundant sensors can be required.

6.4.5.2.6 If any malfunction of a component of the shutdown system results in the system being unable to recognize a shutdown condition, the equipment shall automatically shut down and an alarm shall be initiated. This alarm shall be distinguishable from shutdowns resulting from malfunction of the equipment (fail-safe system).

● **6.4.5.2.7** If a non-fail-safe system is specified, a failure that results in the system being unable to recognize an alarm condition shall also result in all other alarms and shutdowns remaining functional.

6.4.5.2.8 It shall be possible to test every component of every alarm function while the equipment is in operation. Such testing shall not require the disarming of any shutdown function.

6.4.5.2.9 With the exception of the final shutdown device (circuit breaker, steam trip and throttle valve, fuel valve, etc.), it shall be possible to test every component of every shutdown function while the equipment is in operation. The testing of components associated with a shutdown function shall not require disarming of any other shutdown function nor any alarm function.

NOTE 1 This allows all alarms to be bypassed during testing of switches.

NOTE 2 To accomplish this, redundant sensors can be required.

6.4.5.3 Event recorder

● If specified, the alarm/shutdown system shall incorporate an event recorder to record the order of occurrence of alarms and shutdowns.

NOTE The special-event recorder normally associated with a distributed control system (DCS) might not have a sufficiently fast scanning rate.

6.4.5.4 Annunciator

● **6.4.5.4.1** If specified, the alarm/shutdown system shall incorporate a first-out annunciator facility to indicate which parameter first reached the alarm level and which parameter first reached the shutdown level, in the event that multiple alarms and/or shutdown result from a single initial event. Where this facility is not incorporated as part of an integrated control and monitoring system, a separate annunciator instrument shall be provided.

6.4.5.4.2 If a first-out annunciator feature is specified, whether as a separate instrument or incorporated into an integrated control and monitoring facility, the sequence of operation shall be as follows.

a) The first parameter to reach alarm or shutdown shall cause the flashing of a light and the sounding of an audible device.

b) The alarm or shutdown condition shall be acknowledged by operating an alarm-silencing button common to all alarms and shutdowns.

c) When the alarm or shutdown is acknowledged, the audible device shall be silenced but the light shall remain steadily lit as long as that alarm or shutdown condition exists.

d) If another parameter reaches an alarm or shutdown level, the light shall return to the flashing condition and the audible device shall sound, even if the previous alarm/shutdown condition has been acknowledged but still exists.

6.4.5.4.3 If the first-out annunciator feature is provided by a separate instrument, this shall be mounted on a local panel. There shall be approximately 25 % spare points and separate connections shall be provided for remote indication if any alarm operates or any shutdown operates.

6.4.5.5 Alarm and trip devices

6.4.5.5.1 General

● The purchaser should specify whether individual alarm and trip devices are transmitters or switches.

NOTE A transmitter is an instrument that sends the value of the measured variable signal to a remote end device, which takes appropriate action (e.g. alarm relay, display, process control computer).

6.4.5.5.2 Locally-mounted switch initiation

6.4.5.5.2.1 If alarm or shutdown functions are initiated by locally-mounted switches, each alarm switch and each shutdown switch, except as noted in 6.4.5.5.2.7 and 6.4.5.5.2.8, shall be furnished in a separate housing located to facilitate inspection and maintenance.

6.4.5.5.2.2 Hermetically-sealed, single-pole, double-throw switches with a minimum capacity of 5 A at 120 V AC and 0,5 A at 120 V DC shall be provided. Mercury switches shall not be used.

● **6.4.5.5.2.3** The purchaser shall specify whether switches shall be connected to open (de-energize) or close (energize) to initiate alarms and shutdowns.

6.4.5.5.2.4 Alarm and trip switches shall not be adjustable from outside the housing.

6.4.5.5.2.5 Housings for alarm and shutdown switches shall comply with the requirements of 6.4.6.2.

● **6.4.5.5.2.6** The sensing elements of pressure switches shall be of stainless steel (AISI Standard Type 300 stainless steel). Low-pressure switches, which are actuated by falling pressure, shall be equipped with a pressure gauge, valved bleed or vent connection or, if specified, a double-block and bleed connection, to allow controlled depressurizing during testing. High-pressure switches, which are activated by rising pressure, shall be equipped with a valved test connection so that a portable pump can be used to raise the pressure during testing. The arrangement used should be specified by the purchaser.

● **6.4.5.5.2.7** Temperatures shall be measured by thermocouples or resistance temperature detectors, as specified, and shall be connected to local panel-mounted instruments. Multipoint instruments may be used except that alarms and shutdowns shall be connected to separate instruments and separate alarm or shutdown contacts (switches) shall be provided for each temperature monitored. Each alarm and shutdown level shall be separately adjustable.

6.4.5.5.2.8 Vibration and/or axial position switches shall be provided by instruments complying with the requirements of ANSI/API 670; see 6.4.4.3.

6.4.5.5.2.9 Level switches shall be of the float or displacer type mounted in separate enclosures that can be isolated from the associated vessel. Valved test connections shall be provided to enable the level to be artificially raised or lowered as necessary to test the function of the switch.

6.4.6 Electrical systems

6.4.6.1 Electrical systems shall be in accordance with ISO 10438-1.

NOTE For the purposes of this provision, API 614-99, Chapter 1, is equivalent to ISO 10438-1.

6.4.6.2 To guard against accidental contact, enclosures shall be provided for all terminal strips, relays, switches and other energized parts. Electrical power wiring shall be segregated from instrument and control-signal wiring both externally and, as far as possible, inside enclosures. Inside enclosures, which can be required to be opened with the equipment in operation, (e.g. for alarm testing or adjustment), shall be provided with secondary shields or covers for all terminal strips and other exposed parts carrying electrical potential in excess of 50 V. Maintenance access space shall be provided around or adjacent to electrical equipment or in accordance with the appropriate code, such as NFPA 70:2005, Article 110.

6.5 Piping

6.5.1 General

6.5.1.1 Piping design, joint fabrication, examination and inspection shall be in accordance with the codes and standards specified or, where no codes or standards have been specified, the appropriate recognized codes and standards. Welding of piping shall be performed by operators who are qualified and using procedures qualified in accordance with the specified or internationally recognized standards, e.g. ASME B31.3 and Section IX of the ASME Code.

6.5.1.2 Piping systems shall include piping, tubing where permitted, isolating valves, control valves, relief valves, pressure reducers, orifices, temperature gauges and thermowells, pressure gauges, sight flow indicators and all related vents and drains.

6.5.1.3 The vendor shall furnish all piping systems as specified, including mounted appurtenances located within the confines of the main unit's skid-base area, any oil-console-base area, or any auxiliary skid-base area. The piping shall terminate with flanged connections at the edge of the skid base. If soleplates are specified for the equipment train, the extent of the piping system at the equipment train shall be defined by the purchaser. The purchaser should furnish only interconnecting piping between equipment groupings and off-skid-base facilities.

6.5.1.4 The design of piping systems shall achieve the following:

a) proper support and protection to prevent damage from vibration or from shipment, operation and maintenance;

b) proper flexibility and adequate accessibility for operation, maintenance and thorough cleaning;

c) installation in a neat and orderly arrangement adapted to the contours of the equipment without obstructing access areas;

d) elimination of air pockets by the use of valved vents or the use of non-accumulating piping arrangements;

e) complete drainage through low points without disassembly of piping.

6.5.1.5 Piping shall preferably be fabricated by bending and welding to minimize the use of flanges and fittings. Flanges are permitted only at equipment connections, at the edge of any base and for ease of maintenance. The use of flanges at other points is permitted only with the purchaser's specific approval. Other than tees and reducers, welded fittings are permitted only to facilitate pipe layout in congested areas. Threaded connections shall not be used except (with the purchaser's approval) where essential for space or access reasons. Pipe bushings shall not be used.

6.5.1.6 Pipe plugs shall be in accordance with 5.3.6.

6.5.2 Auxiliary systems piping

Unless otherwise specified, the auxiliary systems piping shall be in accordance with ISO 10438.

NOTE 1 For the purposes of this provision, API 614 is equivalent to ISO 10438.

Unless otherwise specified, oil-supply piping and tubing, including fittings (excluding slip-on flanges), shall be stainless steel. For oil-flooded screw compressors, the material of piping upstream of oil filters shall be agreed by the purchaser and the vendor.

NOTE 2 The material of the oil separator and piping upstream of oil filters in oil-flooded screw-compressor systems is typically carbon steel.

6.5.3 Instrument piping

Unless otherwise specified, the instrument piping shall be in accordance with ISO 10438.

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

6.5.4 Process piping

● **6.5.4.1** The extent of, and requirements for, process piping to be supplied by the vendor shall be specified.

6.5.4.2 The requirements of 6.5.1 shall apply to process piping supplied by the vendor.

● **6.5.4.3** 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.

6.5.4.4 For flooded screw compressors, the 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.

6.6 Intercoolers and aftercoolers

● **6.6.1** If specified, the vendor shall furnish a water-cooled shell-and-tube intercooler between each compression stage.

● **6.6.2** The purchaser shall specify whether aftercoolers shall be furnished by the vendor.

● **6.6.3** Water-cooled shell-and-tube intercoolers and aftercoolers shall be designed and constructed in accordance with TEMA class C or R, as specified by the purchaser on the datasheets. Intercoolers and aftercoolers shall be furnished in accordance with the specified pressure design code. If TEMA class R is specified, the heat exchanger shall be in accordance with ISO 16812.

NOTE For the purposes of this provision, ANSI/API 660 is equivalent to ISO 16812.

CAUTION — Heat exchangers and their supporting structures are susceptible to pulsation-induced vibration.

6.6.4 Unless otherwise approved by the purchaser, intercoolers and aftercoolers shall be constructed and arranged to allow removal of tube bundles without dismantling piping or compressor components. Water shall be on the tube side.

6.6.5 Fixed-tube sheet exchangers shall have inspection openings into their gas passages. Rupture disks on the shell side (to protect the shell in case of tube failures) shall be used only when specifically approved by the purchaser.

6.6.6 If air coolers are specified, they shall be in accordance with ISO 13706.

NOTE For the purposes of this provision, ANSI/API 661 is equivalent to ISO 13706.

6.6.7 Unless otherwise specified, air-cooled heat exchangers used for intercoolers shall have automatic temperature control. This control may be accomplished by means of louvers, variable-speed fans, variable-pitch fans, bypass valves or any combination of these. It is for the purchaser to approve the proposed control systems.

6.6.8 Unless otherwise specified, double-pipe intercoolers and aftercoolers may be furnished. A finned double-pipe design may be furnished only when specifically approved by the purchaser.

● **6.6.9** Intercoolers shall be either machine-mounted or separately mounted, as specified.

● **6.6.10** Materials of construction shall be those specified on the datasheets.

6.6.11 If condensate separation and collection facilities are furnished by the vendor, they shall include the following:

a) automatic drain trap with a manual bypass;

b) armoured gauge glass with isolation valves and blowdown valves on the collection pot;

c) separate connections and level switches for a high-level alarm and trip on the collection pot;

d) collection pots sized to provide an agreed-upon holding capacity and a 5 min time span between the high-level alarm and trip, based on the expected normal liquid-condensation rate.

● **6.6.12** If specified, the vendor shall furnish the fabricated piping between the compressor stages and between the intercoolers and aftercoolers. Interstage piping shall conform to ISO 15649.

NOTE ISO 15649 incorporates ANSI/ASME B31.3 by normative reference.

6.7 Inlet air filters

6.7.1 Unless otherwise specified, the vendor shall furnish dry-type multistage high-efficiency air-intake filters for air compressors taking suction from the atmosphere. High-efficiency filters shall be capable of removing 97 % of particles 1 µm (0,004 in) or larger over the inlet capability range. The maximum clean-filter pressure drop shall not exceed 1,2 kPa (0,012 bar; 5,0 in w.g.).

6.7.2 Air-inlet filters shall be suitable for mounting outdoors, preferably at grade, and shall be provided with a weather hood or louvers. For plant locations subject to unusual conditions, such as sandstorms, the inlet to the filter may be elevated some distance above the compressor.

● **6.7.3** Each filter shall be provided with a differential-pressure-indicating transmitter or a differential-pressure indicator and switch, as specified.

6.7.4 Filters shall be designed such that the first-stage (pre-filter) elements may be changed while the unit is operating.

It should be recognized that many configurations and arrangements are available. If specific filter features are desired, these shall be in the purchaser’s inquiry specifications or datasheets.

6.7.5 Unless otherwise specified, an inorganic zinc or hot-dipped galvanized coating is required for the filter frame and inlet piping.

6.8 Inlet separators

6.8.1 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 Solids 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 and rotors.

NOTE 2 Some contaminants, especially catalytic metal particles like iron, increase the rate of oil oxidation and have the possibility of stripping the oil of its polar additives (i.e. anti-wear and extreme-pressure additives, plus rust and oxidation inhibitors and dispersants).

● **6.8.2** If specified, the vendor shall furnish a high-efficiency inlet separator for installation upstream of the compressor, to remove free liquids and solid particles from the process gas stream.

NOTE 1 Free liquids can excessively dilute the recirculated oil stream, particularly at start-up or upset conditions.

NOTE 2 Free liquids can carry dissolved solids that plate out 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.

6.8.3 If an inlet filter/separator is specified, a differential pressure indicator and alarm switch shall be provided across the filter(s).

It should be recognized that many configurations and arrangements are available. If specific filter features are desired, these should be in the purchaser's inquiry specifications or datasheets.

6.8.4 Unless otherwise specified, AISI 300 series stainless steel or high alloy steel types UNS N04400, N04401, N04404, N05500 or N04405, vane- or mesh-type demister shall be furnished. If furnished, mesh-type demisters shall be supported upstream and downstream of the mesh material.

6.9 Pulsation suppressors/silencers for dry screw compressors

6.9.1 The requirement for, and the scope of, an analysis of pulsation and noise suppression shall be agreed between the purchaser and the vendor.

NOTE 1 When designing the compressor and piping system, consider the entire operating range, including the entire speed range in variable-speed applications, range of temperatures, pressures and variation of the gas conditions as well as intermittent operating conditions with purge gas.

NOTE 2 In screw compressor systems, the flow of gas is not steady, but moves through the piping in a series of flow pulses that are superimposed upon the steady (average) flow. The characteristics of the flow pulses are determined by the size and the operating conditions of the compressor (displacement, speed, rotors, pressures, etc.). The mechanical and acoustical response from the piping system is a function of the amplitude and frequencies of the pulses, the thermo-physical properties of the gas and the piping system's characteristics (layout, supports, natural frequencies, etc.).

NOTE 3 Screw compressors generate pulses that often are three-dimensional. Moreover, high frequencies combined with large-diameter vessels or piping make circumferential modes more important to consider.

6.9.2 Unless otherwise specified, 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 without exceeding the pressure-drop limit specified in 6.9.3.

6.9.3 Unless otherwise agreed, the pressure drop through the pulsation suppressors/silencers shall not exceed the following values:

a) for suction silencers: 1 % of the absolute pressure at the pulsation suppressor/silencer inlet;

b) for discharge silencers: 2,5 % of the absolute pressure at the pulsation suppressor/silencer discharge.

The pressure drop shall be stated in the datasheets and shall be accounted for in the calculation of the power required.

In the case of low-pressure and vacuum applications, the pressure drop may exceed the 1 % limit to achieve the necessary pulse attenuation.

NOTE For machines with widely varying operating conditions (e.g. speed, relative molecular mass of the gas), the above-mentioned limits might not be achievable in all cases.

6.9.4 The peak-to-peak pulsation levels, p_{pp}, expressed as a percentage of the mean line-side absolute pressure, on the process piping side of the inlet and discharge silencers shall not exceed 2 % of the mean line absolute pressure or the value calculated from Equation (3), expressed in SI units, and Equation (4), expressed in USC units, whichever is the smaller:

$$p_{\text{pp}} = 28{,}6 / P_{\text{AM}}{}^{1/3} \tag{3}$$

$$p_{\text{pp}} = 15 / P_{\text{AM}}{}^{1/3} \tag{4}$$

where P_{AM} is the absolute mean line-side pressure, expressed in kilopascals (pounds per square inch).

6.9.5 Pulsation suppressors/silencers shall be oriented with respect to the compressor flanges as mutually agreed by the purchaser and vendor.

NOTE Maximum silencer efficiency results from mounting the pulsation suppressors/silencers directly on the compressor flanges.

6.9.6 Pulsation suppressors and silencers should be of the externally lagged type. Alternative types may be considered, but full details of the proposed alternative type shall be submitted with the proposal.

6.9.7 Unless otherwise agreed, 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.

● **6.9.8** If specified, the pulsation suppressor/silencer vendor shall supply detailed drawings to permit an independent study of the acoustical characteristics of the pulsation suppressor/silencers together with the purchaser's piping system.

● **6.9.9** The minimum corrosion allowance for carbon steel shells shall be 3 mm (1/8 in). 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. 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. 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. Internals shall have a minimum thickness of 6 mm (0,25 in).

● **6.9.10** 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. 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.

6.9.11 All welds shall be continuous full penetration.

6.9.12 A DN 20 (NPS 3/4) pressure-test connection shall be provided at each pulsation suppressor/silencer inlet and outlet nozzle. 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. 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. 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.

6.9.13 Unless otherwise specified, 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.

6.9.14 Connections DN 40 (NPS 1-$^1/_2$) and smaller shall be gusseted in two planes to avoid breakage due to pulsation-induced vibration.

6.9.15 Unless otherwise specified by the purchaser, all main connections to pulsation suppressors/silencers shall be flanged.

● **6.9.16** 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.

6.9.17 Side-entering main nozzle connections shall be reinforced with pad-type metal providing a metal area equal to the cutaway area (excluding the thickness of any metal present in the connection wall).

● **6.9.18** Construction shall be suitable for service in an outdoor location. If specified, insulation mounting clips on pulsation suppressors/silencers shall be provided. All connections and nameplates shall be unobstructed by the insulation.

6.10 Special tools

6.10.1 If special tools or fixtures are required to disassemble, assemble or maintain the equipment, they shall be included in the quotation and furnished as part of the initial supply of the equipment. For multiple-unit installations, the requirements for quantities of special tools and fixtures shall be agreed between purchaser and vendor. These or similar special tools shall be used and their use demonstrated during shop assembly and post-test disassembly of the equipment.

6.10.2 If special tools are provided, they shall be packaged in a separate, rugged metal box or boxes and shall be marked “special tools for (tag/item number)”. Each tool shall be stamped or tagged to indicate its intended use.

7 Inspection, testing and preparation for shipment

7.1 General

● **7.1.1** The purchaser should specify the extent of participation in the inspection and testing.

● **7.1.2** If specified, the purchaser’s representative, the vendor’s representative, or both, shall indicate compliance in accordance with an inspector’s checklist (such as that provided in Annex H) by initialling, dating and submitting the completed checklist to the purchaser before shipment.

7.1.3 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.

7.1.4 The vendor shall notify sub-vendors of the purchaser’s inspection and testing requirements.

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

7.1.6 The purchaser should specify the amount of advance notification required for a witnessed or observed inspection or test.

7.2 Inspection

7.2.1 General

7.2.1.1 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) if specified, final assembly maintenance and running clearances;

g) other data specified by the purchaser or required by applicable codes and regulations; see 4.4 and 8.3.1.1.

7.2.1.2 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.

● **7.2.1.3** In addition to the requirements of 5.11.4.1, 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.

7.2.2 Material inspection

7.2.2.1 General

7.2.2.1.1 When radiographic, ultrasonic, magnetic-particle or liquid-penetrant inspection of welds or materials is required or specified, the criteria in 7.2.2.2 to 7.2.2.5 shall apply unless other corresponding procedures and acceptance criteria have been specified. Cast iron may be inspected only in accordance with 7.2.2.4 and/or 7.2.2.5. Welds, cast steel and wrought material shall be inspected in accordance with 7.2.2.2 to 7.2.2.5.2.

NOTE Radiographic and ultrasonic inspection are not appropriate for cast iron.

7.2.2.1.2 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 7.2.2, if necessary.

7.2.2.1.3 Defects that exceed the limits imposed in the other subclauses of 7.2.2 shall be removed to meet the quality standards cited, as determined by the inspection method specified.

7.2.2.2 Radiography

7.2.2.2.1 Radiography shall be in accordance with ASTM E94.

7.2.2.2.2 The acceptance standard used for welded fabrications shall be the pressure design code [e.g. Section VIII, Division 1, UW-51 (for 100 % radiography) and UW-52 (for spot radiography) of the ASME Code]. The acceptance standard used for castings shall be the pressure design code (e.g. Section VIII, Division 1, Appendix 7, of the ASME Code).

7.2.2.3 Ultrasonic inspection

7.2.2.3.1 Ultrasonic inspection shall be in accordance with Section V, Articles 5 and 23, of the ASME Code.

7.2.2.3.2 The acceptance standard used for welded fabrications shall be the pressure design code (e.g. Section VIII, Division 1, Appendix 12, of the ASME Code). The acceptance standard used for castings shall be the pressure design code (e.g. Section VIII, Division 1, Appendix 7, of the ASME Code).

7.2.2.4 Magnetic-particle inspection

Both wet and dry methods of magnetic-particle inspection shall be in accordance with ASTM E709, according to the types given 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

7.2.2.5 Liquid-penetrant inspection

7.2.2.5.1 Liquid-penetrant inspection shall be in accordance with Section V, Article 6, of the ASME Code.

7.2.2.5.2 The acceptance standard used for welded fabrications shall be the pressure design code (e.g. Section VIII, Division 1, Appendix 8, of the ASME Code) and Section V, Article 24, of the ASME Code. The acceptance standard used for castings shall be the pressure design code (e.g. Section VIII, Division 1, Appendix 7, of the ASME Code).

7.2.3 Mechanical inspection

7.2.3.1 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.

7.2.3.2 All oil-system components furnished shall meet the cleanliness requirements of ISO 10438.

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

● **7.2.3.3** 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.

● **7.2.3.4** 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.

7.3 Testing

7.3.1 General

7.3.1.1 Equipment shall be tested in accordance with 7.3.2 and 7.3.3. Other tests that may be specified by the purchaser are described in 7.3.4.

7.3.1.2 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.

7.3.1.3 The vendor shall notify the purchaser not less than five working days before the date the equipment is ready for testing. If the testing is rescheduled, the vendor shall notify the purchaser not less than five working days before the new test date.

7.3.2 Hydrostatic tests

7.3.2.1 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). The test liquid shall be at a higher temperature than the nil-ductility transition temperature of the material being tested.

NOTE 1 The nil-ductility temperature is the highest temperature at which a material experiences complete brittle fracture without appreciable plastic deformation.

NOTE 2 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.

7.3.2.2 If the part tested is to operate at a temperature at which the strength of a material is below the strength of that material at 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 maximum allowable temperature. The stress values used shall conform to those given in ANSI/ASME B31.3 for piping or in the specified pressure design code for vessels. 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.

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).

7.3.2.3 The chloride content of liquids used to test austenitic stainless steel materials shall not exceed 50 mg/kg (50 parts per million by mass). 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 Chloride content is limited in order to prevent stress corrosion cracking.

7.3.2.4 Tests shall be maintained for a sufficient period of time to permit complete examination of parts under pressure. The hydrostatic test shall be considered satisfactory when neither leaks nor seepage through the pressure-containing parts or joints are observed for a minimum of 30 min. Large, heavy, pressure-containing parts or complex systems can require a longer testing period as agreed upon by the purchaser and the vendor.

Gaskets used during hydrotest of an assembled casing shall be of the same design as supplied with the casing.

7.3.3 Mechanical running test

7.3.3.1 Requirements prior to the mechanical running test

7.3.3.1.1 The contract shaft seals and bearings shall be used in the machine for the mechanical running test.

7.3.3.1.2 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. For pressure-lubrication systems, oil flow rates for each bearing housing shall be measured.

7.3.3.1.3 Test-stand oil filtration shall be 10 µm (b > 200) (see 5.10.3.2). Oil-system components downstream of the filters shall meet the cleanliness requirements of ISO 10438 before any test is started.

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

7.3.3.1.4 Bearings intended to be lubricated by an oil-mist system shall be pre-lubricated.

7.3.3.1.5 All joints and connections shall be checked for tightness and any leaks shall be corrected.

7.3.3.1.6 All warning, protective and control devices used during the test shall be checked and adjusted as required.

7.3.3.1.7 Testing with the contract coupling or couplings is preferred.

7.3.3.1.8 The vibration characteristics determined by the use of the instrumentation specified in 7.3.3.1.9 to 7.3.3.1.11 shall serve as the basis for acceptance or rejection of the machine (see 5.7.3.6).

7.3.3.1.9 Shop test facilities shall include the capability of seismic monitoring of casing vibration.

Seismic-vibration data should be recorded in horizontal and vertical directions, at radial planes transverse to each bearing centreline and also in the axial direction, using shop instrumentation during the test.

NOTE Compressor-equipment configuration can limit measuring device location.

7.3.3.1.10 All purchased vibration proximity probes, cables, oscillator-demodulators and seismic probes shall be in use during the test. If vibration probes are not furnished by the equipment vendor, or if the purchased probes are not compatible with shop readout facilities, then shop devices and readouts that meet the accuracy requirements of ANSI/API 670 shall be used.

7.3.3.1.11 If vibration proximity probes are specified and supplied, shop test facilities shall include instrumentation with the capability of continuously monitoring and plotting revolutions per minute, peak-to-peak displacement and phase angle (x-y-y′). Presentation of vibration displacement and phase marker shall also be by oscilloscope.

7.3.3.2 Speed requirements for the mechanical running test

7.3.3.2.1 The mechanical running test shall be run at maximum continuous speed for a minimum of 4 h.

7.3.3.2.2 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.

7.3.3.2.3 The speed for variable-speed equipment shall be increased to trip speed (see Table 2) and the equipment shall be run for a minimum of 15 min.

7.3.3.2.4 The speed for variable-speed equipment shall be reduced to the maximum continuous speed and the equipment shall be run continuously for 4 h.

7.3.3.3 Requirements during the mechanical running test

7.3.3.3.1 During the mechanical running test, the mechanical operation of all equipment being tested and the operation of the test instrumentation shall be satisfactory. The measured vibration shall not exceed the limits specified in Table 4 or Table 5, as applicable, and shall be recorded throughout the operating speed range.

7.3.3.3.2 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 (1 500 Hz). 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 Table 4 or Table 5, 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 the major part of the total vibration level as limited in 5.7.3.6.

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.

- **7.3.3.3.3** If specified, all real-time vibration data as agreed by the purchaser and vendor shall be recorded and a copy provided to the purchaser.

- **7.3.3.3.4** If specified, lube-oil and seal-oil inlet pressures and temperatures shall be varied through the range permitted in the operating manual. This shall be done during the 4 h test.

7.3.3.4 Requirements after the mechanical running test is completed

7.3.3.4.1 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.

7.3.3.4.2 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 ISO 10440.

7.3.3.4.3 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 7.3.3.4.4 and 7.3.3.4.5.

7.3.3.4.4 The casing (including end seals) shall be pressurized with an inert gas to the maximum sealing pressure or the maximum seal design pressure (as agreed by the purchaser and the vendor), 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.

Test-gas relative molecular mass should approximate contract-gas relative molecular mass. Helium for low relative-molecular-mass contract gas and nitrogen or R22 refrigerant gas for high relative molecular mass should be considered.

7.3.3.4.5 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 7.3.3.4.4 and 7.3.3.4.5 can necessitate two separate tests.

7.3.3.5 Heat run

7.3.3.5.1 For dry screw compressors, a heat run shall be performed prior to the 4 h mechanical test run. 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[12)]] for a minimum of 30 min.

NOTE 1 Heat-run temperature relates to the actual operating temperature at specified conditions, not relief-valve settings or maximum allowable operating temperature. Excessive internal clearances required for higher-temperature operation result in decreased volumetric efficiency under normal operating conditions.

NOTE 2 On machines with water-flush seals and high leakage rate, there is the possibility of not achieving the heat-run temperature.

A high-discharge-temperature shutdown point should be set below the heat-run temperature.

7.3.3.5.2 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.

12) Rankin is a deprecated unit.

7.3.4 Optional tests

7.3.4.1 General

If specified, the shop tests described in 7.3.4.2 to 7.3.4.13 shall be performed. Test details shall be mutually agreed upon by the purchaser and the vendor.

7.3.4.2 Performance test

● The machine shall be tested in accordance with ISO 1217. See 5.1.15 a).

Vibration levels shall be measured and recorded during this test as specified in 7.3.3.1.9 to 7.3.3.1.11.

7.3.4.3 Complete-unit test

● Such components as compressors, gears, drivers and auxiliaries that make up a complete unit shall be tested together during the mechanical running test. If specified, torsional vibration measurements shall be made to verify the vendor's analysis. For a torsional test, it is necessary to include all main rotating components. The complete-unit test may be performed in place of, or in addition to, separate tests of individual components specified.

7.3.4.4 Deceleration test

● If proximity probes are specified, synchronous vibration amplitude and phase angle versus speed for deceleration during coastdown shall be plotted before and after the 4 h run. Both the filtered (one per revolution) and the unfiltered vibration levels shall also be plotted. If specified, these data shall also be furnished in polar form. The speed range covered by these plots shall be from 400 r/min to the specified driver trip speed.

7.3.4.5 Tandem test

● Machines arranged for tandem drive shall be tested as a unit during the mechanical running test, using the shop driver and oil systems.

7.3.4.6 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.

7.3.4.7 Helium test

● Pressure-containing parts, such as compressor casings and cylinders, shall be tested for gas leakage with helium at the maximum allowable working pressure. The test shall be conducted with the casing submerged in water. The water shall be at a higher temperature than the nil-ductility transition temperature for the material from which the part is made. The maximum allowable working pressure shall be maintained for a minimum of 30 min, with no bubbles permitted. As an alternative, a non-submerged soap-bubble test or other approved method to check for gas leakage may be performed if approved by the purchaser. See ASTM E1003 for more information.

A helium test should be specified if the molar mass of the gas handled is less than 12, or if the gas contains more than 0,1 mol % hydrogen sulfide.

7.3.4.8 Sound-level test

● The sound-level test shall be performed in accordance with ISO 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.

7.3.4.9 Auxiliary-equipment test

- 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.

7.3.4.10 Post-test inspection

- If specified, the compressor, the gear and the driver shall be dismantled, inspected and reassembled after satisfactory completion of the mechanical running test. The purchaser should specify whether the gas test required by 7.3.3.4.3 shall be performed before or after the post-test inspection.

7.3.4.11 Full-pressure/full-load/full-speed test

- The objectives and details of the full-pressure/full-load/full-speed test shall be developed jointly by the purchaser and the vendor. This test may be substituted for the mechanical running test.

7.3.4.12 Inspection of hub/shaft fit for hydraulically mounted couplings

- 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.

7.3.4.13 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 7.3.3.4.2.

7.3.5 Test data

Immediately upon completion of each witnessed mechanical, performance and optional test, copies of the data logged shall be given to the witness.

The purchaser and the vendor shall mutually agree that the test data have met the acceptance criteria shown in the test specification.

7.3.6 Test report

- If specified, the vendor shall provide test reports within the timetable identified on the VDDR (see example form in Annex I).

7.4 Preparation for shipment

7.4.1 Equipment shall be prepared for the type of shipment specified, including blocking of the rotor when necessary. Blocked rotors shall be identified by means of corrosion-resistant tags attached with stainless steel wire. 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. If storage for a longer period is contemplated, the purchaser should consult with the vendor regarding the recommended procedures to be followed.

7.4.2 The vendor shall provide the purchaser with the instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site and before start-up, as described in API RP 686-96, Chapter 3.

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

a) 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 1 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.

● g) If specified, flanged openings shall be provided with metal closures at least 5 mm (3/16 in) thick with elastomer gaskets and at least four full-diameter bolts. For studded openings, all nuts needed for the intended service shall be used to secure closures. Each opening shall be car-sealed so that the protective cover cannot be removed without the seal being broken.

h) 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 2 These are shipping plugs; permanent plugs are covered in 5.3.11.

i) 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.

j) 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.

k) The equipment shall be identified with item and serial numbers. Material shipped separately shall be identified with securely affixed, corrosion-resistant metal tags indicating the item and serial number of the equipment for which it is intended. Crated equipment shall be shipped with duplicate packing lists, one inside and one on the outside of the shipping container.

l) A spare rotor set, when purchased, shall be prepared for unheated indoor storage for a period of at least three years. It shall be treated with a rust preventive and shall be housed in a vapour-barrier envelope with a slow-release, volatile corrosion inhibitor. The rotor shall be crated for domestic or export shipment as specified. 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. The probe-target area barriers shall be marked with the words "Probe area – do not cut". If specified, the rotor shall be prepared for vertical storage. 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. Instructions on the use of the fixture shall be included in the installation, operation and maintenance manuals.

NOTE 3 TFE and PTFE are not recommended as cradle support liners since they cold flow and impregnate into the surface.

m) 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.

n) 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.

7.4.4 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.

7.4.5 Bearing assemblies shall be fully protected from the entry of moisture and dirt. 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. Where applicable, bags shall be installed in wire cages attached to flanged covers and bag locations shall be indicated by corrosion-resistant tags attached with stainless steel wire.

7.4.6 One copy of the manufacturer’s installation instructions shall be packed and shipped with the equipment.

7.4.7 Connections on auxiliary piping, removed for shipment, shall be match-marked for ease of reassembly.

● **7.4.8** If specified, the fit-up and assembly of machine-mounted piping, intercoolers, etc. shall be completed in the vendor’s shop prior to shipment.

● **7.4.9** If specified, the vendor shall provide lifting tools suitable for lifting the equipment or equipment package.

Lifting tools may include spreader bars, shackles and slings.

8 Vendor’s data

8.1 General

8.1.1 The information to be furnished by the vendor is specified in 8.2 and 8.3.

8.1.2 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.

● **8.1.3** A coordination meeting shall be held, preferably at the vendor’s plant, 4 to 6 weeks after order commitment. Unless otherwise specified, 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.

8.2 Proposals

8.2.1 General

The vendor shall forward the original proposal, with the specified number of copies, to the addressee specified in the inquiry documents. The proposal shall include, as a minimum, the data specified in 8.2.2 to 8.2.4, and a specific statement that the equipment and all its components and auxiliaries are in strict accordance with this part of ISO 10440. 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. 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 8.1.2.

8.2.2 Drawings

8.2.2.1 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.]

8.2.2.2 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.

8.2.3 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 (5.1.19);

c) vendor drawing and data requirements form (see Annex I) 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;

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 5.11.1.4;

k) description of any special requirements, whether specified in the purchaser's inquiry or required by this part of ISO 10440;

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.

8.2.4 Curves

The vendor shall provide complete performance curves to encompass the map of operations, with any limitations indicated thereon. For constant-speed equipment, refer to the operating point on the data sheet.

8.2.5 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.

8.3 Contract data

8.3.1 General

8.3.1.1 Contract data shall be furnished by the vendor in accordance with the agreed VDDR form; see example in Annex I.

8.3.1.2 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.

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

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

8.3.2 Drawings and technical data

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. 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.

8.3.3 Progress reports

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

NOTE Refer to I.2 oo) for content of these reports.

8.3.4 Parts lists and recommended spares

8.3.4.1 The vendor shall submit complete parts lists for all equipment and accessories supplied. These lists shall include part names, manufacturers' unique part numbers, materials of construction (identified by applicable International Standards). Each part shall be completely identified and shown on appropriate cross-sectional, assembly-type cutaway or exploded-view isometric drawings. 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. Standard purchased items shall be identified by the original manufacturer's name and part number.

8.3.4.2 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. These should include spare parts recommendations of sub-suppliers that were not available for inclusion in the vendor's original proposal.

8.3.5 Installation, operation, maintenance and technical-data manuals

8.3.5.1 General

The vendor shall provide sufficient written instructions and all necessary drawings to enable the purchaser to install, operate, and maintain all of the equipment covered by the purchase order. This information shall be compiled in a manual or manuals with a cover sheet showing the information listed in 8.1.2, an index sheet and a complete list of the enclosed drawings by title and drawing number. The manual or manuals shall be prepared specifically for the equipment covered by the purchase order. "Typical" manuals are unacceptable.

8.3.5.2 Installation manual

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. 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. 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 I.2 ll).

8.3.5.3 Operating and maintenance manual

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. 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 I.2 mm).

8.3.5.4 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 I.2 ss).

Annex A
(informative)

Typical datasheets

ROTARY-TYPE POSITIVE-DISPLACEMENT COMPRESSOR DATASHEET SI UNITS

JOB NO. ____ ITEM NO. ____
PURCHASE ORDER NO. ____ DATE ____
REQUISITION NO. ____
INQUIRY NO. ____
PAGE 1 OF 9 BY ____

○ DRAWING UNITS: ○ SI ○ USC ○ 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 Nm³/h (1,013 bar and 0 °C) (DRY) (3.40)						
14	○ MASS FLOW, kg/hr- (WET)(DRY)						
15	**INLET CONDITIONS:** ○ COMPRESSOR INLET FLANGE ○ CUSTOMER CONNECTION						
16	○ PRESSURE - kPa [absolute (bar)]						
17	○ TEMPERATURE (°C)						
18	○ RELATIVE HUMIDITY (%)						
19	○ RELATIVE MOLECULAR MASS (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 (m³/h) (3.16)						
23	**DISCHARGE CONDITIONS:** ○ COMPRESSOR DISCHARGE FLANGE ○ CUSTOMER CONNECTION						
24	○ PRESSURE - kPa [absolute (bar)]						
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 (mg/kg)[1]						
30	☐ kW REQUIRED (ALL LOSSES INCL.)						
31	☐ SPEED (rev/min)						
32	☐ PRESSURE RATIO (R)						
33	☐ VOLUMETRIC EFFICIENCY (%)						
34	☐ SILENCER ΔP kPa [(bar)] (6.9.3)						
35	○ SETTLE-OUT PRESSURE - kPa [absolute (bar)] (5.1.5)						
36	☐ PERFORMANCE CURVE NO.						
37	[1] Equivalent to the deprecated ppm.						

38 **PROCESS CONTROL:** (6.4.2.1)
39 METHOD: ○ SLIDE VALVE ____
40 ○ BYPASS FROM ____ TO ____
41 ○ BYPASS: ○ MANUAL ○ AUTO
42 ○ SPEED VARIATION FROM ____ TO ____
43 ○ OTHER ____
44 SIGNAL: ○ SOURCE ____
45 ○ TYPE ____
46 ○ RANGE: 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
53

ROTARY-TYPE POSITIVE-DISPLACEMENT COMPRESSOR DATASHEET SI UNITS

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GAS ANALYSIS (5.1.15 d) ○ 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							(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 ______ kPa (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 ______

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 ______
ACOUSTIC HOUSING (5.1.20) ○ YES ○ NO
SOUND LEVEL ______ dB @ ______ m ______
dB RE: 20 MICRO PASCAL

APPLICABLE SPECIFICATIONS:

○ ACOUSTIC ______
○ MOTOR ______

PAINTING:

○ MANUFACTURER'S STD.
○ OTHER ______

SHIPMENT: (7.4.1)

○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQ'D
○ LONG TERM STORAGE FOR ______ MONTHS

REMARKS: ______

ROTARY-TYPE POSITIVE-DISPLACEMENT COMPRESSOR DATASHEET SI UNITS

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☐ **SPEEDS:**	☐ **SHAFT:** (5.5.1.2)
MAX. CONT. (3.22) ______ rev/min TRIP (3.55) ______ rev/min	MATERIAL ______
MAX. TIP SPEEDS: ______ m/s @ MAX. OPER. SPEED	DIA @ ROTORS (mm) ______ DIA @ COUPLING (mm) ______
MIN. ALLOW (3.25) ______ rev/min	SHAFT END ☐ TAPERED ☐ CYLINDRICAL (5.5.1.5 and 5.5.1.6)
☐ **LATERAL CRITICAL SPEEDS:** (5.7.1.4)	**SHAFT SLEEVES:**
FIRST CRITICAL ______ rev/min	○ AT SHAFT SEALS ______ ☐ MATL. ______
DAMPED ______ UNDAMPED ______	☐ **TIMING GEARS:** (5.5.2)
MODE SHAPE ______	PITCH LINE DIAMETER (mm) MALE: ______ FEMALE: ______
LATERAL CRITICAL SPEED - BASIS:	MATERIAL ______ TYPE ______
○ DAMPED UNBALANCE RESPONSE ANALYSIS	☐ **SHAFT SEALS:** (5.6)
☐ OTHER TYPE ANALYSIS: ______ (SPECIFY)	○ SEAL SYSTEM TYPE (5.6.1.7) ______
☐ **POCKET-PASSING FREQUENCY:** ______ Hz	☐ OIL LEAKAGE (CC/MIN/SEAL) ______
☐ **TORSIONAL CRITICAL SPEEDS:** (5.7.2)	○ TYPE BUFFER GAS (5.6.2.1) ______
FIRST CRITICAL ______ rev/min	☐ BUFFER GAS FLOW (PER SEAL)
SECOND CRITICAL ______ rev/min	NORMAL: ______ kg/hr. @ ______ kPa (bar)
☐ **VIBRATION:** (5.7.3.6) ______	MAX.: ______ kg/hr. @ ______ kPa (bar)
HOUSING ______ mm/s RMS	☐ **BEARING HOUSING:** (5.9)
SHAFT ______	TYPE (SEPARATE, INTEGRAL) ______ SPLIT ______
☐ **ROTATION, LOOKING AT COMPRESSOR DRIVEN END:** ☐ CW ☐ CCW	MATERIAL ______
☐ **CASING:**	☐ **HYDRODYNAMIC RADIAL BEARING:** (IDENTIFY HIGHEST LOADED BEARING 5.8.3.1)
MODEL ______	TYPE ______ SPAN (mm) ______
CASING SPLIT ______	AREA (mm^2) ______ LOADING (N/mm^2): ACT. ______ ALLOW. ______
MATERIAL ______ ○ CLADDING (5.2.10)	NO. PADS ______ ROTOR ON ______ OR BETWEEN ______ PADS
OPERATION: ○ DRY ○ FLOODED, w/ ______ LIQUID	PAD MATERIAL ______
THICKNESS (mm) ______ CORR. ALLOW (mm) ______	TYPE BABBITT ______ THICKNESS ______ (mm)
MAX. ALLOWABLE WORK PRESS. (3.21) ______ kPa (bar)	○ TEMP SENSORS (5.8.1.5) ______
RELIEF-VALVE SETTING ______ kPa (bar)	○ TC ○ RTD TYPE ______
MARGIN FOR ACCUMULATION ___ ___ ___ kPa (bar)	NO. PER BRG ______
LEAK-TEST GAS: ______ PRESS kPa (bar): ______ (7.3.3.4.3)	☐ **ROLLING ELEMENT RADIAL BEARING** (5.8.2)
TEST PRESS. kPa (bar) HE (7.3.4.7) ______ HYDRO (7.3.2) ______	TYPE: ______, Ndm: ______
MAX. ALLOW. TEMP. ______ °C MIN. OPER. TEMP. ______ °C	______
COOLING JACKET ☐ YES ☐ NO	______
☐ **ROTORS:** (5.5.1)	ENERGY DENSITY (kW-rev/min): ______
DIAMETER (mm): MALE: ______ FEMALE: ______	☐ **HYDRODYNAMIC THRUST BEARING:** (IDENTIFY HIGHEST LOADED BEARING) (5.8.3.2)
NO. LOBES: MALE: ______ FEMALE: ______	TYPE ______
TYPE: ______	MFR. ______ AREA (mm^2) ______
TYPE FABRICATION ______	LOADING (N/mm^2): ______ ACT. ______ ALLOW. ______
MATERIAL ______	NUMBER OF PADS ______
MAX. YIELD STRENGTH (N/mm^2) ______	PAD MATERIAL ______
BRINELL HARDNESS MAX. ______ MIN. ___ ___	TYPE BABBITT ______ THICKNESS ______ (mm)
ROTOR LENGTH TO DIAMETER RATIO (L/D) MALE: ___ ___	○ TEMP SENSORS (5.8.1.5) ______
ROTOR CLEARANCE (mm) ______	○ TC ○ RTD TYPE ______
______	NO PER BRG ______ ☐ ACTIVE ☐ INACTIVE
______ ______	☐ **ROLLING ELEMENT THRUST BEARING** (5.8.2)
INTERNALLY COOLED ☐ YES ☐ NO	TYPE: ______, Ndm: ______
	______
	______
	ENERGY DENSITY (kW/min): ______

REMARKS: ______

______

______

ROTARY-TYPE POSITIVE-DISPLACEMENT COMPRESSOR DATASHEET SI UNITS

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☐ **PROCESS CONNECTIONS - COMPRESSOR CASING(5.3):**

	SIZE	RATING	FACING	ORIENTATION
INLET				
DISCHARGE				

☐ **PROCESS CONNECTIONS - CUSTOMER INTERFACE:**

INLET				
DISCHARGE				

☐ **CASING - ALLOWABLE PIPING FORCES AND MOMENTS: (5.4)**

	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:**

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: API 670 ______

○ 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

AXIAL POSITION DETECTOR: (6.4.4.3)

○ IN ACCORDANCE WITH: API 670 ______

○ TYPE ______ ☐ MODEL ______

○ MFR. ______ ☐ NO. REQ'D ______

○ 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 ______

OTHER (SPECIFY) ______

	DRIVER-COMP OR DRIVER	GEAR-COMP
○ MAKE		
☐ MODEL		
○ MOUNT CPLG. HALVES		
○ SPACE REQUIRED		
○ LIMITED END FLOAT REQ'D		
○ MOMENT SIMULATOR REQUIRED (6.2.5)		
☐ CPLG. RATING (kW/100 rev/min)		
☐ KEYED (1) OR (2) OR HYDR. FIT		

BASEPLATE & SOLEPLATES: (6.3.2 & 6.3.3)

SOLEPLATES 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 (5.10.2.3 & 5.10.3, ANNEX D)

○ COMMON (5.10.2.1) ○ DEDICATED SYSTEM

○ OIL FILTER (5.10.3.2)

○ OIL COOLER (5.10.3.3): TYPE ______ NO. ______

○ OIL PUMP (5.10.3.4): TYPE ______ NO. ______

○ OIL SEPARATOR (5.10.3.5)

☐ TYPE ______ ☐ NO. ______

☐ OIL CARRYOVER (mg/kg) ______ (l/DAY) ______

☐ RETENTION TIME (MIN) ______

○ RELIEF VALVE ○ LEVEL GAUGE

☐ LEVEL SWITCH ☐ PRESSURE DIFFERENTIAL INDICATOR

☐ ELECTRIC HEATER

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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 ΔP ______ 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
HP (DRIVER) ______ kW

SHOP INSPECTION AND TESTS (7.1):

	REQ'D	WITNESS	OBSERVE
SHOP INSPECTION (7.1.5)	○	○	○
HYDROSTATIC (7.3.2)	○	○	○
HELIUM LEAK (7.3.4.7)	○	○	○
MECHANICAL RUN (7.3.3)	○	○	○
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 (7.3.4.3)	○	○	○
USE SHOP LUBE & SEAL SYSTEM	○	○	○
USE JOB LUBE & SEAL SYSTEM (7.3.4.9)	○	○	○
USE SHOP VIBRATION PROBES, ETC.	○	○	○
USE JOB VIB. & AXIAL DISP. PROBES	○	○	○
USE JOB SEISMIC TRANSDUCERS	○	○	○
USE JOB MONITORING EQUIPMENT	○	○	○
PRESSURE COMP. TO FULL OPER. PRESSURE	○	○	○
DISASSSEMBLE-REASSEMBLE COMP. AFTER TEST (7.3.4.10)	○	○	○
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)	○	○	○

☐ **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):**

	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 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)

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 (8.2.3 f)
- ○ ROTOR ASSEMBLY
- ○ SEALS ○ GASKETS, O-RINGS
- ○ START-UP/COMMISSIONING
- ○ 2 YEARS' SUPPLY
- ○ OTHER: ______

REMARKS: ______

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VENDOR SHALL 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 ○ YES ○ 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:
○ ZONE ____ GROUP ____ CLASS ____
○ 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 ________
10 ☐ FREE-STANDING ☐ WEATHERPROOF ☐ TOTALLY ENCLOSED ☐ EXTRA CUTOUTS
11 ☐ VIBRATION ISOLATORS ☐ STRIP HEATERS ☐ PURGE CONNECTIONS
12 ☐ ANNUNCIATOR: FURNISHED BY: ☐ VENDOR ☐ PURCHASER ☐ OTHERS ________
13 ANNUNCIATOR LOCATED ON ☐ LOCAL PANEL ☐ MAIN CONTROL BOARD
14 ☐ CUSTOMER CONNECTIONS BROUGHT OUT TO TERMINAL BOXES BY VENDOR

15 **INSTRUMENT SUPPLIERS:**

	Instrument			
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:	MFR. ____	SIZE & TYPE:	____
21	○ DIFF.-PRESSURE SWITCHES:	MFR. ____	SIZE & TYPE:	____
22	○ TEMPERATURE SWITCHES:	MFR. ____	SIZE & TYPE:	____
23	○ LEVEL SWITCHES:	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	○ FLOW INDICATORS: (6.4.4.9)	MFR. ____	SIZE & TYPE:	____
28	○ GAS FLOW INDICATOR:	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	○ ____	MFR. ____	SIZE & TYPE:	____

35 NOTE: ☐ SUPPLIED BY VENDOR ○ SUPPLIED BY PURCHASER

36 **PRESSURE-GAUGE REQUIREMENTS**

	FUNCTION	LOCALLY MOUNTED (3.12)	LOCAL PANEL (3.31)	FUNCTION	LOCALLY MOUNTED (3.12)	LOCAL PANEL (3.31)
38	LUBE-OIL PUMP DISCHARGE ____	☐ ○	☐ ○	GOV. CONTROL OIL ____	☐ ○	☐ ○
39	LUBE-OIL FILTER ΔP ____	☐ ○	☐ ○	GOV. CONTROL OIL ΔP ____	☐ ○	☐ ○
40	LUBE-OIL SUPPLY ____	☐ ○	☐ ○	MAIN STEAM IN ____	☐ ○	☐ ○
41	SEAL-OIL PUMP DISCHARGE ____	☐ ○	☐ ○	1ST STAGE STEAM ____	☐ ○	☐ ○
42	SEAL-OIL FILTER ΔP ____	☐ ○	☐ ○	STEAM CHEST ____	☐ ○	☐ ○
43	SEAL-OIL SUPPLY (EACH LEVEL) ____	☐ ○	☐ ○	EXHAUST STEAM ____	☐ ○	☐ ○
44	SEAL-OIL DIFFERENTIAL ____	☐ ○	☐ ○	EXTRACTION STEAM ____	☐ ○	☐ ○
45	REFERENCE GAS ____	☐ ○	☐ ○	STEAM EJECTOR ____	☐ ○	☐ ○
46	BALANCE LINE ____	☐ ○	☐ ○	COMPRESSOR SUCTION ____	☐ ○	☐ ○
47	SEAL EDUCTOR ____	☐ ○	☐ ○	COMPRESSOR DISCHARGE ____	☐ ○	☐ ○
48	BUFFER SEAL ____	☐ ○	☐ ○	____	☐ ○	☐ ○
49	OIL/GAS COALESCING FILTER ΔP	☐ ○	☐ ○	____	☐ ○	☐ ○

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VENDOR SHALL 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)	LOCAL PANEL (3.31)	FUNCTION	LOCALLY MOUNTED (3.12)	LOCAL PANEL (3.31)
4	LUBE-OIL DISCHARGE FROM EA. ______	☐ ○	☐ ○	COOLER-OIL INLET & OUTLET ______	☐ ○	☐ ○
5	COMPR. JOURNAL BEARING ______	☐ ○	☐ ○	SEAL-OIL OUTLET ______	☐ ○	☐ ○
6	DRIVER JOURNAL BEARING ______	☐ ○	☐ ○	COMPRESSOR SUCTION ______	☐ ○	☐ ○
7	GEAR JOURNAL BEARING ______	☐ ○	☐ ○	COMPRESSOR DISCHARGE ______	☐ ○	☐ ○
8	COMPRESSOR THRUST BEARING ______	☐ ○	☐ ○	LUBE-OIL RESERVOIR ______	☐ ○	☐ ○
9	DRIVER THRUST BEARING ______	☐ ○	☐ ○	LUBE-OIL SUPPLY ______	☐ ○	☐ ○
10	GEAR THRUST BEARING ______	☐ ○	☐ ○	______	☐ ○	☐ ○

11 **MISCELLANEOUS INSTRUMENTATION:**
12 ☐ ○ DRIVER START/STOP ☐ LOCAL PANEL ☐ SEPARATE PANEL ☐ 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 AND/OR SEAL-OIL RESERVOIR, S.O. DRAIN TRAPS & S.O. OVERHEAD TANK
16 ☐ ○ VIBRATION AND SHAFT-POSITION PROBES & PROXIMITORS
17 ☐ ○ VIBRATION AND SHAFT-POSITION READOUT EQUIPMENT
18 ☐ ○ VIBRATION READOUT LOCATED ON: ☐ LOCAL PANEL ☐ SEPARATE PANEL ☐ 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

24 **ALARM & SHUTDOWN: (6.4.5.2)**

	FUNCTION	ALARM	TRIP	FUNCTION	PRE-ALARM	TRIP
26	☐ ○ LOW LUBE-OIL PRESSURE	______	______	☐ ○ TURBINE VIBRATION	______	______
27	☐ ○ HI LUBE-OIL FILTER ΔP	______	______	☐ ○ TURBINE AXIAL POSITION	______	______
28	☐ ○ HI SEAL-OIL FILTER ΔP	______	______	☐ ○ GEAR VIBRATION	______	______
29	☐ ○ LOW LUBE-OIL RESERVOIR LEV.	______	______	☐ ○ GEAR AXIAL POSITION	______	______
30	☐ ○ LOW SEAL-OIL RESERVOIR LEV.	______	______	☐ ○ COMPRESSOR MOTOR SHUTDOWN	______	______
31	☐ ○ HI SEAL-OIL LEVEL	______	______	☐ ○ TRIP & THROTTLE VALVE SHUT	______	______
32	☐ ○ LOW SEAL-OIL LEVEL	______	______	☐ ○ HI TURB. STEAM SEAL LEAKAGE	______	______
33	☐ ○ HI SEAL-OIL PRESSURE	______	______	☐ ○ HI COMPR. THRUST BRG. TEMP.	______	______
34	☐ ○ LOW SEAL-OIL PRESSURE	______	______	☐ ○ HI COMPR. JOURNAL BRG. TEMP.	______	______
35	☐ ○ AUX. SEAL-OIL PUMP START	______	______	☐ ○ HI DRIVER THRUST BRG. TEMP.	______	______
36	☐ ○ AUX. LUBE-OIL PUMP START	______	______	☐ ○ HI DRIVER JOURNAL BRG. TEMP.	______	______
37	☐ ○ HI SEAL-OIL OUTLET TEMP. (COOLER)	______	______	☐ ○ HI GEAR THRUST BRG. TEMP.	______	______
38	☐ ○ HI LIQUID-LEV. SUCT. SEPARATOR	______	______	☐ ○ HI GEAR JOURNAL BRG. TEMP.	______	______
39	☐ ○ COMPRESSOR HI DISCH. TEMP.	______	______	☐ ○ COMPRESSOR ΔP	______	______
	☐ ○ COMPRESSOR VIBRATION	______	______	☐ ○ LOW SEAL-GAS PRESSURE	______	______
	☐ ○ COMPRESSOR AXIAL POSITION	______	______	☐ ○ HI COALESCING GAS/OIL FILTER ΔP	______	______
40	☐ ○ HI LUBE-OIL SUPPLY TEMPERATURE	______	______	☐ ○ ______	______	______

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 PURCHASER'S ELECTRICAL AND INSTRUMENT CONNECTIONS WITHIN THE CONFINES OF THE BASEPLATE AND CONSOLE SHALL BE:
48 ☐ BROUGHT OUT TO TERMINAL BOXES ☐ MADE DIRECTLY BY THE PURCHASER
49 COMMENTS REGARDING INSTRUMENTATION: ______
50

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APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ○ AS BUILT
FOR ______ UNIT ______
SITE ______ DRIVEN EQUIP. ______
SERVICE ______ NO. REQURED ______
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. ______ (kPa) (bar) TEMP. ___ °C
○ WATER ALLOW. Δ*P* ___ (kPa) (bar) & TEMP. RISE ___ °C
○ WATER-SIDE MIN. CORR. ALLOW. ___ mm
AND FOUL FACTOR ______
○ (AIR) (GAS) SUPPLY PRESS. ______ (kPa) (bar)
○ ______
○ WEATHER PROTECTED, TYPE ______
○ FORCED VENTILATED
○ OPEN - DRIPPROOF
○ OPEN
○ EExe. ○ EExpe
○ EExd(e) ○ Ex_nxp / ExN

BASIC DATA:
○ ___ VOLTS ___ PHASE ___ HERTZ
☐ NAMEPLATE kW ___ SERVICE FACTOR (6.1.2.1 g) ___
○ SYNCHRONOUS rev/min
○ 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_h/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**

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1	**ACCESSORY EQUIPMENT (CONT'D)**	**MANUFACTURER'S DATA (CONT'D.)**
2	○ LIGHTNING ARRESTERS	BEARING: TYPE ______ LUBR. ______
3	○ C.T. FOR AMPMETER	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 AMPMETER (MOUNTED BY ______)	(AIR) (GAS) REQD. ______ m^3/h PRESS. MAINT. ______ mm H_2O
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 (MILLIMETERS):**
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 (X_d) ______	______ ○ ○
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 RES'TR REQD.	______
51	SUPPLIED BY ______	______

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○ DRAWING UNITS: ○ SI ○ USC ○ DUAL (4.3)

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 (3.28) (5.1.3)	MAXIMUM	OTHER CONDITIONS (5.1.4) A	B	C	D
○ CERTIFIED POINT (✓) (5.1.4)						
○ GAS HANDLED (ALSO SEE PAGE 2)						
○ REQUIRED CAPACITY MMSCFD/SCFM (14.7 PSIA AND 60°F) (DRY) (3.40)						
○ MASS FLOW, lbs/hr – (WET)(DRY)						
INLET CONDITIONS: ○ COMPRESSOR INLET FLANGE ○ CUSTOMER CONNECTION						
○ PRESSURE (PSIA)						
○ TEMPERATURE (°F)						
○ RELATIVE HUMIDITY (%)						
○ RELATIVE MOLECULAR MASS (M)						
☐ Cp/Cv (K_1) OR (K_{AVG}) (5.1.15 d)						
☐ COMPRESSIBILITY (Z_1) OR (Z_{AVG}) (5.1.15.3 d)						
☐ INLET VOLUME FLOW (CFM) (3.16)						
DISCHARGE CONDITIONS: ○ COMPRESSOR DISCHARGE FLANGE ○ CUSTOMER CONNECTION						
○ PRESSURE (PSIA)						
☐ TEMPERATURE (°F)						
☐ Cp/Cv (K_2) OR (K_{AVG})						
☐ COMPRESSIBILITY (Z_2) OR (Z_{AVG})						
☐ DEW POINT (°F)						
○ OIL CARRYOVER (parts per million by mass)						
☐ BHP REQUIRED (ALL LOSSES INCL.)						
☐ SPEED (rev/min)						
☐ PRESSURE RATIO (R)						
☐ VOLUMETRIC EFFICIENCY (%)						
☐ SILENCER ΔP (PSI) (6.9.3)						
○ SETTLE-OUT PRESSURE (PSIA) (5.1.5)						
☐ PERFORMANCE CURVE NO.						

PROCESS CONTROL: (6.4.2.1)

METHOD: ○ SLIDE VALVE ______
○ BYPASS FROM ______ TO ______
○ BYPASS: ○ MANUAL ○ AUTO
○ SPEED VARIATION FROM ______ TO ______
○ OTHER ______

SIGNAL: ○ SOURCE ______
○ TYPE ______
○ RANGE: FOR PNEUMATIC CONTROL ______ rev/min @ ______ PSIG ______ rev/min @ ______ PSIG ______
○ OTHER ______

SERVICE: ○ SPECIAL-PURPOSE (3.51) ○ GENERAL-PURPOSE (3.13)
○ CONTINUOUS ○ INTERMITTENT ○ STANDBY (3.53) ○ DRY SCREW (3.8) ○ FLOODED SCREW (3.10)

REMARKS: Unless otherwise noted, all pressures are GAUGE pressures.

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	GAS ANALYSIS (5.1.15 d)		NOR-MAL	MAX-IMUM	OTHER CONDITIONS A	B	C	D	○ REMARKS
2	○ MOL % ○ ____								
3		M.W.							
4	AIR	28.966							
5	OXYGEN	32.000							
6	NITROGEN	28.016							
7	WATER VAPOR	18.016							
8	CARBON MONOXIDE	28.010							
9	CARBON DIOXIDE	44.010							
10	HYDROGEN SULFIDE	34.076							(5.11.1.10)
11	HYDROGEN	2.016							
12	METHANE	16.042							
13	ETHYLENE	28.052							
14	ETHANE	30.068							
15	PROPYLENE	42.078							
16	PROPANE	44.094							
17	I-BUTANE	58.120							
18	n-BUTANE	58.120							
19	I-PENTANE	72.146							
20	n-PENTANE	72.146							
21	HEXANE PLUS								
22									
23									
24	○ CORROSIVE								(5.11.1.7)
25	○ SOLID PARTICLE								(5.1.25)
26	○ LIQUID PARTICLE								(5.1.25)
27	○ NACE MATERIALS								(5.11.1.10)
28	TOTAL								
29	RELATIVE MOLECULAR MASS								

30 **SITE DATA:**
31 **LOCATION:** (5.1.18)
32 ○ INDOOR ○ HEATED ○ UNDER ROOF
33 ○ OUTDOOR ○ UNHEATED ○ PARTIAL SIDES
34 ○ GRADE ○ MEZZANINE ○ ____
35 ○ WINTERIZATION REQ'D. ○ TROPICALIZATION REQ'D.
36 ○ ELEVATION ____ FT. BAROMETER ____ (PSIA)
37 ○ RANGE OF AMBIENT TEMPS.:

		DRY BULB	WET BULB
38	SITE RATED °F		
39	NORMAL °F		
40	MAXIMUM °F		
41	MINIMUM °F		

42 **ELECTRICAL AREA CLASSIFICATION:** (5.1.18, NFPA 70)
43 ○ AREA: CL. ____ GR. ____ DIV. ____
44 **UNUSUAL CONDITIONS:** ○ DUST ○ FUMES
45 ○ OTHER ____
46 ____
47 ____
48 ____
49 ____
50 ○ VENDOR HAVING UNIT RESPONSIBILITY: (3.56) ____
51 ____
52 ____

NOISE SPECIFICATIONS: (5.1.19)
○ APPLICABLE TO MACHINE
SEE SPECIFICATION ____
○ APPLICABLE TO NEIGHBORHOOD
SEE SPECIFICATION ____
ACOUSTIC HOUSING: (5.1.20) ○ YES ○ NO
SOUND LEVEL ____ dB @ ____ FT. ____
dB RE: 20 MICRO PASCAL
APPLICABLE SPECIFICATIONS:
○ ACOUSTIC ____
○ MOTOR ____
____
____

PAINTING:
○ MANUFACTURER'S STD.
○ OTHER ____

SHIPMENT: (7.4.1)
○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQ'D
○ LONG TERM STORAGE FOR ____ MONTHS

53 **REMARKS:** ____
54 ____
55

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SPEEDS:
MAX. CONT. (3.22) rev/min TRIP (3.55) rev/min
MAX. TIP SPEEDS: FPS @ MAX. OPER. SPEED
MIN. ALLOW (3.25) rev/min
LATERAL CRITICAL SPEEDS: (5.7.1.4)
FIRST CRITICAL rev/min
DAMPED UNDAMPED
MODE SHAPE
LATERAL CRITICAL SPEED - BASIS:
DAMPED UNBALANCE RESPONSE ANALYSIS
OTHER TYPE ANALYSIS: (SPECIFY)
POCKET-PASSING FREQUENCY: Hz
TORSIONAL CRITICAL SPEEDS: (5.7.2)
FIRST CRITICAL rev/min
SECOND CRITICAL rev/min
VIBRATION: (5.7.3.6)
HOUSING IPS RMS
SHAFT
ROTATION, LOOKING AT COMPRESSOR DRIVEN END: CW CCW
CASING:
MODEL
CASING SPLIT
MATERIAL CLADDING (5.2.10)
OPERATION: DRY FLOODED, w/ LIQUID
THICKNESS (IN.) CORR. ALLOW (IN.)
MAX. ALLOWABLE WORK PRESS. (3.21) PSIG
RELIEF-VALVE SETTING PSIG
MARGIN FOR ACCUMULATION PSIG
LEAK-TEST GAS: PRESS. (PSIG) (7.3.3.4.3)
TEST PRESS. (PSIG) HE (7.3.4.7) HYDRO (7.3.2)
MAX. ALLOW. TEMP. °F MIN. OPER. TEMP. °F
COOLING JACKET YES NO
ROTORS: (5.5.1)
DIAMETER (IN.) MALE: FEMALE:
NO.LOBES: MALE: FEMALE:
TYPE:
TYPE FABRICATION
MATERIAL
MAX. YIELD STRENGTH (PSI)
BRINELL HARDNESS MAX. MIN.
ROTOR LENGTH TO DIAMETER RATIO (L/D) MALE:
ROTOR CLEARANCE (IN.)

INTERNALLY COOLED YES NO

SHAFT: (5.5.1.2)
MATERIAL
DIA @ ROTORS (IN.) DIA @ COUPLING (IN.)
SHAFT END TAPERED CYLINDRICAL (5.5.1.5 & 5.5.1.6)
SHAFT SLEEVES:
AT SHAFT SEALS MATL.
TIMING GEARS: (5.5.2)
PITCH-LINE DIAMETER (IN.) MALE: FEMALE:
MATERIAL
SHAFT SEALS: (5.6)
SEAL-SYSTEM TYPE (5.6.1.7)
OIL LEAKAGE (GAL/DAY/SEAL)
TYPE BUFFER GAS (5.6.2.1)
BUFFER GAS FLOW (PER SEAL)
NORMAL: #/MIN. @ PSIG
MAX.: #/MIN. @ PSIG
BEARING HOUSING: (5.9)
TYPE (SEPARATE, INTEGRAL) SPLIT
MATERIAL
HYDRODYNAMIC RADIAL BEARING (IDENTIFY HIGHEST LOADED BEARING) (5.8.3.1)
TYPE SPAN (IN)
AREA (IN.^{2}) LOADING (PSI): ACT. ALLOW.
NO. PADS ROTOR ON OR BETWEEN PADS
PAD MATERIAL
TYPE BABBITT THICKNESS (IN.)
TEMP SENSORS (5.8.1.5)
TC RTD TYPE
NO. PER BRG
ROLLING ELEMENT RADIAL BEARING (5.8.2)
TYPE: Ndm:
ENERGY DENSITY:
HYDRODYNAMIC THRUST BEARING (IDENTIFY HIGHEST LOADED BEARING) (5.8.3.2)
TYPE
MFR. AREA (IN.^{2})
LOADING (PSI): ACT. ALLOW.
NUMBER OF PADS
PAD MATERIAL
TYPE BABBITT THICKNESS (IN.)
TEMP SENSORS (5.8.1.5)
TC RTD TYPE
NO PER BRG ACTIVE INACTIVE
ROLLING ELEMENT THRUST BEARING (5.8.2)
TYPE: Ndm:
ENERGY DENSITY (kW/min)

REMARKS:

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☐ **PROCESS CONNECTIONS - COMPRESSOR CASING (5.3):**

	SIZE	ANSI RATING	Facing	Orientation
CASING (5.3)				
INLET				
DISCHARGE				

☐ **PROCESS CONNECTIONS - CUSTOMER INTERFACE:**

INLET				
DISCHARGE				

☐ **CASING - ALLOWABLE PIPING FORCES AND MOMENTS: (5.4)**

	INLET		DISCHARGE			
	FORCE LB	MOMT FT-LB	FORCE LB	MOMT FT-LB	FORCE LB	MOMT FT-LB
AXIAL X						
VERTICAL Y						
HORIZ. 90° Z						

	INLET		DISCHARGE			
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: API 670 ______

○ TYPE: SEISMIC ______ ☐ DISPLACEMENT ______

☐ MODEL ______

○ MFR. ______

○ NO. AT EACH 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

AXIAL POSITION DETECTOR: (6.4.4.3)

○ IN ACCORDANCE WITH: API 670 ______

○ TYPE ______ ☐ MODEL ______

○ MFR. ______ ☐ NO. REQ'D ______

○ OSCILLATOR-DETECTORS SUPPLIED BY ______

○ MFR. ______ ☐ MODEL ______

○ MONITOR SUPPLIED BY ______

○ LOCATION ______ ENCLOSURE ______

○ MFR. ______ ☐ MODEL ______

☐ SCALE RANGE ______ ○ ALARM: ☐ SET @ ______

○ SHUTDOWN: ☐ SET @ ______ ○ TIME DELAY ______ SEC

COUPLINGS: (6.2)

○ IN ACCORDANCE WITH: API 671 ______

OTHER (SPECIFY) ______

	DRIVER-COMP OR DRIVER	GEAR-COMP
○ MAKE		
☐ MODEL		
○ MOUNT CPLG. HALVES		
○ SPACE REQUIRED		
○ LIMITED END FLOAT REQ'D		
○ MOMENT SIMULATOR REQUIRED (6.2.5)		
☐ CPLG. RATING (HP/100 rev/min)		
☐ KEYED (1) OR (2) OR HYDR. FIT		

BASEPLATE & SOLEPLATES: (6.3.2 & 6.3.3)

SOLEPLATES 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 (5.10.2.3 & 5.10.3, ANNEX D)

○ COMMON (5.10.2.1) ○ DEDICATED SYSTEM

○ OIL FILTER (5.10.3.2)

○ OIL COOLER (5.10.3.3): TYPE ______ NO: ______

○ OIL PUMP (5.10.3.4): TYPE ______ NO: ______

○ OIL SEPARATOR (5.10.3.5)

☐ TYPE ______ ☐ NO. ______

☐ OIL CARRYOVER (PPM-BY WT) ______ (GAL/DAY) ______

☐ RETENTION TIME (MIN) ______

○ RELIEF VALVE ○ LEVEL GAUGE

☐ LEVEL SWITCH ☐ PRESSURE DIFFERENTIAL INDICATOR

☐ ELECTRIC HEATER

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UTILITY CONDITIONS: (ALL UNITS ARE "GAUGE")

STEAM		DRIVERS		HEATING	
INLET	MIN.	____ PSIG	____ °F	____ PSIG	____ °F
	NORM	____ PSIG	____ °F	____ PSIG	____ °F
	MAX.	____ PSIG	____ °F	____ PSIG	____ °F
EXHAUST	MIN.	____ PSIG	____ °F	____ PSIG	____ °F
	NORM	____ PSIG	____ °F	____ PSIG	____ °F
	MAX.	____ PSIG	____ °F	____ PSIG	____ °F

ELECTRICITY:

	DRIVERS	HEATING	CONTROL	SHUT-DOWN
VOLTAGE				
HERTZ				
PHASE				

COOLING WATER

TEMP. INLET ____ °F MAX. RETURN ____ °F
PRESS. NORM ____ PSIG DESIGN ____ PSIG
MIN. RETURN ____ PSIG MAX. ALLOW Δ P ____ PSI
WATER SOURCE ____

INSTRUMENT AIR:

MAX. PRESS. ____ PSIG MIN. ____ PSIG

☐ **TOTAL UTILITY CONSUMPTION:**

COOLING WATER ____ GPM
STEAM, NORMAL ____ lbs/hr
STEAM, MAX. ____ lbs/hr
INSTRUMENT AIR ____ SCFM
HP (DRIVER) ____ HP

SHOP INSPECTION AND TESTS (7.1):

	REQ'D	WITNESS	OBSERVE
SHOP INSPECTION (7.1.5)	○	○	○
HYDROSTATIC (7.3.2)	○	○	○
HELIUM LEAK (7.3.4.7)	○	○	○
MECHANICAL RUN (7.3.3)	○	○	○
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 (7.3.4.3)	○	○	○
USE SHOP LUBE & SEAL SYSTEM	○	○	○
USE JOB LUBE & SEAL SYSTEM (7.3.4.9)	○	○	○
USE SHOP VIBRATION PROBES, ETC.	○	○	○
USE JOB VIB. & AXIAL DISP. PROBES,	○	○	○
USE SEISMIC TRANSDUCERS & MONITORS	○	○	○
USE JOB-MONITORING EQUIPMENT	○	○	○
PRESSURE COMP. TO FULL OPER. PRESSURE	○	○	○
DISASSSEMBLE-REASSEMBLE COMP.			
AFTER TEST (7.3.4.10)	○	○	○
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)	○	○	○

☐ **MASSES (LBS):**

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 (FEET & INCHES):**

	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 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)

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 (8.2.3 f)
○ ROTOR ASSEMBLY
○ SEALS ○ GASKETS, O-RINGS
○ START-UP/COMMISSIONING
○ 2 YEARS' SUPPLY
○ OTHER: ____

REMARKS: ____

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VENDOR SHALL FURNISH ALL PERTINENT DATA FOR THIS SPECIFICATION SHEET BEFORE RETURNING.
ITEM NO. ____ SERVICE ____ JOB NO. ____
MANUFACTURER ____

REFERENCE SPECIFICATIONS: (6.4.1.2)
ISO 10438 ○ YES ○ NO
NOTE For the purposes of this provision API 614 is equivalent to ISO 10438.

APPLICABLE SPECIFICATIONS: ○ IEC ____ ○ NEMA ____
AREA CLASSIFICATION:
○ AREA: CL. ____ GR. ____ DIV. ____ ○ NON-HAZARDOUS
MOTOR CONTROL & INSTRUMENT VOLTAGE:
VOLTS ____ PHASE ____ CYCLES ____
ALARM & SHUTDOWN VOLTAGE:
VOLTS PHASE CYCLES OR DC

LOCAL CONTROL PANEL: (6.4.3)
FURNISHED BY: ☐ VENDOR ☐ PURCHASER ☐ OTHERS ____
☐ FREE-STANDING ☐ WEATHERPROOF ☐ TOTALLY ENCLOSED ☐ EXTRA CUTOUTS
☐ VIBRATION ISOLATORS ☐ STRIP HEATERS ☐ PURGE CONNECTIONS
☐ ANNUNCIATOR: FURNISHED BY: ☐ VENDOR ☐ PURCHASER ☐ OTHERS ____
ANNUNCIATOR LOCATED ON ☐ LOCAL PANEL ☐ MAIN CONTROL BOARD
☐ CUSTOMER CONNECTIONS BROUGHT OUT TO TERMINAL BOXES BY VENDOR

INSTRUMENT SUPPLIERS:

○ PRESSURE GAUGES:	MFR.		SIZE & TYPE:	
○ TEMPERATURE GAUGES:	MFR.		SIZE & TYPE:	
○ LEVEL GAUGES:	MFR.		SIZE & TYPE:	
○ DIFF.-PRESSURE GAUGES:	MFR.		SIZE & TYPE:	
○ PRESSURE SWITCHES:	MFR.		SIZE & TYPE:	
○ DIFF.-PRESSURE SWITCHES:	MFR.		SIZE & TYPE:	
○ TEMPERATURE SWITCHES:	MFR.		SIZE & TYPE:	
○ LEVEL SWITCHES:	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:	
____	MFR.		SIZE & TYPE:	

NOTE: ☐ SUPPLIED BY VENDOR ○ SUPPLIED BY PURCHASER

PRESSURE-GAUGE REQUIREMENTS

FUNCTION	LOCALLY MOUNTED (3.12)	LOCAL PANEL (3.31)	**FUNCTION**	LOCALLY MOUNTED (3.12)	LOCAL PANEL (3.31)
LUBE-OIL PUMP DISCHARGE ____	☐ ○	☐ ○	GOV. CONTROL OIL ____	☐ ○	☐ ○
LUBE-OIL FILTER Δ P ____	☐ ○	☐ ○	GOV. CONTROL OIL Δ P ____	☐ ○	☐ ○
LUBE-OIL SUPPLY ____	☐ ○	☐ ○	MAIN STEAM IN ____	☐ ○	☐ ○
SEAL-OIL PUMP DISCHARGE ____	☐ ○	☐ ○	1ST STAGE STEAM ____	☐ ○	☐ ○
SEAL-OIL FILTER Δ P ____	☐ ○	☐ ○	STEAM CHEST ____	☐ ○	☐ ○
SEAL-OIL SUPPLY (EACH LEVEL) ____	☐ ○	☐ ○	EXHAUST STEAM ____	☐ ○	☐ ○
SEAL-OIL DIFFERENTIAL ____	☐ ○	☐ ○	EXTRACTION STEAM ____	☐ ○	☐ ○
REFERENCE GAS ____	☐ ○	☐ ○	STEAM EJECTOR ____	☐ ○	☐ ○
BALANCE LINE ____	☐ ○	☐ ○	COMPRESSOR SUCTION ____	☐ ○	☐ ○
SEAL EDUCTOR ____	☐ ○	☐ ○	COMPRESSOR DISCHARGE ____	☐ ○	☐ ○
BUFFER SEAL ____	☐ ○	☐ ○	____	☐ ○	☐ ○
OIL/GAS COALESCING FILTER Δ P	☐ ○	☐ ○	____		

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VENDOR SHALL FURNISH ALL PERTINENT DATA FOR THIS SPECIFICATION SHEET BEFORE RETURNING.
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MANUFACTURER ______

TEMPERATURE-GAUGE REQUIREMENTS:

FUNCTION	LOCALLY MOUNTED (3.12)	LOCAL PANEL (3.31)	FUNCTION	LOCALLY MOUNTED (3.12)	LOCAL PANEL (3.31)
LUBE-OIL DISCHARGE FROM EA. ______	☐ ○	☐ ○	COOLER-OIL INLET & OUTLET ______	☐ ○	☐ ○
COMPR. JOURNAL BEARING ______	☐ ○	☐ ○	SEAL-OIL OUTLET ______	☐ ○	☐ ○
DRIVER JOURNAL BEARING ______	☐ ○	☐ ○	COMPRESSOR SUCTION ______	☐ ○	☐ ○
GEAR JOURNAL BEARING ______	☐ ○	☐ ○	COMPRESSOR DISCHARGE ______	☐ ○	☐ ○
COMPRESSOR THRUST BEARING ______	☐ ○	☐ ○	LUBE-OIL RESERVOIR ______	☐ ○	☐ ○
DRIVER THRUST BEARING ______	☐ ○	☐ ○	LUBE-OIL SUPPLY ______	☐ ○	☐ ○
GEAR THRUST BEARING ______	☐ ○	☐ ○	______	☐ ○	☐ ○

MISCELLANEOUS INSTRUMENTATION:

☐ ○ DRIVER START/STOP ☐ LOCAL PANEL ☐ SEPARATE PANEL ☐ MAIN BOARD
☐ ○ SIGHT FLOW INDICATORS, EACH JOURNAL & THRUST BEARING & EACH COUPLING OIL RETURN LINE
☐ ○ SIGHT FLOW INDICATORS, EACH SEAL-OIL RETURN LINE
☐ ○ LEVEL GAUGES, LUBE AND/OR SEAL-OIL RESERVOIR, S.O. DRAIN TRAPS & S.O. OVERHEAD TANK
☐ ○ VIBRATION AND SHAFT-POSITION PROBES & PROXIMITORS
☐ ○ VIBRATION AND SHAFT-POSITION READOUT EQUIPMENT
☐ ○ VIBRATION READOUT LOCATED ON: ☐ LOCAL PANEL ☐ SEPARATE PANEL ☐ MAIN BOARD
☐ ○ TURBINE-SPEED PICKUP DEVICES
☐ ○ TURBINE-SPEED INDICATORS
☐ ○ TURBINE-SPEED INDICATORS LOCATED ON: ☐ LOCAL PANEL ☐ MAIN BOARD
☐ ○ REMOTE HAND SPEED CHANGER - MOUNTED ON LOCAL PANEL
☐ ○ ALARM HORN & ACKNOWLEDGMENT SWITCH

ALARM & SHUTDOWN: (6.4.5.2)

FUNCTION	ALARM	TRIP	FUNCTION	PRE-ALARM	TRIP
☐ ○ LOW LUBE-OIL PRESSURE	______	______	☐ ○ TURBINE VIBRATION	______	______
☐ ○ HI LUBE-OIL FILTER ΔP	______	______	☐ ○ TURBINE AXIAL POSITION	______	______
☐ ○ HI SEAL-OIL FILTER ΔP	______	______	☐ ○ GEAR VIBRATION	______	______
☐ ○ LOW LUBE-OIL RESERVOIR LEV.	______	______	☐ ○ GEAR AXIAL POSITION	______	______
☐ ○ LOW SEAL-OIL RESERVOIR LEV.	______	______	☐ ○ COMPRESSOR MOTOR SHUTDOWN	______	______
☐ ○ HI SEAL-OIL LEVEL	______	______	☐ ○ TRIP & THROTTLE VALVE SHUT	______	______
☐ ○ LOW SEAL-OIL LEVEL	______	______	☐ ○ HI TURB. STEAM SEAL LEAKAGE	______	______
☐ ○ HI SEAL-OIL PRESSURE	______	______	☐ ○ HI COMPR. THRUST BRG. TEMP.	______	______
☐ ○ LOW SEAL-OIL PRESSURE	______	______	☐ ○ HI COMPR. JOURNAL BRG. TEMP.	______	______
☐ ○ AUX. SEAL-OIL PUMP START	______	______	☐ ○ HI DRIVER THRUST BRG. TEMP.	______	______
☐ ○ AUX. LUBE-OIL PUMP START	______	______	☐ ○ HI DRIVER JOURNAL BRG. TEMP.	______	______
☐ ○ HI SEAL-OIL OUTLET TEMP. (COOLER)	______	______	☐ ○ HI GEAR THRUST BRG. TEMP.	______	______
☐ ○ HI LIQUID-LEV. SUCT. SEPARATOR	______	______	☐ ○ HI GEAR JOURNAL BRG. TEMP.	______	______
☐ ○ COMPRESSOR HI DISCH. TEMP.	______	______	☐ ○ COMPRESSOR ΔP	______	______
☐ ○ COMPRESSOR VIBRATION	______	______	☐ ○ LOW SEAL-GAS PRESSURE	______	______
☐ ○ COMPRESSOR AXIAL POSITION	______	______	☐ ○ HI COALESCING GAS/OIL FILTER ΔP	______	______
☐ ○ HI LUBE-OIL SUPPLY TEMPERATURE	______	______	☐ ○ ______	______	______

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 SWITCHES SHALL BE SEPARATE.
PURCHASER'S 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: ______

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APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ○ AS BUILT
FOR ______ UNIT ______
SITE ______ DRIVEN EQUIP. ______
SERVICE ______ NO. REQURED ______
MANUFACTURER ______ MODEL ______ SERIAL NO. ______
NOTE: ○ INDICATES INFORMATION TO BE COMPLETED BY PURCHASER ☐ BY MANUFACTURER

MOTOR DESIGN DATA	MOTOR DESIGN DATA (CONT'D)
APPLICABLE SPECIFICATIONS:	**STARTING:** (6.1.2.1 b)
○ IEC ______ ○ NEMA ______	○ FULL VOLTAGE ○ REDUCED VOLTAGE ______ %
○ API 541 (6.1.2.2) ______	○ LOADED ○ UNLOADED
○ ______	○ VOLTAGE DIP ______ %
SITE DATA:	**VIBRATION:**
AREA: ○ CL. ___ GR. ___ DIV. ___ ○ NON-HAZARDOUS	○ IEC STANDARD ○ NEMA STANDARD ______
○ ALT. ___ FT. ○ AMB. TEMPS: MAX. ___ °F, MIN. ___ °F	**NOISE:**
UNUSUAL CONDITIONS: ○ DUST ○ FUMES	○ IEC STANDARD ○ NEMA STANDARD ______
○ OTHER ______	ACCESSORY EQUIPMENT
DRIVE SYSTEM: ○ DIRECT CONNECTED	○ BASEPLATE ○ SOLEPLATE ○ STATOR SHIFT
○ GEAR	○ MFR. STD. FANS ○ NON-SPARKING FANS
○ OTHER ______	○ D.C. EXCITATION:
TYPE MOTOR: (6.1.2.1)	☐ KW REQD ______ ○ VOLTS ______
○ SQUIRREL-CAGE INDUCTION ○ NEMA DESIGN ______	BY: ○ PURCHASER ○ MANUFACTURER
○ SYNCHRONOUS ______	DESCRIPTION ______
○ POWER FACTOR REQD. ______	○ **ENCLOSED COLLECTOR RINGS:**
EXCITATION: ○ BRUSHLESS ○ SLIP RING	○ PURGED: MEDIUM ______ PRESS. ______ PSIG
○ FIELD DISCHARGE RESISTOR BY MOTOR MFR.	○ EXPLOSION-RESISTANT NON-PURGED
○ WOUND ROTOR INDUCTION	○ FORCED VENTILATION
○ ______	☐ CFM ______ PRESS. DROP ______ IN. H_2O
ENCLOSURE: (6.1.2.1 c)	○ **BEARING TEMP DEVICES:**
○ TEFC	☐ LOCATION
○ TEWAC ___ ○ TEIGF, USING ______ GAS	☐ DESCRIPTION
○ DOUBLE WALL CARBON STEEL TUBES	☐ SET @ ______ °F FOR ALARM ______ °F FOR SHUTDOWN
○ WATER SUPPLY: PRESS. ______ PSIG TEMP. ___ °F	○ **SPACE HEATERS:**
○ WATER ALLOW. Δ P ______ PSI & TEMP. RISE ______ °F	☐ ______ KW ○ ___ VOLTS ______ PHASE ______ HERTZ
○ WATER-SIDE MIN. CORR. ALLOW. ______ IN.	○ MAX. SHEATH TEMP. ______ °F
AND FOUL FACTOR ______	**WINDING TEMPERATURE DETECTORS:**
○ (AIR) (GAS) SUPPLY PRESS. ______ PSIG	○ THERMISTORS: NO./PHASE ______
○ ______	TYPE: ○ POS. TEMP. COEFF. ○ NEG. TEMP. COEFF.
○ WEATHER PROTECTED, TYPE ______	TEMPERATURE SWITCH: ○ YES ○ NO
○ FORCED VENTILATED	○ RESISTANCE TEMPERATURE DETECTORS: NO./PHASE ______
○ OPEN - DRIPPROOF	☐ RESISTANCE MATL. ______ ☐ ______ OHMS
○ OPEN	SELECTOR SWITCH & INDICATOR BY: ○ PURCHR. ○ MFR.
	☐ MAX. STATOR WINDING TEMPS:
	______ °F FOR ALARM ______ °F FOR SHUTDOWN
BASIC DATA:	**WINDING TEMP. DETECTOR & SPACE HEATER LEADS:**
○ ______ VOLTS ______ PHASE ______ HERTZ	○ IN SAME CONDUIT BOX
☐ NAMEPLATE HP ______ SERVICE FACTOR (6.1.2.1 g) ______	○ IN SEPARATE CONDUIT BOXES
○ SYNCHRONOUS rev/min	○ **MOTOR ARRANGED FOR DIFFERENTIAL PROTECTION:**
○ INSULATION: CLASS ______ TYPE ______	○ SELF-BALANCE PRIMARY CURRENT METHOD
○ TEMP. RISE: ___ °F ABOVE ___ °F BY ______	○ C.T. DESCRIPTION ______
______	○ EXTENDED LEADS ☐ LENGTH ______ FT.
______	○ **SURGE CAPACITORS**

ROTARY-TYPE POSITIVE-DISPLACEMENT COMPRESSOR DATASHEET USC UNITS

JOB NO. ______ ITEM NO. ______
REVISION NO. ______ DATE ______
PAGE 9 OF 9 BY ______

ACCESSORY EQUIPMENT (CONT'D)

○ LIGHTNING ARRESTERS
○ C.T. FOR AMPMETER
○ DESCRIPTION ______
MAIN CONDUIT BOX SIZED FOR:
○ MAIN MOTOR LEADS ○ TYPE: ______
○ INSULATED ○ NON-INSULATED
○ C.T.'S FOR DIFF. PROTECTION (MOUNTED BY ______)
○ SURGE CAPACITORS (MOUNTED BY ______)
○ LIGHTNING ARRESTERS (MOUNTED BY ______)
○ C.T. FOR AMPMETER (MOUNTED BY ______)
○ SPACE FOR STRESS CONES
○ AIR FILTERS:
☐ MFR. ______ ☐ TYPE ______

☐ MANUFACTURER'S DATA

MANUFACTURER ______
FRAME NO. ______ FULL LOAD RPM (IND.) ______
EFFICIENCY: F.L. ______ 3/4 L ______ 1/2 L ______
PWR. FACTOR (IND.): F.L. ______ 3/4 L ______ 1/2 L ______
CURRENT (RATED VOLT.): FULL LOAD ______ LOCKED ROT. ______
LOCKED ROTOR POWER FACTOR ______
LOCKED ROTOR WITHSTAND TIME (COLD START) ______
TORQUES (FT-LBS): FULL LOAD ______
LOCKED ROTOR ______ STARTING (SYN.) ______
PULL-UP (IND) ______ PULL-IN (SYN.) ______
BREAKDOWN (IND.) ______ PULL-OUT (SYN.) ______
______
OPEN CIRCUIT TIME CONSTANT (SEC.) ______
SYMMETRICAL CONTRIBUTION TO 30 TERMINAL FAULT:
AT 1/2 CYCLES ______ AT 5 CYCLES ______
REACTANCES: SUB-TRANSIENT (X''_d) ______
TRANSIENT (X'_d) ______ SYNCHRONOUS (X_d) ______
A.C. STATOR RESISTANCE ______ OHMS @ ______ °F
RATED KVA ______
KVA INRUSH @ FULL VOLT. & LOCKED ROTOR (SYN.) ______ %
KVA @ FULL VOLTAGE & 95% SPEED ______ %
MAX. LINE CURR. IN STATOR ON 1ST SLIP CYC. @ PULL-OUT
(SYN.) ______
ACCELERATION TIME (MTR ONLY @ RATED VOLT.) ______ SEC
ACCEL. TIME (MTR & LOAD @ 85% RATED VOLT.) ______ SEC
ROTOR/FIELD WK^2 @ MTR SHAFT (LB-FT^2) ______
ROTATION FACING COUPLING END ______
NO. OF STARTS PER HOUR ______
______
FIELD DISCHARGE RESISTOR ______ OHMS
RATED EXCITATION FIELD VOLTAGE ______ D.C.
RESISTANCE OF EXCITATION FIELD @ 77°F ______ OHMS
EXCITATION FIELD AMPS @ FULL LOAD & RATED P.F. ______
EXCITATION FIELD AMPS: MAX. ______ MIN. ______
EXCITATION FIELD ☐ RHEOSTAT ☐ FIXED RES'TR REQD.
SUPPLIED BY ______

MANUFACTURER'S DATA (CONT'D.)

BEARING: TYPE ______ LUBR. ______
LUBE OIL REQUIRED: ______ GPM @ ______ PSIG
TOTAL SHAFT END FLOAT ______
LIMIT END FLOAT TO ______
MOTOR ROTOR: ☐ SOLID ☐ SPLIT
MOTOR HUB: ☐ SOLID ☐ SPLIT
FOR TEWAC & TEIGF MOTORS:
COOLING WATER REQD. ______ CFM
C.W. TEMP. RISE ______ °F PRESS. DROP ______ PSIG
(AIR) (GAS) REQD. ______ CFM PRESS. MAINT. ______ IN. H_2O
CURVES REQD. BASED ON MTR SATURATION @ RATED VOLTAGE:
○ SPEED VS TORQUE (ALSO @ ______ % RATED VOLTAGE)
○ SPEED VS. POWER FACTOR
○ SPEED VS CURRENT

MASSES (LBS):

NET MASS ______ SHIPPING MASS ______
ROTOR MASS ______ MAX. ERECTION MASS ______
MAX. MAINT. MASS (IDENTIFY) ______

DIMENSIONS (FEET & INCHES):

L ______ W ______ H ______

SHOP INSPECTION AND TESTS

	REQUIRED	WITNESS
SHOP INSPECTION	○	○
TESTING PER ○ IEC ○ NEMA	○	○
MFR. STD. SHOP TESTS	○	○
IMMERSION TEST	○	○
SPECIAL TESTS (LIST BELOW)		
______	○	○
______	○	○
______	○	○
______	○	○

PAINTING:

○ MANUFACTURER'S STANDARD
○

SHIPMENT (7.4.1)

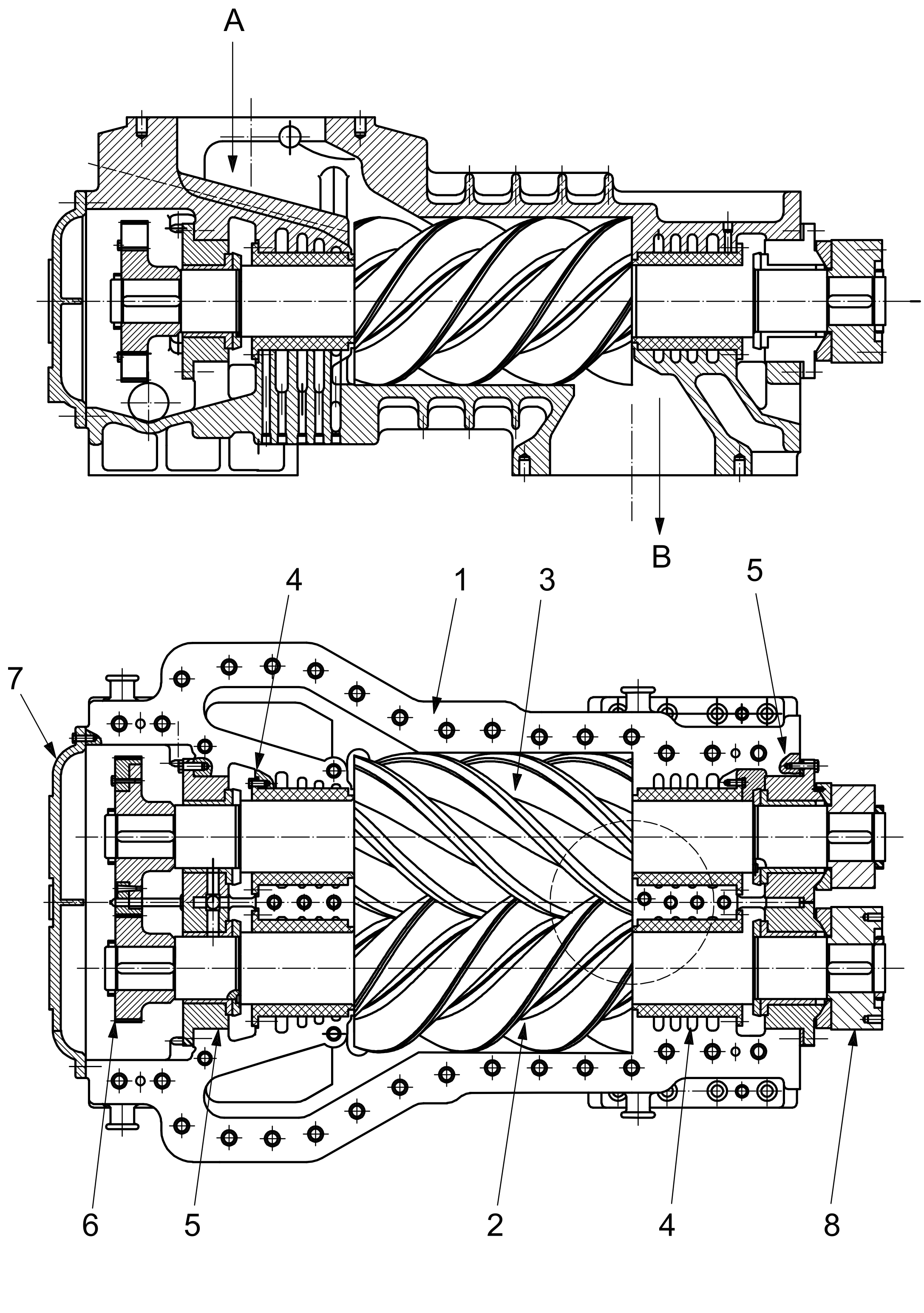
○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQUIRED
○ OUTDOOR STORAGE OVER 3 MONTHS

REMARKS:

Annex B
(informative)

Nomenclature for rotary-type positive-displacement compressors

Figures B.1 and B.2 give the general nomenclature. Figures B.3 to B.6 are related to the vibration- and the temperature-probe mounting.

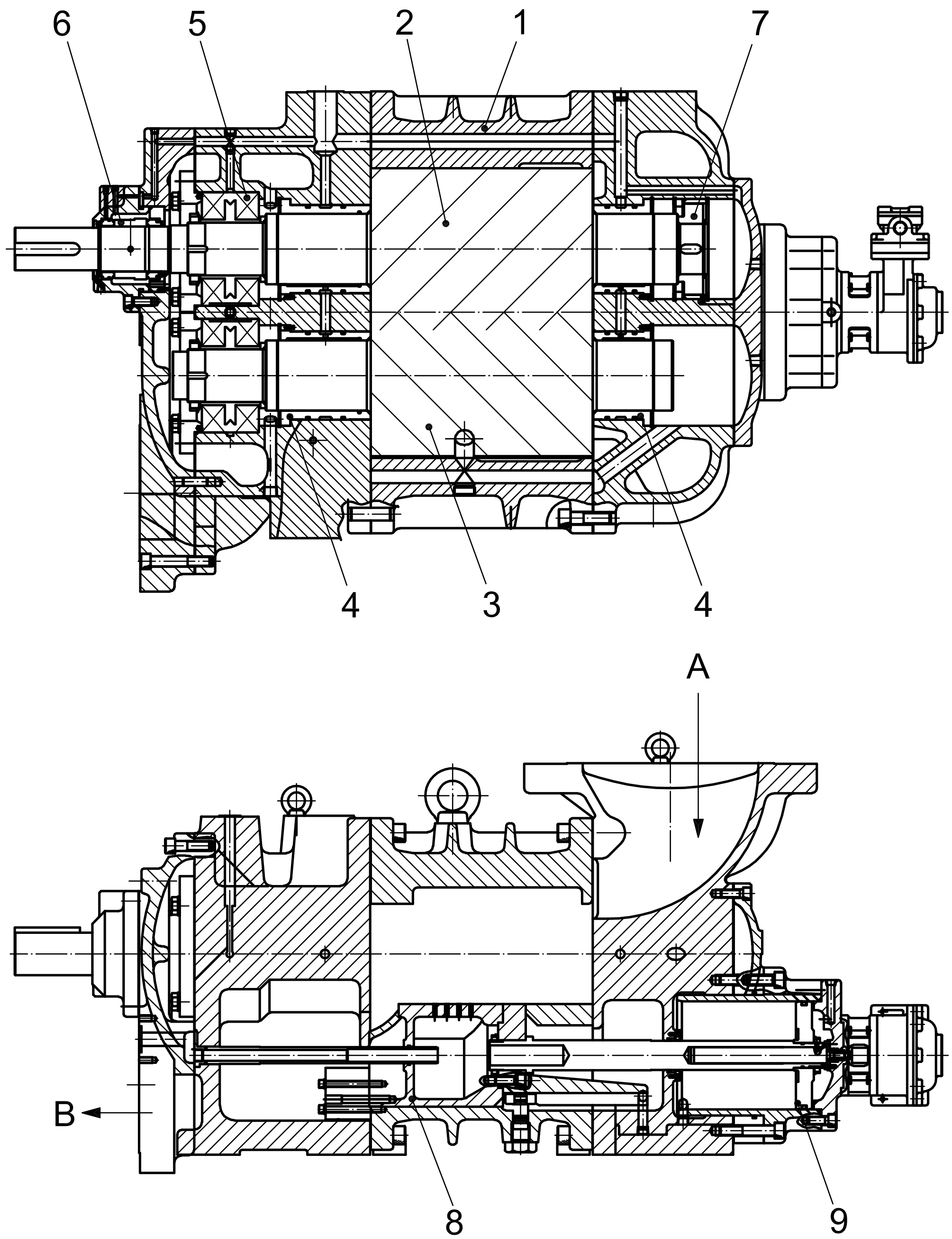


Key

A inlet
B outlet

1 casing
2 male rotor
3 female rotor
4 shaft seal
5 radial/thrust bearing
6 timing gear
7 end cover
8 drive shaft

Figure B.1 — Sections through dry screw compressor



Key

A inlet

B outlet

1 casing

2 male rotor

3 female rotor

4 radial bearing

5 thrust bearing

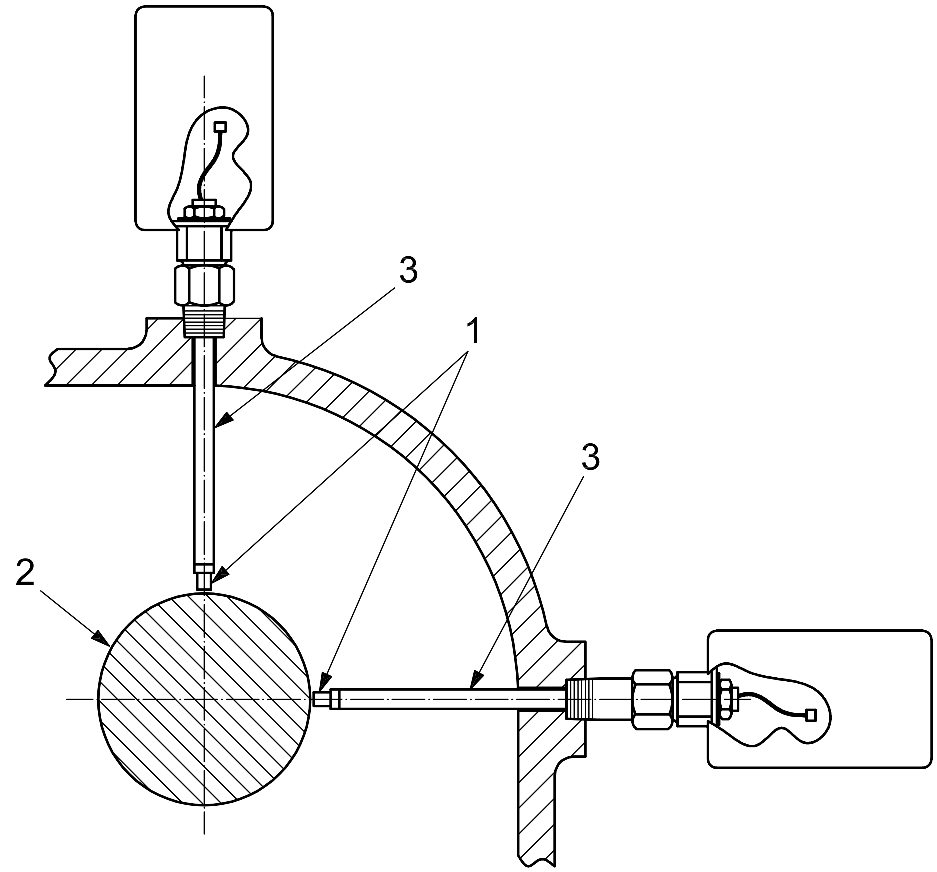
6 shaft seal

7 hydraulic thrust compensating piston

8 capacity-control slide valve

9 double-acting hydraulic piston

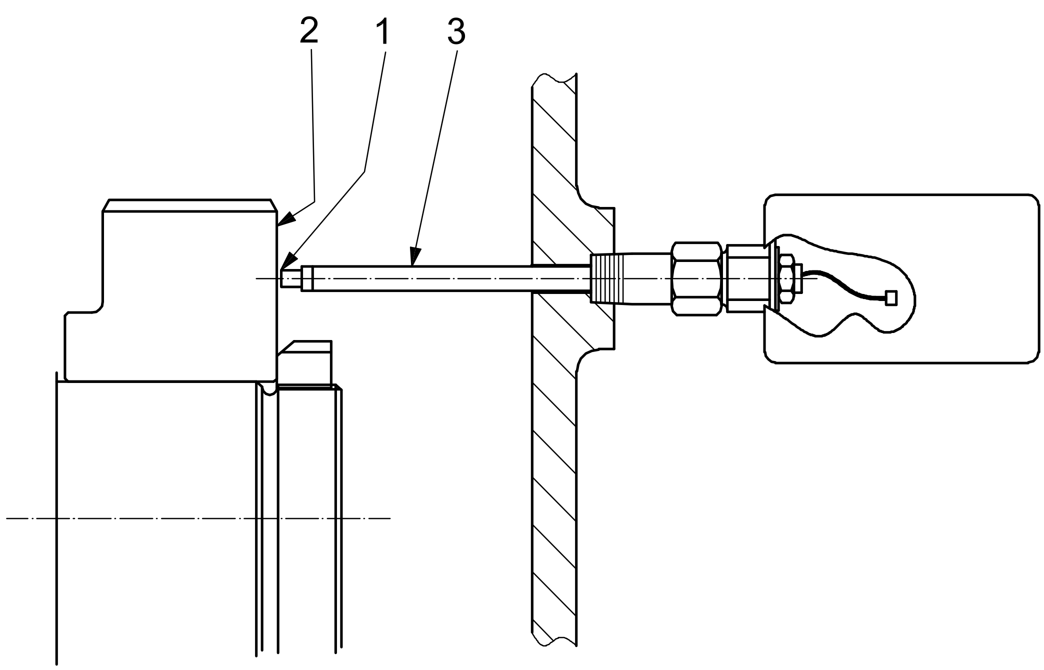
Figure B.2 — Sections through flooded screw compressor



Key

1 vibration probe
2 shaft journal
3 probe holder

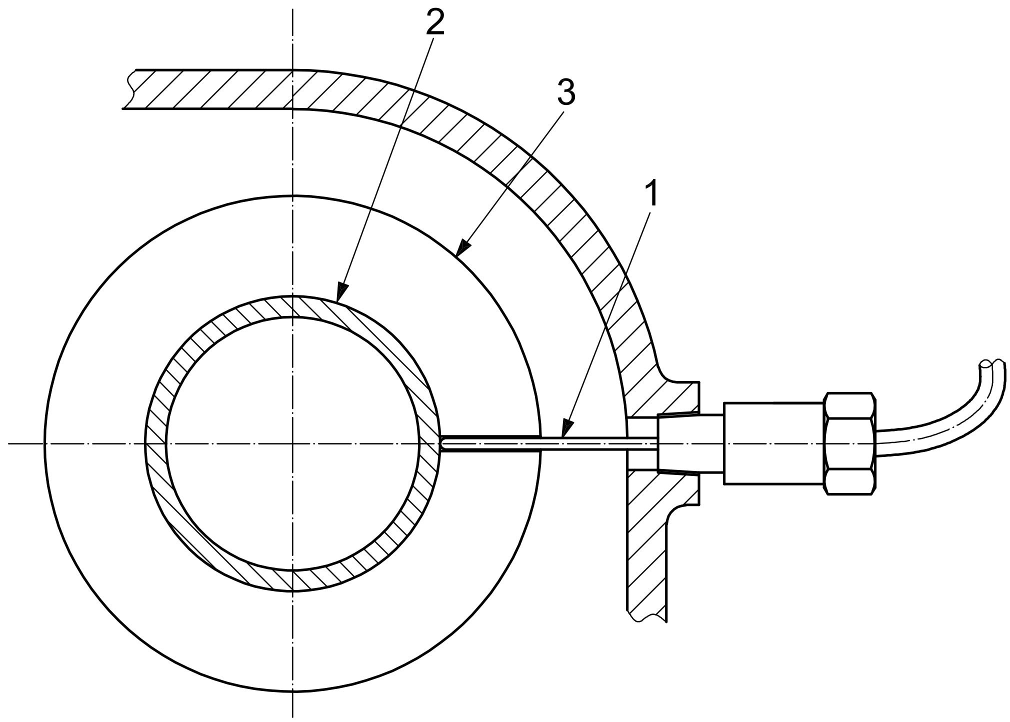
Figure B.3 — Arrangement of radial-vibration probe



Key

1 vibration probe
2 shaft journal
3 probe holder

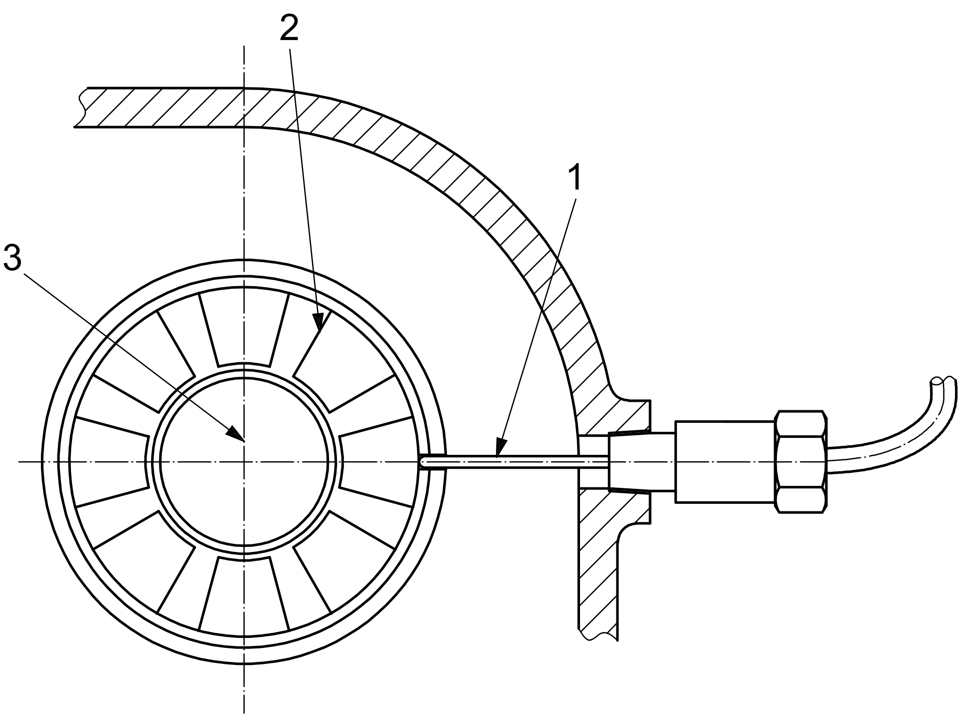
Figure B.4 — Arrangement of axial-vibration probe



Key

1 temperature probe
2 bearing
3 bearing housing

Figure B.5 — Arrangement of radial-bearing temperature probe



Key

1 temperature probe
2 thrust bearing
3 compressor rotor centreline

NOTE Alternative arrangement can include an embedded resistance temperature detector (RTD) or thermocouple.

Figure B.6 — Arrangement of thrust-bearing temperature probe

Annex C
(normative)

Forces and moments

C.1 General

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.

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.

Loads may be increased by mutual agreement between the purchaser and vendor; however, it is recommended that expected operating loads be minimized.

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

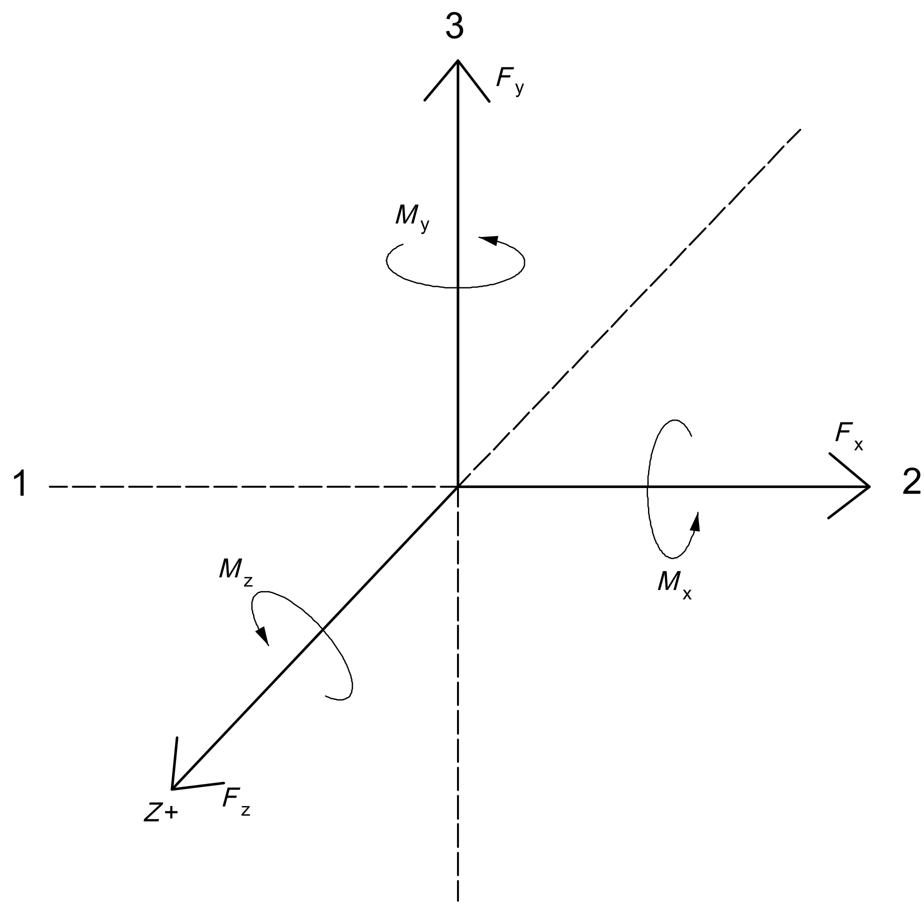
Force N	**Nozzle nominal size DN**								
	100	**150**	**200**	**250**	**300**	**350**	**400**	**450**	**500**
F_x	1 368	2 094	2 815	3 328	3 960	4 908	5 772	6 492	6 182
F_y	3 434	5 253	7 052	8 349	9 938	12 294	14 455	16 269	15 490
F_z	2 336	3 383	4 527	5 178	5 992	6 662	7 492	8 499	8 270
F_r	4 373	6 590	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.									

C.2 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
(normative)

Procedure for determination of residual unbalance

D.1 Scope

This annex describes the procedure used to determine residual unbalance in machine rotors. Although some balancing machines may be set up to read out the exact amount of unbalance, the calibration can be in error. The only sure method of determining is to test the rotor with a known amount of unbalance.

D.2 Definition

Residual unbalance is the amount of unbalance remaining in a rotor after balancing. Unless otherwise specified, residual unbalance shall be expressed in gram·millimetres or ounce·inches.

D.3 Maximum allowable residual unbalance

D.3.1 The maximum allowable residual unbalance per plane shall be calculated in accordance with 5.7.3.1 or 5.7.3.3.

D.3.2 If the actual static load on each journal is not known, assume that the total rotor mass is equally supported by the bearings. For example, a two-bearing rotor with a mass of 2 720 kg (6 000 lb) is assumed to impose a mass of 1 360 kg (3 000 lb) on each journal.

D.4 Residual unbalance check

D.4.1 General

D.4.1.1 When the balancing machine readings indicate that the rotor has been balanced within the specified tolerance, a residual unbalance check shall be performed before the rotor is removed from the balancing machine.

D.4.1.2 To check the residual unbalance, a known trial mass is attached to the rotor sequentially on each lobe and at the same radius [i.e. the same moment (gram·millimetres)]. The check is run at each correction plane and the readings in each plane are tabulated and plotted on the polar graph using the procedure specified in D.4.2.

NOTE The number of weights is equal to the number of lobes on the rotor.

D.4.2 Procedure

D.4.2.1 Select a trial mass and radius that are equivalent to between one and two times the maximum allowable residual unbalance [e.g. if U_{max} is 488,4 g·mm (0,678 oz·in), the trial weight should cause 488,4g·mm to 976,8 g·mm (0,678 oz·in to 1,356 oz·in) of unbalance]. This trial mass and radius shall be sufficient so that the resulting plot in D.4.2.5 encompasses the origin of the polar plot (refer to Figures D.1 through D.6).

D.4.2.2 Starting at the last known heavy spot, mark off the radial position on each lobe. Add the trial mass near the last known heavy spot for that plane. Verify that the balance machine is responding and is within the range and the graph selected for taking the residual unbalance check.

D.4.2.3 Verify that the balancing machine is responding reasonably (i.e. no faulty sensors or displays). For example, if the trial mass is added to the last known heavy spot, the first meter reading should be at least twice as much as the last reading taken before the trial mass was added. Little or no meter reading generally indicates that the rotor was not balanced to the correct tolerance, the balancing machine was not sensitive enough or that a balancing machine fault exists (i.e. a faulty pickup). Whatever the error, it shall be corrected before proceeding with the residual check.

D.4.2.4 Remove the trial mass and attach it to each of the trial positions in turn (that is, 60°, 120°, 180°, 240° and 300° from the initial trial mass position for a six-lobe rotor). Repeat the initial position as a check for repeatability on the residual unbalance worksheet. All verification shall be performed using only one sensitivity range on the balance machine.

D.4.2.5 Plot the balancing-machine amplitude readout versus angular location of trial mass (NOT balancing-machine phase angle) on the polar-plot worksheet for residual unbalance and calculate the amount of residual unbalance (refer to work sheets, Figures D.4 and D.6). The maximum reading occurs when the trial weight is placed at the rotor's remaining heavy spot; the minimum reading occurs when the trial weight is placed opposite the rotor's heavy spot (light spot). The plotted readings should form an approximate circle around the origin of the polar chart. The balance machine angular location readout should approximate the location of the trial weight. The maximum deviation (highest reading) is the heavy spot (represents the plane of the residual unbalance). Blank work sheets are given in Figures D.1 and D.2.

D.4.2.6 Repeat the steps described in D.4.2.1 through D.4.2.5 for each balance plane. If the specified maximum allowable residual unbalance has been exceeded in any balance plane, the rotor shall be balanced more precisely and checked again. If a balance correction is made in any balance plane, then the residual unbalance check shall be repeated in all balance planes.

Customer: ______________________

Job / Project Number: ______________________

OEM equipment S/N: ______________________

Rotor identification number: ______________________

Repair purchase order number: ______________________

Vendor job number: ______________________

Correction plane (left or right) – use sketch ______________________ plane

Balancing speed [ ] rev/min

Maximum rotor operating speed, N [ ] rev/min

Static journal mass, W, closest to this correction plane [ ] kg [ ] lb

Trial mass radius, R, the radius at which the trial mass is placed [ ] mm [ ] in

Calculate maximum allowable residual unbalance, U_{max}, as per 5.7.3.1 or 5.7.3.3:

SI units: $U_{max} = \frac{6\,350 \times W}{N} = \frac{6\,350 \times \_\_\_\_}{\_\_\_\_} =$ [ ] g·mm

USC units: $U_{max} = \frac{4 \times W}{N} = \frac{4 \times \_\_\_\_}{\_\_\_\_} =$ [ ] oz·in

Calculate the trial unbalance, U_T:

Trial unbalance, U_T, is between U_{max} and $2 \times U_{max}$ U_{max} to $2 \times U_{max}$ (Selected multiplier is) [ ]

SI units: [ ] to [ ] = [ ] g·mm

USC units: [ ] to [ ] = [ ] oz·in

Calculate the trial mass, W_T:

Trial mass, $W_T = \frac{U_T}{R}$ = [ ] g·mm / [ ] mm or [ ] oz·in / [ ] in = [ ] g or [ ] oz

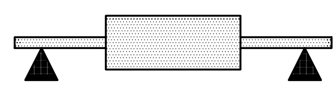
Conversion information:

1 kg = 2.204 6 lbs 1 oz = 28,345 g

Obtain the test data and complete the table:

Position	Trial mass angular location on rotor	Balancing mach readout	
		Amplitude g	**Phase angle** degrees
1	0°		
2	60°		
3	120°		
4	180°		
5	240°		
6	300°		
Repeat 1	0°		

Sketch the rotor configuration:
Rotor sketch



Procedure:

Step 1: Plot the balancing machine amplitude versus trial mass angular rotation on the polar chart (Figure D.2) such that the largest and smallest values fit.

Step 2: The points located on the polar chart should closely approximate a circle. If they do not, then it is probable that the recorded data are in error and the test should be repeated.

Step 3: Determine the maximum and minimum balancing amplitude readings.

Step 4: Using the worksheet (Figure D.2), determine the Y and Z values required for the residual unbalance calculation.

Step 5: Using the worksheet (Figure D.2), calculate the residual unbalance remaining in the rotor.

Step 6: Verify that the determined residual unbalance is equal to or less than the maximum allowable residual unbalance, U_{max}.

HALF KEYS USED FOR ROTOR BALANCING
(add sketch for clarity if necessary)

Location	Mass

Notes:

1) The trial mass angular location should be referenced to a keyway or some other permanent marking on the rotor. The preferred location is the once-per-revolution mark (for the phase reference transducer).

2) The balancing machine amplitude readout for the repeat of 1 should be the same as position 1, indicating repeatability.

3) A primary source of error is not maintaining the same radius for each trial mass location.

Balanced by: ______________ Date ______________ Approved by: ______________ Date ______________

Figure D.1 — Residual unbalance worksheet

Customer: ______________________

Job / Project Number: ______________________

OEM equipment S/N: ______________________

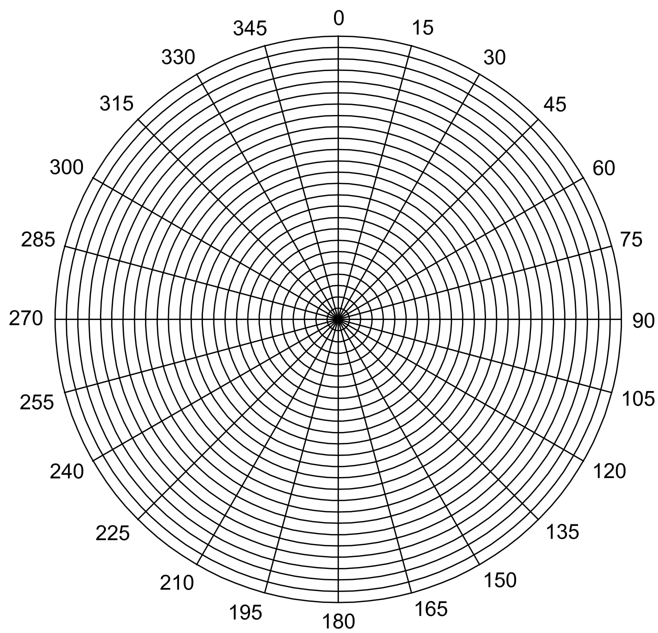
Rotor identification number: ______________________

Repair purchase order number: ______________________

Vendor job number: ______________________

Correction plane (left or right) – use sketch ______________________ plane

Residual unbalance polar plot



Rotor rotation: ☐ CCW ☐ CW Phase is laid out: ☐ CCW ☐ CW

Calculate Y and Z values:

Maximum amplitude value is: ☐ g ☐ oz Minimum amplitude value is: ☐ g ☐ oz

Y = (maximum – minimum) / 2 = (☐ – ☐) / 2 = ☐ g (oz)

Z = (maximum + minimum) / 2 = (☐ + ☐) / 2 = ☐ g (oz)

Residual unbalance left in rotor =

	U_T	×	Y	/	Z	=	
SI units	☐	×	☐	/	☐	=	☐ g·mm
USC units	☐	×	☐	/	☐	=	☐ oz·in

Allowable unbalance tolerance = U_{max} = ☐ g·mm ☐ oz·in

RESULT: Residual unbalance left in rotor is equal to or less than the allowable unbalance tolerance?

☐ PASS ☐ FAIL

☐ As received ☐ Final ☐ Other: ______________________

Balanced by: ____________ Date ____________ Approved by: ____________ Date ____________

Figure D.2 — Polar-plot worksheet for residual unbalance

Customer:	**ABC Refining Co.**	
Job / Project Number:	**00 - 1234**	
OEM equipment S/N:	**C – 1234**	
Rotor identification number:	**1234 C 4320**	
Repair purchase order number:	**PO 12345678**	
Vendor job number:	**Shop – 00 – 1234**	
Correction plane (left or right) – use sketch	**Left**	plane

Balancing speed	**800**	rev/min		
Maximum rotor operating speed, N	**6900**	rev/min		
Static journal mass, W, closest to this correction plane	**530,7**	kg	**1170**	lb
Trial mass radius, R, the radius at which the trial mass is placed	**381**	mm	**15**	in

Calculate maximum allowable residual unbalance, U_{max}, as per 5.7.3.1 or 5.7.3.3:

SI units: $U_{max} = \dfrac{6\,350 \times W}{N} = \dfrac{6\,350 \times \mathbf{530{,}7}}{\mathbf{6\,900}} =$ **488,4** g·mm

USC units: $U_{max} = \dfrac{4 \times W}{N} = \dfrac{4 \times \mathbf{1\,170}}{\mathbf{6\,900}} =$ **0.678** oz·in

Calculate the trial unbalance, U_T:

Trial unbalance, U_T, is between U_{max} and $2 \times U_{max}$ (Selected multiplier is) **1,6**

	U_{max}	to	$2 \times U_{max}$			
SI units:	**488,4**	to	**976,8**	=	**781,4**	g·mm
USC units:	**0.678**	to	**1.356**	=	**1.085**	oz·in

Calculate the trial mass, W_T:

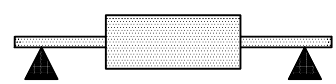
Trial mass, $W_T = \dfrac{U_T}{R} = \dfrac{\mathbf{781{,}4}\ \text{g·mm}}{\mathbf{381}\ \text{mm}}$ or $\dfrac{\mathbf{1.085}\ \text{oz·in}}{\mathbf{15}\ \text{in}}$ = **2,051** g or **0.0723** oz

Conversion information:
1 kg = 2.204 6 lbs 1 oz = 28,345 g

Obtain the test data and complete the table:

Position	Trial mass angular location on rotor	Balancing mach readout	
		Amplitude g	**Phase angle** degrees
1	0 °	**1,60**	**358**
2	60 °	**1,11**	**59**
3	120 °	**1,58**	**123**
4	180 °	**2,21**	**182**
5	240 °	**3,00**	**241**
6	300 °	**2,30**	**301**
Repeat 1	0 °	**1,58**	**359**

Sketch the rotor configuration:
Rotor sketch



Left plane Right plane

HALF KEYS USED FOR ROTOR BALANCING
(add sketch for clarity if necessary)

Location	Mass

Procedure:

Step 1: Plot the balancing machine amplitude versus trial mass angular rotation on the polar chart (Figure D.2) such that the largest and smallest values fit.

Step 2: The points located on the polar chart should closely approximate a circle. If they do not, then it is probable that the recorded data are in error and the test should be repeated.

Step 3: Determine the maximum and minimum balancing amplitude readings.

Step 4: Using the worksheet (Figure D.2), determine the Y and Z values required for the residual unbalance calculation.

Step 5: Using the worksheet (Figure D.2), calculate the residual unbalance remaining in the rotor.

Step 6: Verify that the determined residual unbalance is equal to or less than the maximum allowable residual unbalance, U_{max}.

Notes:

1) The trial mass angular location should be referenced to a keyway or some other permanent marking on the rotor. The preferred location is the once-per-revolution mark (for the phase reference transducer).

2) The balancing machine amplitude readout for the repeat of 1 should be the same as position 1, indicating repeatability.

3) A primary source of error is not maintaining the same radius for each trial mass location.

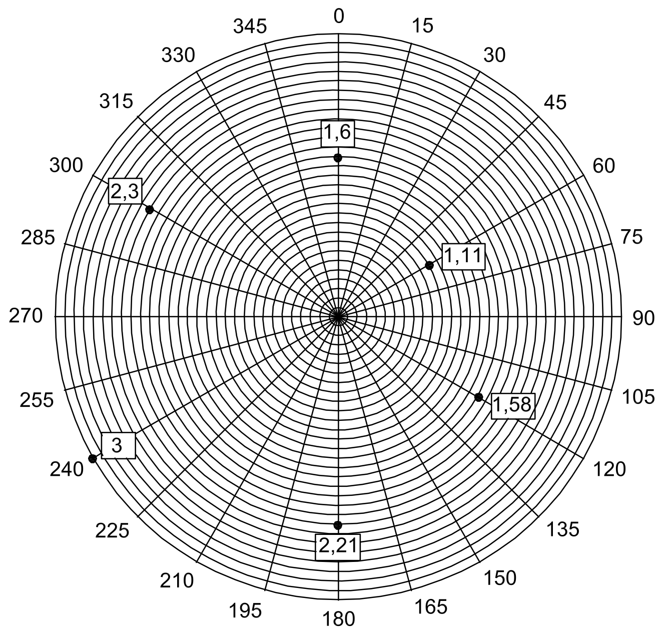
Balanced by: ____________ Date ________ Approved by: ____________ Date ________

Figure D.3 — Sample residual unbalance worksheet — Left plane

These are merely examples for illustration purposes only. Each company should develop its own approach. They are not to be considered exclusive or exhaustive in nature. API makes no warranties, express or implied for reliance on or any omissions from the information contained in this document.

Customer:	**ABC Refining Co.**
Job / Project Number:	**00 – 1234**
OEM equipment S/N:	**C – 1234**
Rotor identification number:	**1234 – C – 4320**
Repair purchase order number:	**PO 12345678**
Vendor job number:	**Shop – 00 – 1234**
Correction plane (left or right) – use sketch	**Left** plane

Residual unbalance polar plot



Rotor rotation: [X] CCW [ ] CW Phase is laid out: [ ] CCW [X] CW

Calculate Y and Z values:

Maximum amplitude value is: **3,00** g Minimum amplitude value is: **1,11** g

Y = (maximum – minimum) / 2 = (**3,00** – **1,11**) / 2 = **0,95** g

Z = (maximum + minimum) / 2 = (**3,00** + **1,11**) / 2 = **2,06** g

Residual unbalance left in rotor =

	U_T	x	Y	/	Z	=		
SI units	**781**	x	**0,95**	/	**2,06**	=	**359,3**	g·mm
USC units	**1.085**	x	**0.034**	/	**0.073**	=	**0.505**	oz·in

Allowable unbalance tolerance = U_{max} = **488,4** g·mm **0.678** oz·in

RESULT: Residual unbalance left in rotor is equal to or less than the allowable unbalance tolerance?

[X] PASS [ ] FAIL

[ ] As received [ ] Final [X] Other: **w/o trim hardware**

Balanced by: **CJ, TR *& RC** Date **5/24/2000** Approved by: **CC** Date **5/24/2000**

Figure D.4 — Sample polar-plot worksheet for residual unbalance — Left plane

These are merely examples for illustration purposes only. Each company should develop its own approach. They are not to be considered exclusive or exhaustive in nature. API makes no warranties, express or implied for reliance on or any omissions from the information contained in this document.

Customer:	**ABC Refining Co.**
Job / Project Number:	**00 - 1234**
OEM equipment S/N:	**C – 1234**
Rotor identification number:	**1234 C 4320**
Repair purchase order number:	**PO 12345678**
Vendor job number:	**Shop – 00 – 1234**
Correction plane (left or right) – use sketch	**Right** plane

Balancing speed	**800**	rev/min		
Maximum rotor operating speed, N	**6900**	rev/min		
Static journal mass, W, closest to this correction plane	**571,5**	kg	**1260**	lb
Trial mass radius, R, the radius at which the trial mass is placed	**203**	mm	**8**	in

Calculate maximum allowable residual unbalance, U_{max}, as per 5.7.3.1 or 5.7.3.3:

SI units: $U_{max} = \frac{6\,350 \times W}{N} = \frac{6\,350 \times \mathbf{571,5}}{\mathbf{6900}} = \mathbf{525,9}$ g·mm

USCunits: $U_{max} = \frac{4 \times W}{(N)} = \frac{4 \times \mathbf{1260}}{\mathbf{6900}} = \mathbf{0.730}$ oz·in

Calculate the trial unbalance, U_T:

Trial unbalance, U_T, is between U_{max} and $2 \times U_{max}$ (Selected multiplier is) **1,6**

	U_{max}	to	$2 \times U_{max}$			
SI units:	**525,9**	to	**1051,9**	=	**841,5**	g·mm
USC units:	**0.730**	to	**1.461**	=	**1.168**	oz·in

Calculate the trial mass (W_T):

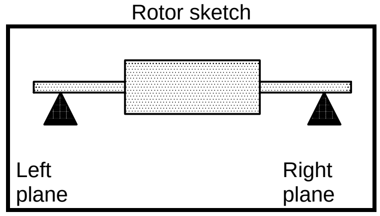
Trial mass (W_T) = $\frac{U_T}{R}$ = $\frac{\mathbf{841,5}\ \text{g·mm}}{\mathbf{203}\ \text{mm}}$ or $\frac{\mathbf{1.168}\ \text{oz·in}}{\mathbf{8}\ \text{in}}$ = **4,14** g or **0.146** oz

Conversion information:
1 kg = 2.204 6 lbs   1 oz = 28,345 g

Obtain the test data and complete the table:

Position	Trial mass angular location on rotor	Balancing mach readout	
		Amplitude g	**Phase angle** degrees
1	0 °	**4,60**	**3**
2	60 °	**4,20**	**58**
3	120 °	**4,70**	**121**
4	180 °	**5,20**	**180**
5	240 °	**5,80**	**235**
6	300 °	**5,10**	**301**
Repeat 1	0 °	**4,60**	**2**

Sketch the rotor configuration:
Rotor sketch



HALF KEYS USED FOR ROTOR BALANCING
(add sketch for clarity if necessary)

Location	Mass

Procedure:

Step 1: Plot the balancing machine amplitude versus trial mass angular rotation on the polar chart (Figure D.2) such that the largest and smallest values fit.

Step 2: The points located on the polar chart should closely approximate a circle. If they do not, then it is probable that the recorded data are in error and the test should be repeated.

Step 3: Determine the maximum and minimum balancing amplitude readings.

Step 4: Using the worksheet (Figure D.2), determine the Y and Z values required for the residual unbalance calculation.

Step 5: Using the worksheet (Figure D.2), calculate the residual unbalance remaining in the rotor.

Step 6: Verify that the determined residual unbalance is equal to or less than the maximum allowable residual unbalance (U_{max}).

Notes:

1) The trial mass angular location should be referenced to a keyway or some other permanent marking on the rotor. The preferred location is the once-per-revolution mark (for the phase reference transducer).
2) The balancing machine amplitude readout for the repeat of 1 should be the same as position 1, indicating repeatability.
3) A primary source of error is not maintaining the same radius for each trial mass location.

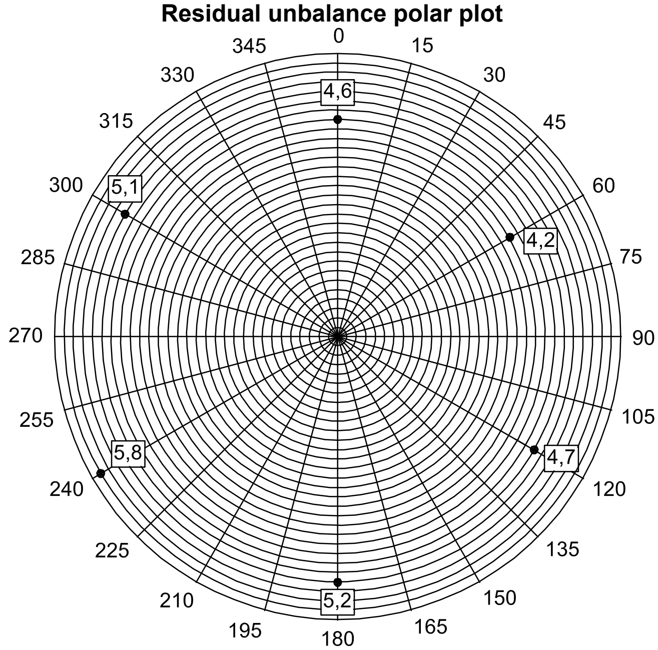
Balanced by: ____________ Date ____________ Approved by: ____________ Date ____________

Figure D.5 — Sample residual unbalance worksheet — Right plane

These are merely examples for illustration purposes only. Each company should develop its own approach. They are not to be considered exclusive or exhaustive in nature. API makes no warranties, express or implied for reliance on or any omissions from the information contained in this document.

Customer:	**ABC Refining Co.**
Job / Project Number:	**00 – 1234**
OEM equipment S/N:	**C – 1234**
Rotor identification number:	**1234 – C – 4320**
Repair purchase order number:	**PO 12345678**
Vendor job number:	**Shop – 00 – 1234**
Correction plane (left or right) – use sketch	**Right** plane

Residual unbalance polar plot



Rotor rotation: [X] CCW [ ] CW

Phase is laid out: [ ] CCW [X] CW

Calculate Y and Z values:

Maximum amplitude value is: **5,80** g Minimum amplitude value is: **4,20** g

Y = (maximum – minimum) / 2 = (**5,80** – **4,20**) / 2 = **0,8** g

Z = (maximum + minimum) / 2 = (**5,80** + **4,20**) / 2 = **5,0** g

Residual unbalance left in rotor =

	U_T	×	Y	/	Z	=		
SI units	**841,5**	×	**0,8**	/	**5**	=	**134,6**	g·mm
USC	**1.168**	×	**0.029**	/	**0.177**	=	**0.191**	oz·in

Allowable unbalance = U_{max} = **525,9** g·mm **0.730** oz·in

RESULT: Residual unbalance left in rotor is equal to or less than the allowable unbalance tolerance?

[X] PASS [ ] FAIL

[ ] As received [ ] Final [X] Other: **w/o trim hardware**

Balanced by: **CJ, TR *& RC** Date **5/24/2000** Approved by: **CC** Date **5/24/2000**

Figure D.6 — Sample polar-plot worksheet for residual unbalance — Right plane

These are merely examples for illustration purposes only. Each company should develop its own approach. They are not to be considered exclusive or exhaustive in nature. API makes no warranties, express or implied for reliance on or any omissions from the information contained in this document.

Annex E
(normative)

Typical schematics for pressurized oil systems for flooded screw compressors

E.1 Requirements for oil systems and oil-system components for flooded and dry screw compressors are detailed in 5.10.

E.2 Schematics for oil systems for dry screw compressors are covered in ISO 10438.

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

E.3 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 Figures E.1, E.2 and E.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.

E.4 Relief valves are illustrated as angle-type, the most common pattern. A straight-through pattern may be used if it is adequate for the required service conditions.

NOTE The oil separator's relief valve is shown on the downstream side of the coalescing filter to minimize oil loss during system depressurization.

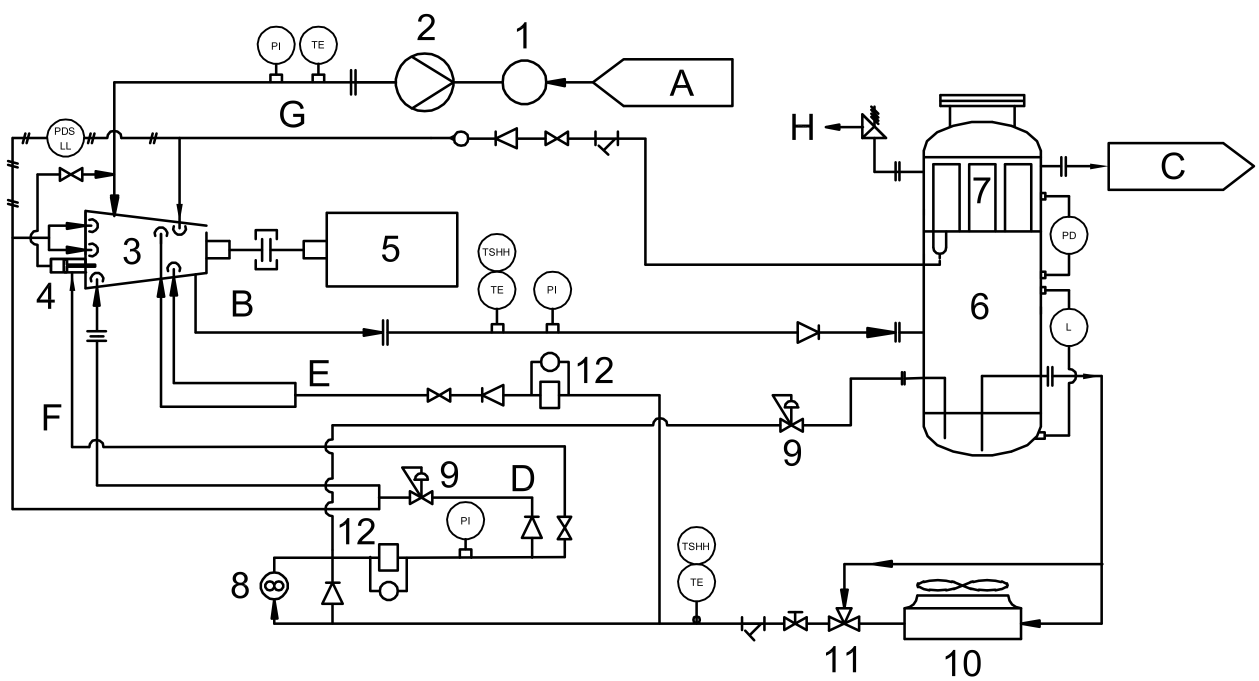
E.5 The oil separator supplied on an oil-flooded screw compressor skid package is a specialized piece of equipment often employing the manufacturer's proprietary internal design features. It is designed to effectively remove the oil entrained in the process-gas stream prior to final process-gas discharge from the package. Oil carryover rates should be agreed by the vendor and the purchaser (see 5.10.3.5.2). 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 E.4 and E.5.

Oil separator orientation may be vertical or horizontal.

E.6 The symbols used on Figures E.1 to E.3 are listed in Table E.1.

Table E.1 — Symbols used on Figures E.1 to E.3

P	Pressure instrument	PI	Pressure indicator
PD	Pressure differential instrument	PDSLL	Pressure differential switch — Very low
T	Temperature instrument	TE	Temperature element
L	Level instrument	TSHH	Temperature switch — Very high



Key

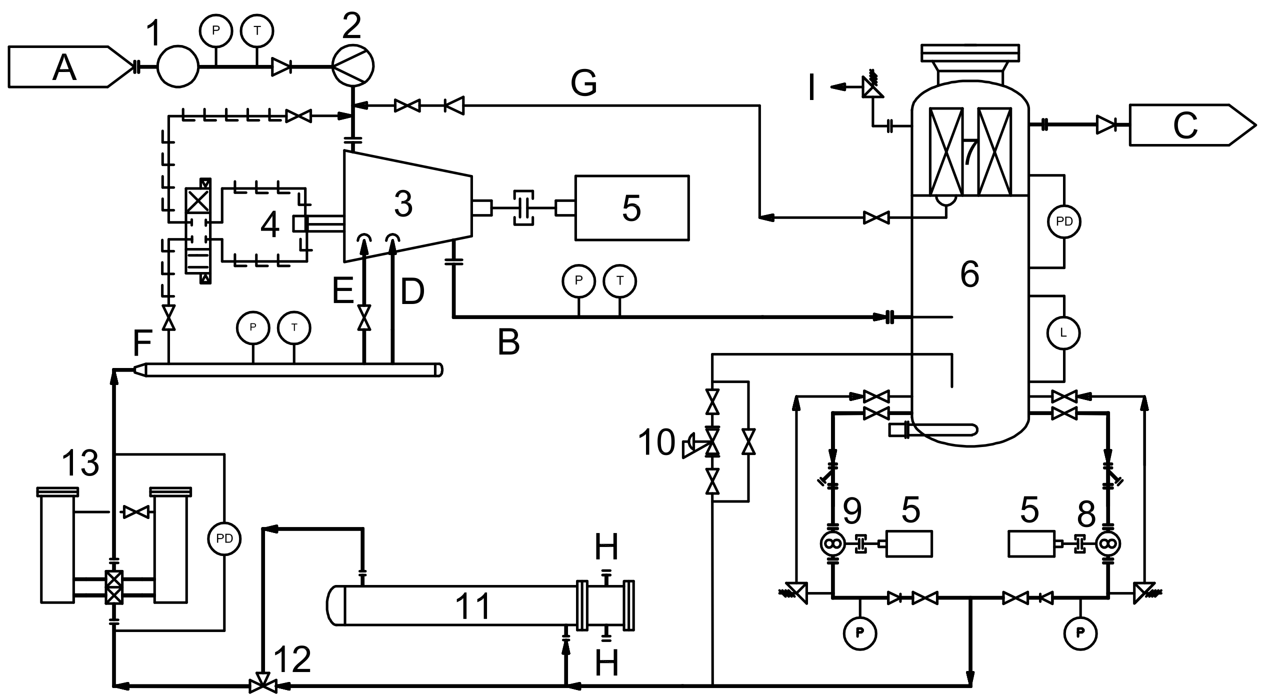
System components

1 inlet scrubber
2 strainer
3 compressor
4 slide valve
5 motor
6 oil separator
7 coalescing element
8 oil pump
9 pressure control valve
10 oil cooler
11 temperature control valve
12 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 relief-valve discharge

Figure E.1 — Typical arrangement 1



Key

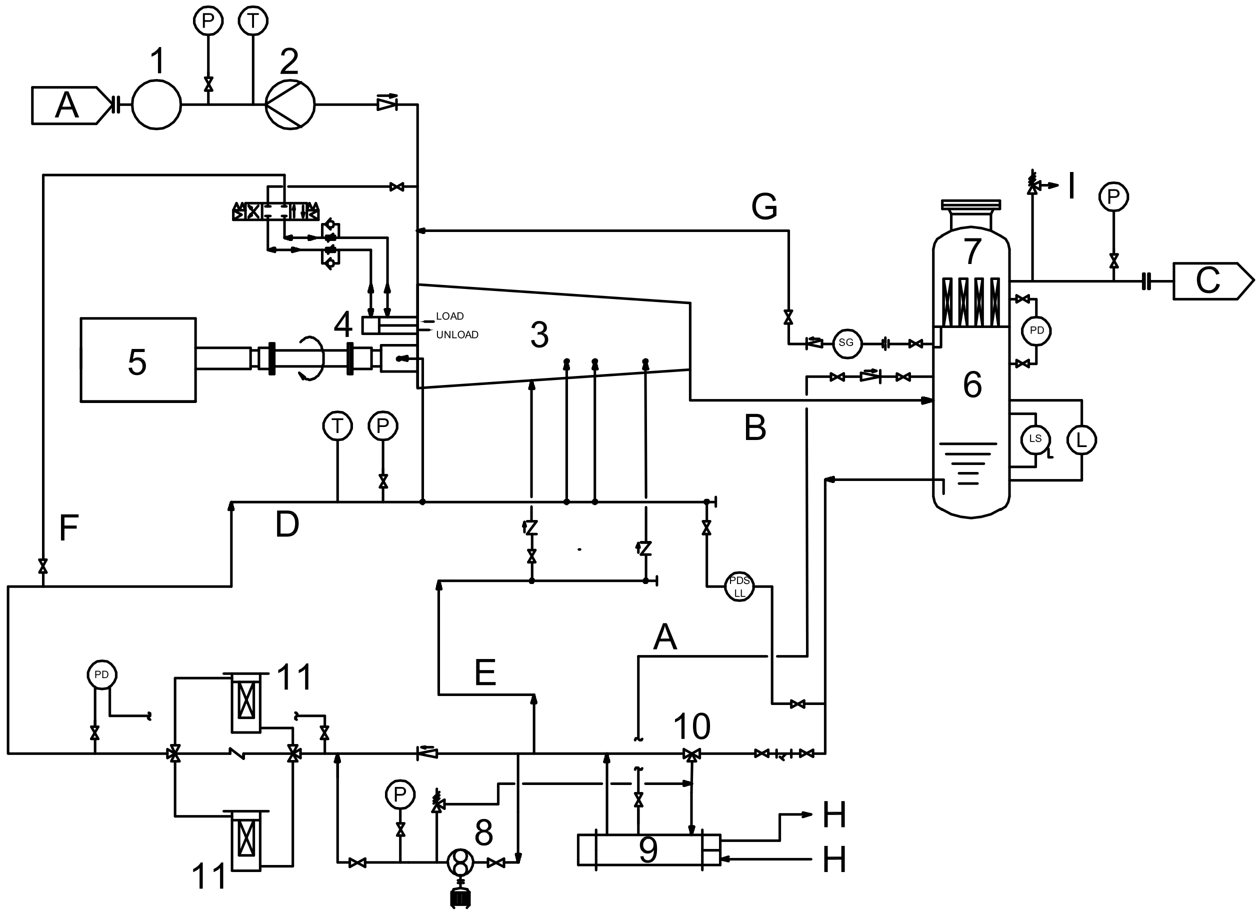
System components

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

Figure E.2 — Typical arrangement 2



Key

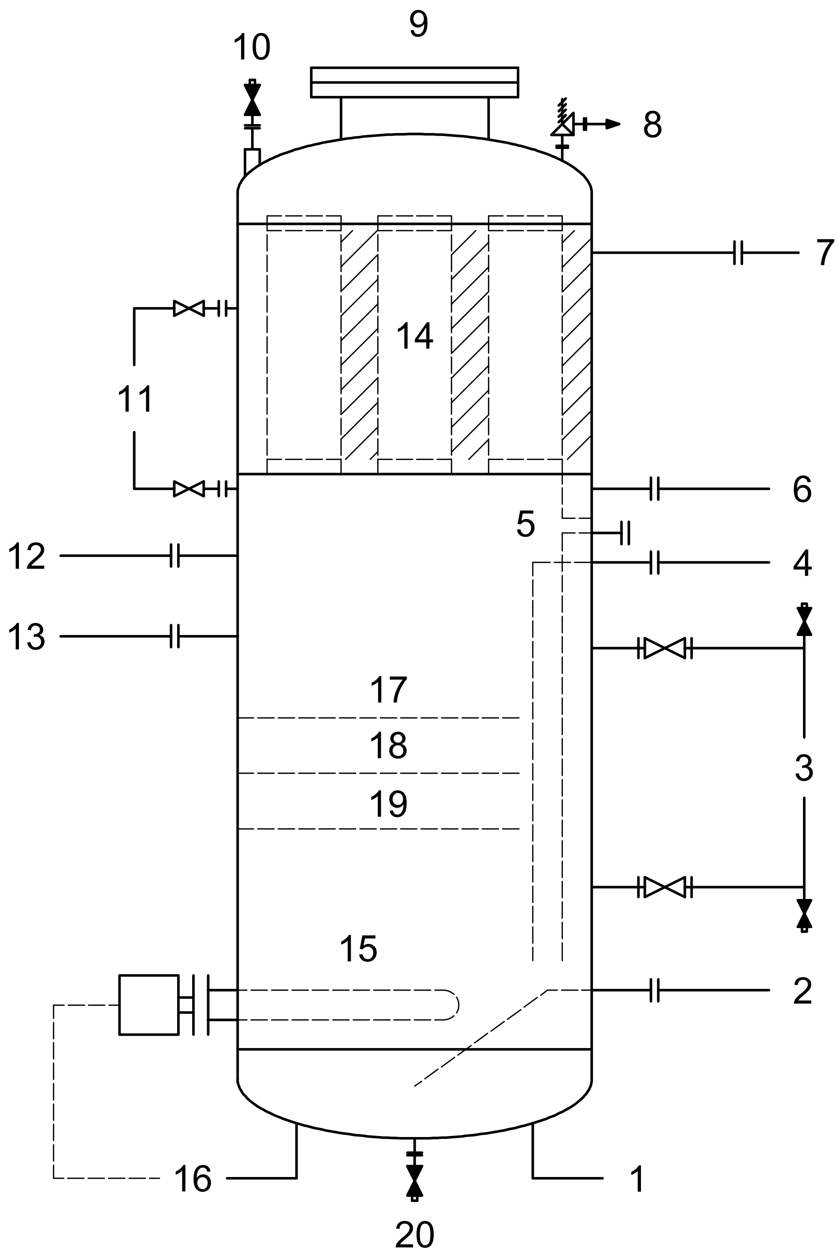
System components

1 inlet scrubber
2 strainer
3 compressor
4 slide valve
5 motor
6 oil separator
7 coalescing element
8 oil pump
9 oil cooler
10 temperature control valve
11 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

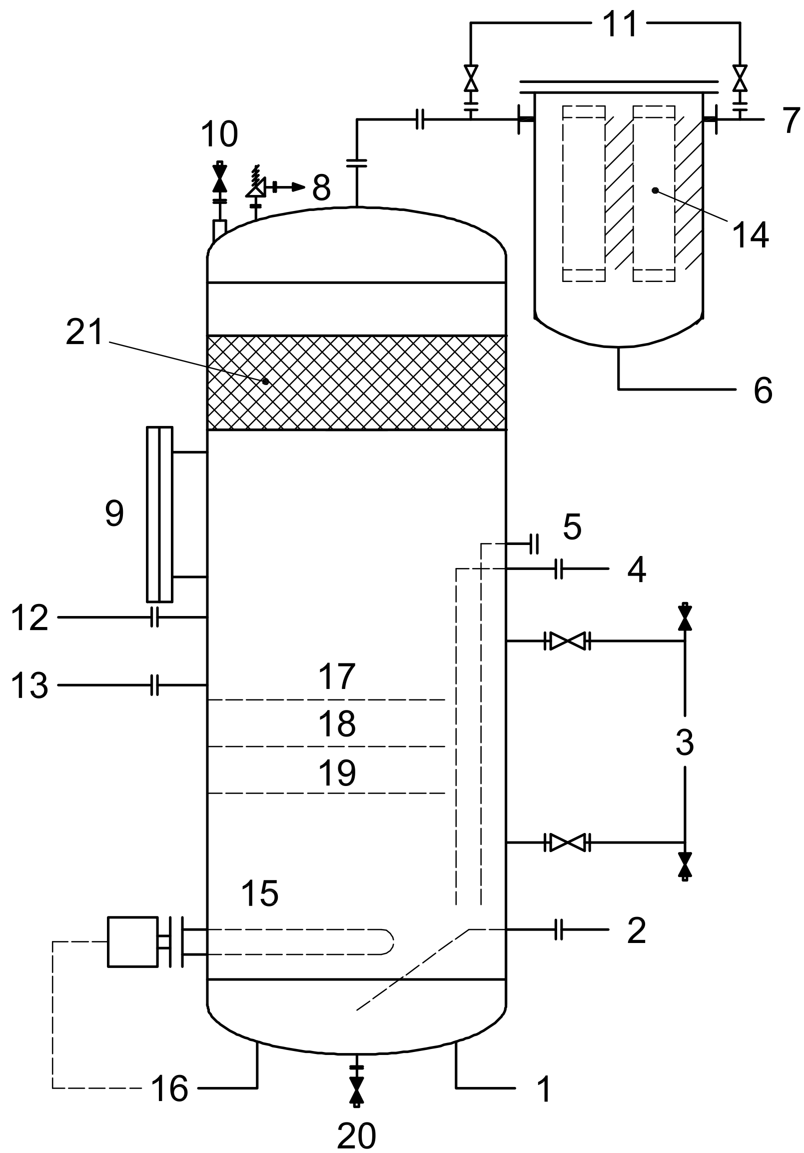
Figure E.3 — Typical arrangement 3



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 E.4 — 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 E.5 — Oil separator with external coalescer chamber

Annex F
(informative)

Materials and their specifications for rotary compressors

CAUTION — Table F.1 is intended as a general guide. See 5.11.1.1 and 5.11.1.2. It should not be used without a knowledgeable review of the specific services involved.

Table F.1 — Materials and their specifications for rotary compressors

Component	**Material**	**Specification**	**Material application** DS = dry screw OF = oil-flooded	**Form**	**Temperature limits of materials[a]** °C Min.	°C Max.	°F Min.	°F Max.
Casing (cast)	Gray iron	ASTM A278 class 40	OF	Cast	– 29	260	– 20	500
	Gray iron	EN 1561 GJL-250	OF & DS	Cast	– 10	250	14	482
	Gray iron	JIS G 5501 FC250	OF	Cast	– 29	232	– 20	450
	Gray iron	JIS G 5501 FC300	OF & DS	Cast	– 29	232	– 20	450
	Gray iron	JIS G 5501 FC350	OF	Cast	– 29	232	– 20	450
	Ductile iron	ASTM A395, grade 60	OF	Cast	– 29	260	– 20	500
	Ductile iron	EN 1563 GGG 40.3	DS	Cast	– 20	300	– 4	572
	Ductile iron	EN 1563 GJS-400-15	OF & DS	Cast	– 10	250	14	482
	Ductile iron	EN 1563 GJS-400-18-LT	OF & DS	Cast	– 20	300	– 4	572
	Steel	ASTM A216 grade WCB	DS & DS	Cast	– 29	400	– 20	750
	Steel	EN 10213 (all parts) GP240 GH	OF & DS	Cast	– 10	300	14	572
	Steel	EN 10213 (all parts) GS-21Mn5	OF	Cast	– 46	343	– 51	649
	Steel	JIS G 5152 SCPL1	OF	Cast	– 45	350	– 49	662
	Steel	JIS G 5152 SCPL11	OF & DS	Cast	– 60	350	– 76	662
	Steel	JIS G 5152 SCPL21	OF	Cast	– 75	200	– 103	392
	Steel	JIS G 5152 SCPL31	OF	Cast	– 100	200	– 148	392
	Steel	JIS G 5202 SCW480	OF & DS	Cast	– 29	399	– 20	750
	Steel	JIS G 5121 SCS13	DS	Cast	– 196	350	– 321	662
	Stainless steel	ASTM A351 grades CF3, CF3M, CF8, CF8M	DS	Cast	– 196	343	– 320	650
	Stainless steel	ASTM A351 grade CF3, CF3M	DS	Cast	– 195	345	– 319	653
	Stainless steel	ASTM A743 grade CA6 - NM	DS	Cast	– 195	345	– 319	653
	Stainless steel	EN 10213 (all parts) GX3 CrNiMo13-4	DS	Cast	– 105	300	– 157	572
	Stainless steel	EN 10213 (all parts) GX5CrNiMoNb19-11-2	DS	Cast	– 200	300	– 328	572
	Stainless steel	JIS G 5121 SCS14	DS	Cast	– 196	350	– 321	662
	Stainless steel	JIS G 5121 SCS5/13Cr-4Ni	DS	Cast	– 196	350	– 321	662
Shaft	Ductile iron	JIS G 5502 FCD700	OF	Cast	– 29	350	– 20	662
	Steel	AISI 1030-1035	OF	Forged	– 29	399	– 20	750
	Steel	AISI 1040-1050	OF & DS	Forged	– 29	343	– 20	650
	Steel	ASTM A350 LF2	OF	Forged	– 45		– 49	
	Steel	ASTM A668 class D - 1030 carbon steel	DS	Forged	– 29	399	– 20	750

Table F.1 (*continued*)

Component	Material	Specification	Material application DS = dry screw OF = oil-flooded	Form	Temperature limits of materials[a]			
					°C		°F	
					Min.	Max.	Min.	Max.
Shaft (continued)	Steel	EN 10083 (all parts) 25 CrMo4	DS	Forged	– 10	300	14	572
	Steel	EN 10083 (all parts) C45N	OF	Forged	– 29	399	– 20	750
	Steel	JIS G 4051 S30C	OF & DS	Forged	– 10	450	14	842
	Steel	JIS G 4051 S45C	OF	Forged	– 10	450	14	842
	Steel	JIS G 4051 S55C	OF	Forged	– 10	450	14	842
	Steel	JIS G 4105 SCM430	DS	Forged	– 30	400	– 22	752
	Steel	SAE1137	OF	Forged	—	—	—	—
	Stainless steel	ASTM A473 type 304L	DS	Forged	– 196	400	– 321	752
	Stainless steel	ASTM A473 type 316L	DS	Forged	– 196	400	– 321	752
	Stainless steel	ASTM A479 class 1 Type 410	DS	Bar	– 59	345	– 75	650
	Stainless steel	EN 10088 (all parts) X3CrNiMo 13-4	DS	Forged	– 105	300	– 157	572
	Stainless steel	EN 10088 (all parts) X17CrNi16-2	DS	Forged	—	—	—	—
	Stainless steel	JIS G 3214 SUS F 6NM/13Cr-4Ni	DS	Forged	– 105	300	– 157	752
	Stainless steel	JIS G 3214 SUS304	DS	Forged	– 196	400	– 321	752
	Stainless steel	JIS G 3214 SUS316	DS	Forged	– 196	400	– 321	752
	Stainless steel	JIS G 3214 SUS405	DS	Forged	– 10	400	14	752
Rotor body	Ductile iron	JIS G 5502 FCD600	OF	Cast	– 29	260	– 20	500
	Ductile iron	JIS G 5502 FCD700	OF	Cast	– 29	350	– 20	662
	Steel	AISI 1030-1045	OF & DS	Forged	– 29	399	– 20	750
	Steel	ASTM A350 LF2	OF	Forged	– 45	149	– 49	300
	Steel	ASTM A668 class D - 1030 carbon steel	DS	Forged	– 29	399	– 20	750
	Steel	EN 10083 (all parts) 25CrMo 4	DS	Forged	– 10	300	14	572
	Steel	EN 10083 (all parts) C45N	OF	Forged	– 29	399	– 20	750
	Steel	JIS G 3221 SFCM 930S	OF	Forged	– 29	399	– 20	750
	Steel	JIS G 4051 S30C	OF & DS	Forged	– 10	450	14	842
	Steel	JIS G 4051 S45C	OF	Forged	– 10	450	14	842
	Steel	JIS G 4051 S55C	OF	Forged	– 10	450	14	842
	Steel	JIS G 4105 SCM430	OF	Forged	– 30	400	– 22	752
	Steel	SAE1137	OF	Forged	—	—	—	—
	Stainless steel	ASTM A473 tYPE 431	DS	Forged	—	—	—	—
	Stainless steel	ASTM A473 type 304L	DS	Forged	– 196	400	– 321	752
	Stainless steel	ASTM A473 type 316L	DS	Forged	– 196	400	– 321	752
	Stainless steel	ASTM A479 class 1 Type 410	DS	Bar	– 59	345	– 75	650
	Stainless steel	EN 10088 (all parts) X3CrNiMo 13-4	DS	Forged	– 105	300	– 157	572
	Stainless steel	JIS G 3214 SUS 405	DS	Forged	– 10	400	14	752
	Stainless steel	JIS G 3214 SUS F 6NM/13Cr-4Ni	DS	Forged	– 105	300	– 157	572
	Stainless steel	JIS G 3214 SUS304	DS	Forged	– 196	400	– 321	752
	Stainless steel	JIS G 3214 SUS316	DS	Forged	– 196	400	– 321	752

Table F.1 (*continued*)

Component	Material	Specification	Material application DS = dry screw OF = oil-flooded	Form	Temperature limits of materials[a]			
					°C		°F	
					Min.	Max.	Min.	Max.
Pulsation devices	Ductile iron	EN 1563 GGG40.3	DS	Cast	– 20	300	– 4	572
	Steel	ASTM A516-60	DS	Plate	—	—	—	—
	Steel	ASTM A516-70 made to A 593	OF & DS	Plate	– 46[b]	—	– 50[b]	—
	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	—
	Steel	EN 10025 (all parts) S235JRG2-1	DS	Plate	– 10	400	14	752
	Steel	EN 10213 (all parts) GP240 GH	DS	Cast	– 10	300	14	572
	Steel	EN 10216 (all parts) P265 GH/HII	DS	Plate	– 10	400	14	752
	Steel	JIS G 3103 SB410	OF & DS	Plate	0	350	32	662
	Steel	JIS G 3103 SB480	OF & DS	Plate	0	350	32	662
	Steel	JIS G 3106 SM400B	OF & DS	Plate	0	350	32	662
	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	DS	Pipe	– 195	—	– 320	—
	Stainless steel	ASTM A312 types 304 and 316	OF & DS	Pipe	– 195	—	– 320	—
	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 SUS304	OF & DS	Plate	– 196	400	– 321	752
	Stainless steel	JIS G 4304 SUS316	OF & DS	Plate	– 196	400	– 321	752

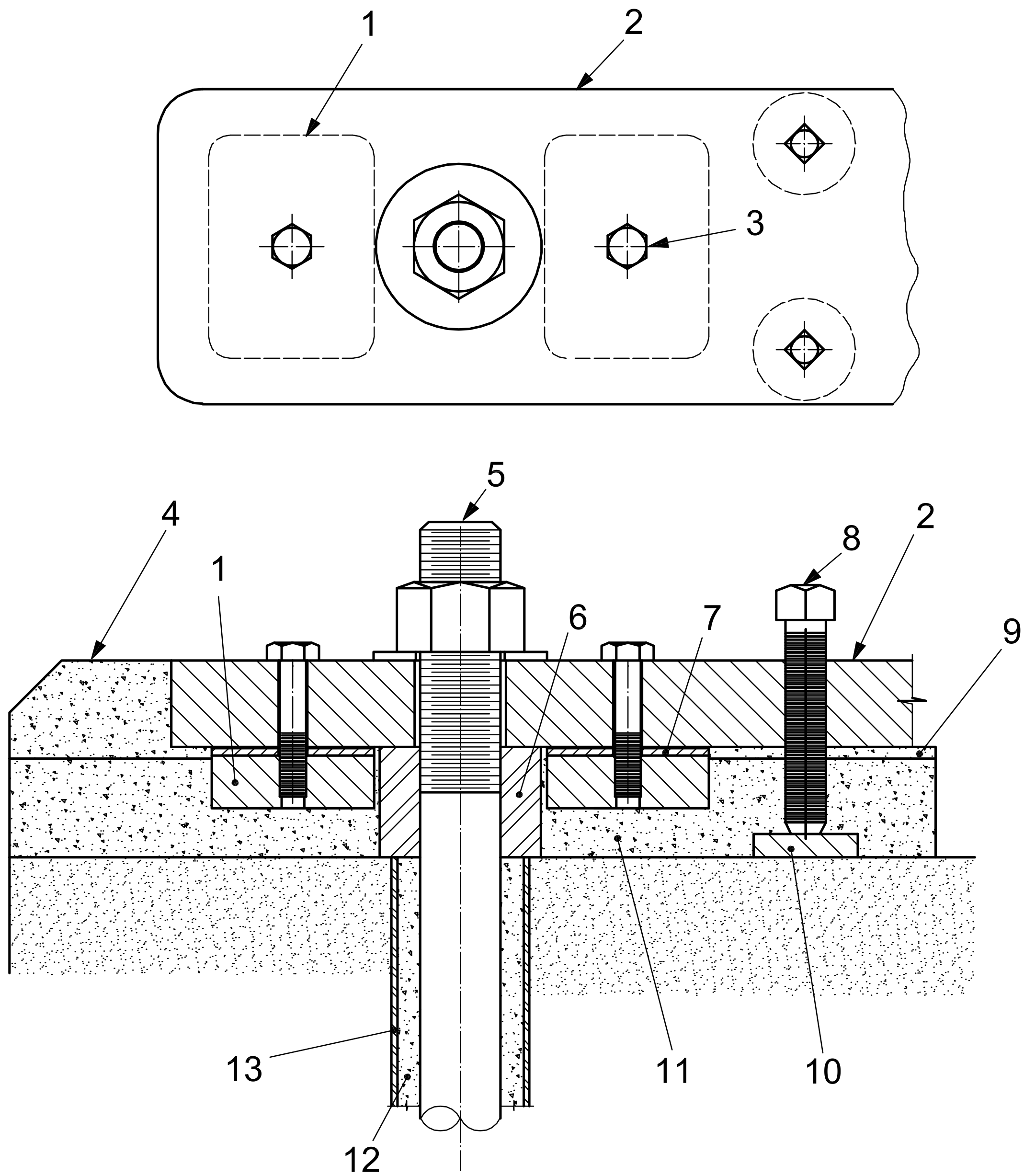
[a] The operating temperature limits of the compressor may be different, but shall be within the temperature limits of the materials.

[b] Shall be impact tested for the operating temperature.

Annex G
(informative)

Typical mounting-plate arrangements

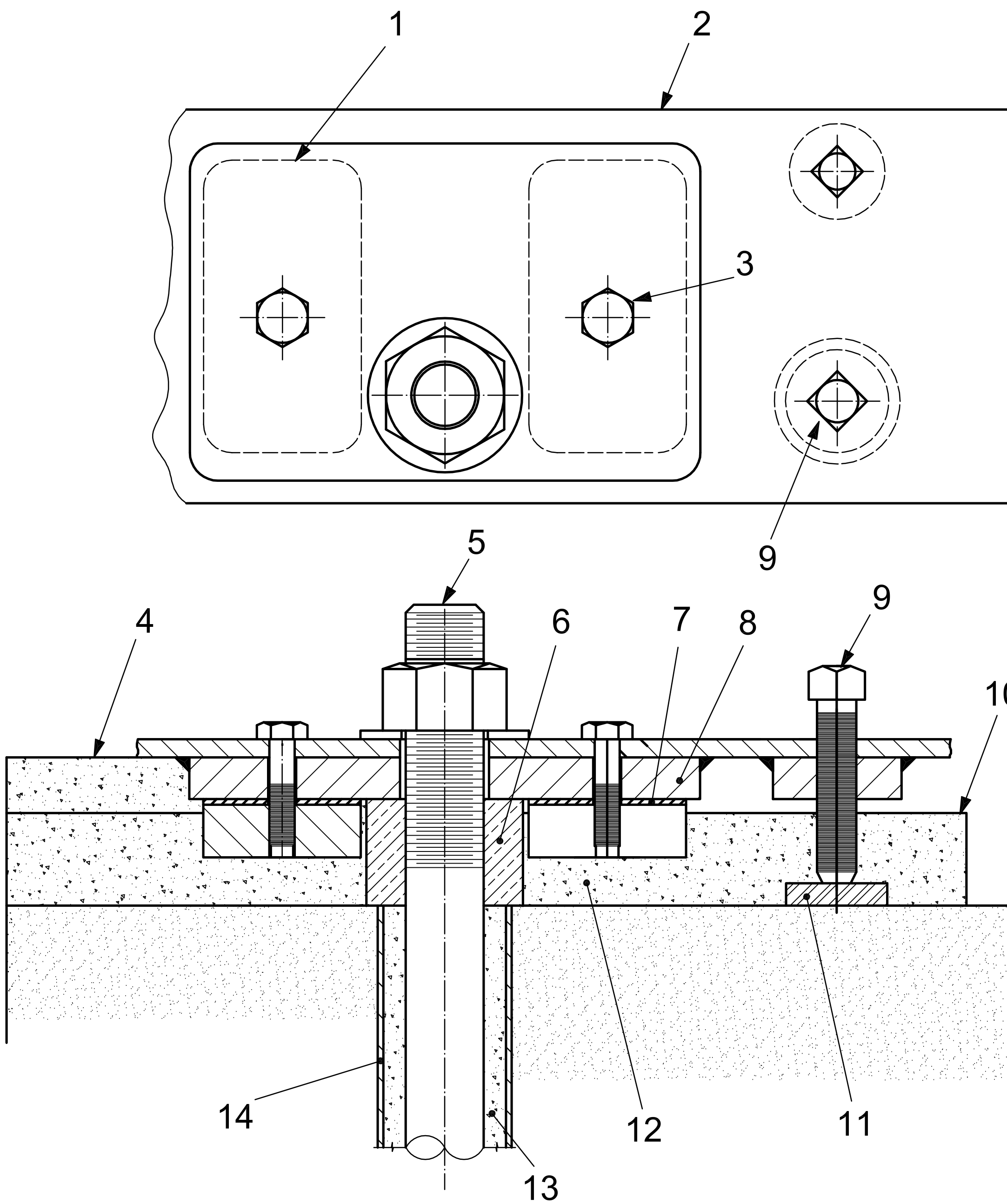
The figures in this annex show the arrangement for soleplates (Figure G.1) and baseplates (Figure G.2).



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 G.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 G.2 — Typical mounting-plate arrangement — Baseplate with subplate

Annex H
(informative)

Inspector's checklist

Item	Reference subclause	Date inspected	Inspected by	Status
Material inspection	7.2.2			
Piping fabrication and installation	6.5.1.1, 6.5.4.2			
Hydrostatic test	7.3.2			
Heat run	7.3.3.5			
Mechanical running test	7.3.3			
Gas leakage test	7.3.3.4.3			
Optional tests:				
Performance test	7.3.4.2			
Complete unit test	7.3.4.3			
Deceleration test	7.3.4.4			
Tandem test	7.3.4.5			
Gear test	7.3.4.6			
Helium test	7.3.4.7			
Sound-level test	7.3.4.8			
Auxiliary-equipment test	7.3.4.9			
Post-test inspection	7.3.4.10			
Full-pressure / full-load / full-speed test	7.3.4.11			
Inspection of hub / shaft fit for hydraulically mounted couplings	7.3.4.12			
Spare parts test	7.3.4.13			
Additional test – as specified				
Examination of internals for cleanliness:	7.2.3			
Piping				
Oil reservoir				
Bearing housings				
Gear housings				
Coolers				
Filters				
Other				
Nameplate and rotation arrows	5.12			
Overall dimensions and connection locations[a]				
Flange dimensions and finish[a]				
Anchor bolt layout and size[a]				

Item	Reference subclause	Date inspected	Inspected by	Status
Preparation for shipment				
Corrosion protection – exterior	7.4.3 a) 7.4.3 b)			
Corrosion protection – interior	7.4.3 c)			
Corrosion protection – lubricated surfaces	7.4.3 d)			
Closures of all openings	7.4.3 g) 7.4.3 h) 7.4.3 i)			
Equipment nameplate data	5.12.4			
Equipment identification	7.4.3 j)			
Piping connections identification (tagging)	7.4.4			
Additional inspections – as required				

[a] Check against certified drawings.

Annex I
(informative)

Typical vendor drawing and data requirements

I.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 I.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)

I.2 Documents

The following list describes the items that are presented alpha-numerically in I.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 centreline 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, centres 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 centreline,

      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 coastdown,

   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, including a residual unbalance report in accordance with Annex D;

ee) rotor combined mechanical and electrical runout in accordance with 5.7.3.8;

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 7.3.4);

ll) installation manual describing the following (see 8.3.5.2):

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 8.3.4;

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 6.10);

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 8.2.2,

4) as-built assembly clearances,

5) spare-parts list in accordance with 8.3.4,

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.

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[3] ANSI/ASA S2.19-1999 (R2004), *American National Standard Mechanical Vibration — Balance Quality Requirements of Rigid Rotors — Part 1: Determination of Permissible Residual Unbalance*

[4] API 683, *Quality Improvement Manual for Mechanical Equipment in Petroleum, Chemical, and Gas Industries*

[5] API 541, *Form-Wound Squirrel Cage Induction Motors — 500 Horsepower and Larger*

[6] API 546, *Brushless Synchronous Machines — 500 kVA and Larger*

[7] ANSI/API 612, *Petroleum, Petrochemical and Natural Gas Industries — Steam Turbines — Special-purpose Applications*

[8] API 614-99, *Lubrication, Shaft-Sealing, and Control-Oil Systems and Auxiliaries for Petroleum, Chemical and Gas Industry Services*

[9] ANSI/API 661, *Air-Cooled Heat Exchangers for General Refinery Services*

[10] ASME Boiler and Pressure Vessel Code, Section VIII, *Pressure Vessels*

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[12] ASTM A515/A515M, *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service*

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[15] ASTM A193/A193M-06, *Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications*

[16] ASTM A194/A194M-06, *Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both*

[17] ASTM A213/A213M, *Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes*

[18] ASTM A216/A216M, *Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service*

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[20] ASTM A307-04, *Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength*

[21] ASTM A312/A312M, *Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes*

[22] ASTM A333/A333M, *Standard Specification for Seamless and Welded Steel Pipe for Low-Temperature Service*

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[30] ASTM A743/A743M, *Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion-Resistant, for General Application*

[31] EN 1561, *Founding — Grey cast irons* [14)]

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[33] EN 10213 (all parts), *Technical delivery conditions for steel castings for pressure purposes*

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[36] EN 10025 (all parts), *Hot rolled products of structural steels*

[37] EN 10216 (all parts), *Seamless steel tubes for pressure purposes — Technical delivery conditions*

[38] JIS G 3103, *Carbon steel and molybdenum alloy steel plates for boilers and pressure vessels* [15)]

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[43] JIS G 4051, *Carbon steels for machine structural use*

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[49] JIS G 5501, *Gray iron castings*

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