Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services

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Foreword

This standard is based on the accumulated knowledge and experience of manufacturers and users of reciprocating compressors. The objective of this publication is to provide a purchase specification to facilitate the procurement and manufacture of reciprocating compressors for use in petroleum, chemical, and gas industry services.

The primary purpose of this standard is to establish minimum requirements.

Energy conservation is of concern and has become increasingly important in all aspects of equipment design, application, and operation. Thus, innovative energy-conserving approaches should be aggressively pursued by the manufacturer and the user during these steps. Alternative approaches that may result in improved energy utilization should be thoroughly investigated and brought forth. This is especially true of new equipment proposals since the evaluation of purchase options will be based increasingly on total life costs as opposed to acquisition cost alone.

Equipment manufacturers, in particular, are encouraged to suggest alternatives to those specified when such approaches achieve improved energy effectiveness and reduced total life costs without the sacrifice of safety or reliability.

This standard requires the purchaser to specify certain details and features. Although it is recognized that the purchaser may desire to modify, delete, or amplify sections of this standard, it is strongly recommended that such modifications, deletions, and amplifications be made by supplementing this standard, rather than by rewriting or incorporating sections thereof into another standard.

A bullet (●) at the beginning of a subsection or paragraph indicates that either a decision by, or further information from, the purchaser is required. Further information should be shown on the data sheets (see example in Annex A) or stated in the quotation request and purchase order.

For effective use of this standard and ease of reference to the text, the use of the data sheets in Annex A is recommended.

The purchaser's checklist in Annex D can also be used for purchaser's specific requirements or decisions.

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

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Shall: As used in a standard, "shall" denotes a minimum requirement in order to conform to the standard.

Should: As used in a standard, "should" denotes a recommendation or that which is advised but not required in order to conform to the standard.

May: As used in a standard, "may" denotes a course of action permissible within the limits of a standard.

Can: As used in a standard, "can" denotes a statement of possibility or capability.

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Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001, standards@api.org.

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Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services

1 Scope

This standard covers the minimum requirements for reciprocating compressors and their drivers for use in petroleum, chemical, and gas industry services for handling process air or gas with either lubricated or nonlubricated cylinders.

Compressors covered by this standard are low- to moderate-speed machines. Also included are related lubrication systems, controls, instrumentation, intercoolers, aftercoolers, pulsation suppression devices, and other auxiliary equipment. Compressors not covered by this standard are as follows:

a) integral gas engine–driven compressors;

b) compressors with single-acting trunk-type (automotive-type) pistons that also serve as crossheads;

c) either plant or instrument-air compressors that discharge at a gauge pressure of 9 bar (125 psig) or below;

d) diaphragm compressors.

2 Normative References

2.1 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) issued at the time of purchase order applies.

API *Measurement of Petroleum Measurement Standards (MPMS)* Chapter 15, *Guidelines for the Use of Petroleum Industry-specific International System (SI) Units*

API Standard 541, *Form-wound Squirrel Cage Induction Motors—375 kW (500 Horsepower) and Larger*

API Standard 546, *Brushless Synchronous Machines—500 kVA and Larger*

API Standard 547, *General-purpose Form-wound Squirrel Cage Induction Motors—185 kW (250 hp) through 2240 kW (3000 hp)*

API Standard 571, *Damage Mechanisms Affecting Fixed Equipment in the Refining Industry*

API Standard 611, *General-purpose Steam Turbines for Petroleum, Chemical, and Gas Industry Services*

API Standard 612, *Petroleum, Petrochemical, and Natural Gas Industries—Steam Turbines—Special-purpose Applications*

API Standard 613, *Special-purpose Gears for Petroleum, Chemical, and Gas Industry Services*

API Standard 614, *Lubrication, Shaft-sealing, and Oil-control Systems and Auxiliaries*

API Standard 616, *Gas Turbines for the Petroleum, Chemical, and Gas Industry Services*

API Standard 660, *Shell-and-Tube Heat Exchangers*

API Standard 661, *Petroleum, Petrochemical, and Natural Gas Industries—Air-cooled Heat Exchangers*

API Standard 670, *Machinery Protection Systems*

API Standard 671, *Special-purpose Couplings for Petroleum, Chemical, and Gas Industry Services*

API Standard 677, *General-purpose, Extruder, and Epicyclic Gear Units for Petroleum, Chemical, and Gas Industry Services*

API Recommended Practice 686, *Recommended Practice for Machinery Installation and Installation Design*

API Standard 688, *Pulsation and Vibration Control in Positive Displacement Machinery Systems for Petroleum, Petrochemical, and Natural Gas Industry Services*

API Recommended Practice 945, *Avoiding Environmental Cracking in Amine Units*

AGMA 9002 [1], *Bores and Keyways for Flexible Couplings (Inch Series)*

ANSI B11.19 [2], *Performance Requirements for Risk Reduction Measures: Safeguarding and Other Means of Reducing Risk*

ANSI B15.1, *Safety Standards for Mechanical Power Transmission Apparatus*

ASME *Boiler and Pressure Vessel Code* [3], *Section V, Nondestructive Examination*

ASME *Boiler and Pressure Vessel Code*, *Section VIII: Rules for Construction of Pressure Vessels, Division 1*

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

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

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

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

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

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

ASME 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 Metric/Inch Standard*

ASME B46.1, *Surface Texture (Surface Roughness, Waviness, and Lay)*

ASME PTC 36, *Measurement of Industrial Noise: Performance Test Codes*

ASTM A193 [4], *Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications*

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

ASTM A216, *Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service*

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[1] American Gear Manufacturers Association, 1001 N. Fairfax Street, Suite 500, Alexandria, Virginia 22314, www.agma.org.

[2] American National Standards Institute, 1899 L Street, NW, Washington, DC 20036, www.ansi.org.

[3] American Society of Mechanical Engineers, Two Park Avenue, New York, New York 10016, www.asme.org.

[4] ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

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

ASTM A278, *Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650 °F (350 °C)*

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

ASTM A388, *Standard Practice for Ultrasonic Examination of Steel Forgings*

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

ASTM A503, *Standard Specification for Ultrasonic Examination of Forged Crankshafts*

ASTM A515, *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service*

ASTM A536, *Standard Specification for Ductile Iron Castings*

ASTM A578, *Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications*

ASTM A609, *Standard Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof*

ASTM A668, *Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use*

ASTM E94, *Standard Guide for Radiographic Examination Using Industrial Radiographic Film*

ASTM E165, *Standard Practice for Liquid Penetrant Examination for General Industry*

ASTM E709, *Standard Guide for Magnetic Particle Testing*

ASTM E1417, *Standard Practice for Liquid Penetrant Testing*

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

IEC 60034 (all parts) [6], *Rotating Electrical Machines*

IEC 60079 (all parts), *Explosive Atmospheres*

IEC 60529, *Degrees of Protection Provided by Enclosures (IP Code)*

IEC 60848, *GRAFCET Specification Language for Sequential Function Charts*

IEEE 841 [7], *IEEE Standard for Petroleum and Chemical Industry—Premium-Efficiency, Severe-Duty, Totally Enclosed Squirrel Cage Induction Motors from 0.75 kW to 370 kW (1 hp to 500 hp)*

ISO 7-1 [8], *Pipe threads where pressure-tight joints are made on the threads—Part 1: Dimensions, tolerances and designation*

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5 American Welding Society, 8669 NW 36 Street, # 130, Miami, Florida 33166, www.aws.org.

6 International Electrotechnical Commission, 3 Rue de Varembé, CH-1211, Geneva 20, Switzerland, www.iec.ch.

7 Institute of Electrical and Electronics Engineers, 3 Park Avenue, 17th Floor, New York, New York 10016, www.ieee.org.

8 International Organization for Standardization, Chemin de Blandonnet 8, CP 401 – 1214 Vernier, Geneva, Switzerland, www.iso.org.

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 286-2, *Geometrical product specifications—(GPS)—ISO code system for tolerances on linear sizes—Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts*

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

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

ISO 1217, *Displacement compressors—Acceptance tests*

ISO 3740, *Acoustics—Determination of sound power levels of noise sources—Guidelines for the use of basic standards*

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

ISO 3746, *Acoustics—Determination of sound power levels and sound energy levels of noise sources using sound pressure—Survey method using an enveloping measurement surface over a reflecting plane*

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

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

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

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

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

ISO 13631, *Petroleum and natural gas industries—Packaged reciprocating gas compressors*

ISO 14120, *Safety of machinery—Guards—General requirements for the design and construction of fixed and movable guards*

NACE [9], *Corrosion Engineer's Reference Book*

NACE MR0103, *Petroleum, Petrochemical and Natural Gas Industries—Metallic Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments*

NACE SP0403, *Avoiding Caustic Stress Corrosion Cracking of Carbon Steel Refinery Equipment and Piping*

NEMA SM 23 (R2002) [10], *Steam Turbines for Mechanical Drive Service* (withdrawn)

NFPA 70 [11], *National Electrical Code (NEC)*

SSPC SP 6 [12]/NACE No. 3, *Commercial Blast Cleaning*

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[9] NACE International (now the Association for Materials Protection and Performance), 15835 Park Ten Place, Houston, Texas 77084, www.ampp.org.

[10] National Electrical Manufacturers Association, 1300 17th St N 900, Arlington, Virginia 22209, www.nema.org.

[11] National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169, www.nfpa.org.

[12] Society for Protective Coatings (now the Association for Materials Protection and Performance), 15835 Park Ten Place, Houston, Texas 77084, www.ampp.org.

2.2 The NOTES following a section are informative.

● **2.3** The equipment supplied to this standard shall comply with either the applicable ISO standards or the applicable US standards, as specified.

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

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

3.1.1
acoustic simulation
The process whereby the one-dimensional acoustic characteristics of fluids and the influence of the reciprocating compressor dynamic flow on these characteristics are modeled, taking into account the fluid properties and the geometry of the compressor and the connected vessels and piping.

NOTE See API 688 for additional information.

3.1.2
active analysis
A portion of the acoustic simulation in which the pressure pulsation amplitudes, due to imposed compressor operation for the anticipated loading, speed range, and state conditions, are simulated (see 3.1.1).

3.1.3
alarm point
A preset value of a measured parameter at which an alarm is actuated to warn of a condition that requires corrective action.

3.1.4
anchor bolts
Bolts used to attach the mounting plate or machine to the support structure (concrete foundation or steel structure).

NOTE See 3.1.15 for definition of hold-down bolts. Also see Figure K.1.

3.1.5
baseplate
A fabricated steel structure designed to provide support to the complete compressor and/or the drive equipment and other ancillaries that may be mounted upon it.

3.1.6
certified point
Point to which the performance tolerances will be applied.

NOTE This is usually the normal operating point, and the vendor will normally require that this point is within the preferred selection range.

3.1.7
crosshead pin load
The algebraic sum of gas load and inertia load on the crosshead pin parallel to the piston rod.

3.1.8
crosshead pin reversal
A change in direction of force in the piston rod loading (tension to compression or vice versa), which results in a load reversal at the crosshead pin during each revolution. This is commonly called “rod reversal.”

3.1.9
design
Manufacturer's calculated parameter.

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

3.1.10
digital simulation
A method using various mathematical techniques on digital computers to achieve the acoustic simulation (see 3.1.1).

3.1.11
drive train
Includes all drive equipment up to the compressor shaft free-end and all components coupled to the free-end of the crankshaft.

3.1.12
fail safe
A 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.

3.1.13
gas load
The force resulting from differential gas pressure acting on the piston differential area.

NOTE Based on internal cylinder pressure.

3.1.14
gauge board
Bracket or plate used to support and display gauges, switches, and other instruments.

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

3.1.15
hold-down bolts (mounting bolts)
Bolts holding the equipment to the mounting plate.

3.1.16
inertia load
Force resulting from the acceleration and deceleration of a reciprocating mass.

NOTE The inertia force with respect to the crosshead pin is the summation of the products of all reciprocating masses (piston and rod assembly, and crosshead assembly, including pin) and their respective acceleration.

3.1.17
informative
Describes part of the standard that is provided for information and is intended to assist in the understanding of use of the standard.

NOTE 1 Compliance with an informative part of the standard is not mandatory.

NOTE 2 An annex may be informative or normative as indicated. See 3.1.33 for definition of normative.

3.1.18
inlet volume flow
The 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, compressor inlet flange, or compressor discharge. Therefore, actual volume flow should not be used interchangeably with inlet volume flow.

3.1.19
local
The location of a device when mounted on or near the equipment or console.

3.1.20
manufacturer
The organization responsible for the design and manufacture of the equipment.

NOTE The manufacturer is often a different entity from the vendor.

3.1.21
manufacturer's rated capacity
The capacity used to size the compressor, which is the quantity of gas, taken into the compressor cylinder at the specified inlet conditions, while the compressor is operating at the specified discharge pressure.

3.1.22
maximum allowable speed
The highest rotational speed at which the manufacturer's design permits continuous operation.

3.1.23
maximum allowable temperature
The maximum continuous temperature for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified maximum operating pressure.

3.1.24
maximum allowable working pressure
MAWP
The maximum continuous pressure for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified maximum operating temperature.

3.1.25
maximum continuous speed
The highest rotational speed at which the machine, as built, is capable of continuous operation with the specified gas at any of the specified operating conditions.

3.1.26
minimum allowable speed
The lowest rotational speed at which the manufacturer's design permits continuous operation with the specified gas at any of the specified conditions.

3.1.27
minimum allowable suction pressure (for each stage)
The lowest pressure (measured at the inlet flange of the cylinder) below which the combined crosshead pin load, gas load, discharge temperature, or crankshaft torque load (whichever is governing) exceeds the maximum allowable value during operation at the set pressure of the discharge relief valve and other specified inlet gas conditions for the stage.

3.1.28
minimum allowable temperature
The lowest temperature for which the manufacturer has designed the equipment (or any part to which the term is referred).

3.1.29
mode shape (of an acoustic pulsation resonance)
The description of the pulsation amplitudes and phase angle relationship at various points in the piping system. Knowledge of the mode shape allows the analyst to understand the pulsation patterns in the piping system (see 3.1.1).

3.1.30
mounting plate
Baseplates, skids, soleplates, and rails.

3.1.31
normal operating point
The point at which usual operation is expected and optimum efficiency is desired. This point is usually the point at which the manufacturer certifies that performance is within the tolerances stated in this standard.

3.1.32
normally open and normally closed
On-the-shelf state of a device (e.g. automatically activated switch or actuated valve).

NOTE 1 The following table gives examples of various devices and their on-the-shelf state.

Device	On-the-shelf State
Electrically activated devices	De-energized position of the device
Automatically activated pressure switch	State of the contacts at ambient pressure
Flow switch	State of the contacts at no flow
Level switch	State of the contacts at no level
Limit switch	State of the contacts at unactuated condition
Speed switch	State of the contacts at 0 rpm

NOTE 2 During operation of the equipment, these devices may be normally energized or actuated; therefore, the state of these devices during operation may not be the same as their on-the-shelf state.

3.1.33
normative
A requirement to be met in order to comply with the standard.

3.1.34
observed
An inspection or test where the purchaser is notified of the timing of the inspection or test and the inspection or test is performed, as scheduled, even if the purchaser or the purchaser's representative is not present.

3.1.35
owner
The final recipient of the equipment.

NOTE In many instances the owner delegates another agent to be the purchaser of the equipment.

3.1.36
panel
An enclosure used to mount, display, and protect gauges, switches, and other instruments.

3.1.37
passive analysis
A portion of the acoustic simulation in which a constant flow amplitude modulation over an arbitrary frequency range is imposed on the system, normally at the cylinder valve locations. The resulting transfer function defines the acoustic natural frequencies and the mode shapes over the frequency range of interest (see 3.1.1).

3.1.38
piston rod drop
A measurement of the position of the piston rod relative to the measurement probe mounting location(s) (typically oriented vertically at the piston rod pressure packing on horizontal cylinders).

3.1.39
piston rod runout
The change in position of the piston rod in either the vertical or horizontal direction as measured at a single point (typically at or near the piston rod pressure packing case) while the piston rod is moved through the outbound portion of its stroke.

NOTE 1 In horizontal compressors, the piston rod runout is measured in both the vertical and horizontal directions. Horizontal runout is taken on the side of the rod to determine horizontal variations, while vertical runout is taken on the top of the rod to determine vertical variations.

NOTE 2 Practical considerations make it advisable to monitor the runout measurements while rotating the shaft through one complete revolution.

NOTE 3 See Annex C for a detailed discussion of piston rod runout.

3.1.40
pressure casing
The composite of all stationary pressure-containing parts of the unit, including all nozzles and other attached parts.

3.1.41
pressure design code
The recognized pressure vessel standard specified or agreed upon by the purchaser. For example, a recognized standard for pressure vessels is ASME *Boiler and Pressure Vessel Code* (*BPVC*) Section VIII.

3.1.42
purchaser
The agency that issues the order and specification to the vendor.

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

3.1.43
Ra
Arithmetic average of the absolute value of the profile height deviations recorded within the evaluation length and measured from the mean line.

NOTE 1 Adapted from ASME B46.1-2009, paragraph 1.4.1.1.

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

3.1.44
rails
Soleplates extending the full length of each side of the equipment.

3.1.45
rated discharge pressure
The highest pressure required to meet the conditions specified by the purchaser for the intended service.

3.1.46
rated discharge temperature
The highest predicted operating temperature resulting from any specified operating condition.

3.1.47
rated speed
The highest rotational speed required to meet any of the specified operating conditions.

3.1.48
relief valve set pressure
The pressure at which a relief valve starts to lift.

3.1.49
remote
The location of a device when located away from the equipment or console, typically in a control room.

3.1.50
required capacity
The process capacity specified by the purchaser to meet process conditions, with no-negative tolerance (NNT) permitted.

NOTE 1 The required capacity is the quantity of gas taken into the compressor cylinder at the specified inlet conditions, while the compressor is operating at the specified discharge pressure and speed.

NOTE 2 See Annex B for an explanation of the term “no-negative tolerance.”

3.1.51
rolled thread
Thread produced by the action of a form tool that when pressed into the surface of a blank displaces material radially.

3.1.52
settling-out pressure
The pressure within the compressor system when the compressor is shut down without depressuring of the system.

3.1.53
shutdown set point
A preset value of a measured parameter at which automatic or manual shutdown of the system or equipment is required.

3.1.54
skid
A baseplate that has sled-type runners for ease of relocation.

3.1.55
soleplates
Plate attached to the foundation, with a mounting surface for equipment or for a baseplate.

3.1.56
special tool
A tool that is not a commercially available catalog item.

3.1.57
standard volume flow
The flow rate expressed in volume flow units at one of the specified standard conditions as follows:

ISO 13443 Standard Conditions (Natural Gas Standard Reference Conditions)

Flow:	Cubic meters per hour (m^3/h) Cubic meters per minute (m^3/min)
Pressure:	1.01325 bar
Temperature:	15 °C
Relative humidity:	Dry

US Standard Conditions

Flow:	Standard cubic feet per minute (scfm) Million standard cubic feet per day (mmscfd)
Pressure:	14.696 psi
Temperature:	60 °F
Relative humidity:	Dry

NOTE Use of standard volume flow is discouraged due to the many various standard conditions in usage. Standard volume flow should be referenced to the appropriate standard conditions used or should also be supplied with mass flow to prevent conversion errors by those using the data.

3.1.58
total indicator reading (also known as total indicated runout)
TIR
The difference between the maximum and minimum readings of a dial indicator or similar device, monitoring a face or cylindrical surface during one complete revolution of the monitored surface.

NOTE For a cylindrical surface, the indicator reading implies an eccentricity equal to half the reading. For a perfectly flat face, the indicator reading gives an out-of-squareness equal to the reading. If the diameter in question is not cylindrical or flat, interpretation of the TIR is more complex and can be affected by ovality or lobing.

3.1.59
trip speed
The speed at which the independent emergency overspeed device actuates to shut down a variable-speed prime mover. For the purposes of this standard, the trip speed of alternating current electric motors, except adjustable frequency drives, is the speed corresponding to the synchronous speed of the motor at the maximum supply frequency (see Table 2).

3.1.60
unit responsibility
Obligation for coordinating the documentation, delivery, and technical aspects of all the equipment and all auxiliary systems included in the scope of the order.

NOTE The technical aspects to be considered include, but are not limited to, 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.

3.1.61
vendor
Manufacturer or manufacturer's agent 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.

3.1.62
witnessed
An inspection or test where the purchaser is notified of the timing of the inspection or test and a hold is placed on the inspection or test until the purchaser or the purchaser's representative is in attendance.

3.2 Acronyms and Abbreviations

BPVC	*Boiler and Pressure Vessel Code*
EFRC	European Forum for Reciprocating Compressors
MAWP	maximum allowable working pressure
NNT	no-negative tolerance
SI	International System of Units
TIR	total indicator reading
USC	United States customary
VDDR	vendor drawing and data requirements

4 General

4.1 Unit Responsibility

The vendor who has unit responsibility shall ensure that all subvendors comply with the requirements of this standard and all referenced documents.

4.2 Unit Conversion

The factors in API *MPMS* Ch. 15 were used to convert from United States customary (USC) units to International System of Units (SI). The resulting exact SI units were then rounded off.

4.3 Nomenclature

A guide to reciprocating compressor nomenclature is presented in Annex I.

5 Requirements

5.1 Units of Measure

The data, drawings, nameplates, hardware (including fasteners), and equipment supplied to this standard shall use either the SI or USC system of measurement, as specified.

5.2 Language

All vendor data, drawings, and nameplates shall be in English or other language, if specified.

5.3 Statutory Requirements

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

5.4 The hierarchy of documents shall be specified.

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

6 Basic Design

6.1 General

6.1.1 Equipment Reliability

- **6.1.1.1** Only equipment that is field proven, as defined by the purchaser, is acceptable.

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

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

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

6.1.2 The vendor shall advise in the proposal any component designed for finite life.

NOTE It is recognized that these are design criteria.

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

- **6.1.4** The purchaser shall specify all operating conditions for the equipment. The equipment's normal operating point shall be as specified. Unless otherwise specified, the capacity at the normal operating point shall have NNT.

NOTE 1 Operating conditions can include start-up, shutdown, commissioning, transient, and part-load.

NOTE 2 Operation with alternate gases such as nitrogen can have adverse effects on valves, pulsation suppression system, motor sizing, and capacity control system design.

NOTE 3 See Annex B for a discussion of capacity and the term "no-negative tolerance."

6.1.5 Compressors driven by induction motors shall be rated at the actual motor speed for the rated load condition, not at synchronous speed.

- **6.1.6** The pressure design code shall be specified.

- **6.1.7** Control of the sound pressure level 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. ISO 3740, ISO 3744, and ISO 3746 or ASME PTC 36 may be consulted for guidance.

6.1.8 Unless otherwise specified, cooling water system or systems shall be designed for the conditions of Table 1.

Table 1—Cooling System Conditions

Parameter	Requirement	
	SI Units	USC Units
For heat exchangers		
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) (gauge)	≥ 700 kPa (7 bar)	≥ 100 psig
Test pressure (≥ 1.5 MAWP)	≥ 1050 kPa (10.5 bar)	≥ 150 psig
Maximum pressure drop	100 kPa (1 bar)	15 psi
Maximum inlet temperature	30 °C	90 °F
Maximum outlet temperature	50 °C	120 °F
Maximum temperature rise	20 K	30 °F
Minimum temperature rise	10 K	20 °F
Water side fouling factor	0.35 m^2K/kW	0.002 $hr\text{-}ft^2\text{-}°F/Btu$
Corrosion allowance for carbon steel shells	3 mm	$^1/_8$ in.
For cylinder jackets and packing cases		
Maximum allowable working pressure (MAWP) (gauge)	≥ 500 kPa (5 bar)	≥ 75 psig
Test pressure (≥ 1.5 MAWP)	≥ 750 kPa (7.5 bar)	≥ 115 psig

The vendor shall notify the purchaser if the criteria for minimum temperature rise and velocity over heat exchange surfaces results 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.

6.1.9 Provisions shall be made for complete venting and draining of the jacket water system.

6.1.10 Equipment shall be designed to run simultaneously at the relief valve and trip speed settings without damage.

NOTE There can be insufficient driver power to operate under these conditions (see 7.1.1).

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

6.1.12 Reciprocating compressors should normally be specified for constant-speed operation in order to avoid excitation of torsional, acoustic, and/or mechanical resonances. When adjustable-speed drivers are used, all equipment shall be designed to run safely throughout the operating speed range, up to and including the trip speed. For adjustable-speed drives, a list of undesirable running speeds shall be furnished to the purchaser by the vendor. The occurrence of undesirable speeds in the operating range shall be minimized.

NOTE Valve life may be affected if a wide operating speed range is specified.

6.1.13 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.

Table 2—Driver Trip Speeds

Driver Type	Trip Speed (% of Maximum Continuous Speed)
Steam turbine	
NEMA Class A [a]	115 %
NEMA Class B, C, D [a]	110 %
Gas turbine	105 %
Adjustable-speed motor	110 %
Constant-speed motor	102 %
Reciprocating engine	110 %

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

● **6.1.14** Motors, electrical components, and electrical installations shall be suitable for the area classification (Class, Group, Division, or Zone and Temperature Code) specified and shall meet the requirements of IEC 60079 and IEC 60529 (or NFPA 70, Articles 500, 501, 502, and 504), as well as any local codes as specified. On request the purchaser will furnish copies of local codes.

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

6.1.16 All equipment shall be designed to permit rapid and economical maintenance. Major parts such as cylinders, distance pieces, and compressor frames shall be designed and manufactured to ensure accurate alignment on reassembly. This can be accomplished by methods such as shouldering, using cylindrical dowels, or keys.

6.1.17 The purchaser is responsible for the civil design of the compressor system.

● **6.1.18** If specified, an initial installation check by the vendor's representative and an operating temperature alignment check at a later date shall be performed. The details and scope of the check shall be agreed. Such checks shall include, but not be limited to, initial alignment check, grouting, crankshaft web deflection, piston-rod runout, driver alignment, motor air gap, outboard bearing insulation, bearing checks, and piston end clearance.

6.1.19 The power required by the compressor at the normal operating point shall not exceed the stated power by more than 3 %.

6.1.20 Compressors shall be capable of developing the maximum differential pressure specified.

● **6.1.21** The equipment, including all auxiliaries, shall be suitable for operation under the environmental conditions specified. These 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. The scope of winterization and/or tropicalization (e.g. allowances for insulation) shall be agreed.

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

● **6.1.23** The purchaser shall specify flow, gas composition, dew point, and gas conditions. The purchaser can also specify molecular weight, ratio of specific heats (C_p/C_v), and compressibility factors (Z).

NOTE Specified flow at discharge conditions is the mass flow minus any condensation that occurs in the interstage(s).

6.1.24 Unless otherwise specified, the vendor shall use the specified values of flow, the specified gas composition, and the specified gas conditions to calculate molecular weight, ratio of specific heats (C_p/C_v), and compressibility factors (Z). The compressor vendor shall indicate values on the data sheets with the proposal and use them to calculate performance data.

NOTE The dew point of the gas is particularly important in nonlubricated applications.

6.1.25 If any of the compressor cylinders are to be operated partially or fully unloaded for extended periods of time, the purchaser and the vendor shall jointly determine the method to be used (e.g. periodic, momentary loading to purge accumulation of lube oil in the compressor cylinders) to prevent heat and liquid damage.

● **6.1.26** The compressor vendor shall confirm that the unit is capable of continuous operation at any full-load, part-load, or fully unloaded conditions (see 6.1.25) and that the unit is capable of start-up in accordance with 7.1.1.6. If specified, 100 % unloading shall be furnished as part of the system by the supplier.

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

NOTE See E.3.4 for parts list requirements.

6.2 Bolting

6.2.1 Details of threading shall conform to ISO 261, ISO 262, ISO 724, and ISO 965 or ASME B1.1. The use of fine pitch threads shall be avoided in external fasteners subject to routine maintenance, fasteners for pressure retaining parts, and fasteners in cast iron. Fasteners of diameters equal to or greater than 24 mm (1 in.) shall be of the constant 3 mm pitch (8 threads/in.) series.

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

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

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

6.2.4 Manufacturer's marking shall be located on all fasteners 6 mm ($^1/_4$ in.) and larger (excluding washers and headless setscrews). For studs, the marking shall be on the exposed stud end. Fasteners manufactured in accordance with NACE material requirements shall be clearly and permanently marked as such, and their correct locations shall be identified in the installation and maintenance manuals.

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

6.2.5 Bolting on reciprocating or rotating parts shall be positively locked mechanically (spring washers, tab washers, and anaerobic adhesives shall not be used as positive locking methods) unless preload is achieved by hydraulic tensioning or other well-defined methods that generates the exact prestress (see 6.10.1 or 6.10.2.1).

NOTE Locking device is not a substitute for proper preload.

6.2.6 External studs for hydraulic tensioning shall have a protective cover on exposed threads.

6.2.7 Thread engagement in tapped holes shall be at least 1.5 times the fastener nominal diameter.

6.3 Calculating Cold Runout

6.3.1 For horizontal compressors, the vendor shall provide the expected horizontal and vertical cold runout before the shop bar-over test. The manufacturer shall disclose the assumptions used in the calculations.

The vertical tolerance applied to the expected runout shall not exceed ±0.015 % of stroke. The horizontal tolerance shall not exceed 0.064 mm (0.0025 in.), regardless of length of stroke. The expected cold horizontal and vertical rod runout shall be confirmed during the shop bar-over test and shown on the rod runout table. Piston rod runout shall be measured adjacent to the cylinder packing case flange.

NOTE See Annex C for clarification of rod runout and typical rod runout table.

6.3.2 For nonhorizontal cylinders, the procedures and tolerances for runout measurements shall be agreed.

● 6.4 Allowable Speeds

Compressors shall be conservatively rated at a speed less than or equal to that known by the manufacturer to result in low maintenance and trouble-free operation under the specified service conditions. The maximum acceptable average piston speed and the maximum acceptable rotating speed can be specified where experience indicates that specified limits should not be exceeded for a given service.

NOTE Generally, the rotating speed and piston speed of compressors in nonlubricated services may be less than those in equivalent lubricated services.

6.5 Allowable Discharge Temperature

6.5.1 Unless otherwise specified, the maximum predicted discharge temperature shall not exceed 135 °C (275 °F). This limit applies to all specified operating and load conditions. The vendor shall provide the purchaser with both the predicted and adiabatic discharge temperature rise.

For hydrogen-rich services (molecular weight less than or equal to 12) or nonlubricated cylinders, the predicted discharge temperature shall not exceed 120 °C (250 °F).

The discharge temperature shall be reviewed at all loading points.

NOTE 1 The predicted discharge temperature can differ from the adiabatic discharge temperature depending on factors such as the power input to a cylinder, the ratio of compression, the size of the cylinder, and the effect of the coolant. Hydrogen services generally have higher discharge temperatures because of internal leakage and the unusual characteristic of hydrogen, which can release heat when it expands.

NOTE 2 Temperature limits apply to specified operating conditions. Relief valve settings are not included.

6.5.2 A high discharge temperature alarm device shall be provided for each compressor cylinder. The set points and the mode of operation shall be agreed.

The recommended discharge temperature high and high-high alarms are 20 K (40 °F) and 30 K (50 °F) above the maximum predicted discharge temperature. Temperature shutdown, if applied, shall not exceed 175 °C (350 °F). To prevent autoignition, lower temperature limits should be considered for oxygen-bearing gasses.

NOTE A risk assessment may require a high temperature shutdown.

6.6 Crosshead Pin and Gas Loads

6.6.1 The crosshead pin load shall not exceed the manufacturer's maximum allowable continuous crosshead pin load at any specified operating load step. These crosshead pin loads shall be calculated on the basis of the set point pressure of the discharge relief valve of each stage and of the lowest specified suction pressure corresponding to each load step.

6.6.2 The gas load shall not exceed the manufacturer's maximum allowable continuous gas load for the compressor static frame components (cylinders, heads, distance pieces, crosshead guides, crankcase, and bolting) at any specified operating load step. These loads shall be calculated on the basis of the set point pressure of the discharge relief valve of each stage and of the lowest specified suction pressure corresponding to each load step.

6.6.3 The crosshead pin loads and the gas loads shall be calculated for each 5-degree interval of one crankshaft revolution for each specified load step on the basis of internal cylinder pressures using valve and gas passage losses and gas compressibility factors corresponding to the internal cylinder pressure and temperature conditions at each crank angle increment.

6.6.4 For all specified operating load steps, fully unloaded condition and at relief valve set pressures, the crosshead pin loading shall fully reverse between the crosshead pin and bushing during each complete revolution of the crankshaft. The machine shall be designed for continuous operation at a minimum reversal of 15 degrees of crank angle and a 3 % load magnitude. The 3 % load magnitude is based on the peak crosshead pin load in the opposite direction.

NOTE This reversal is required to maintain proper lubrication between the crosshead pin and bushing.

6.7 Critical Speeds

6.7.1 The compressor vendor shall perform the necessary torsional studies to demonstrate the elimination of any torsional vibrations that may hinder the operation of the complete unit within the specified operating speed range in any specified loading step. The vendor shall provide copies of the studies and shall inform the purchaser of all critical speeds from zero to trip speed or synchronous speed that occur during acceleration or deceleration (see E.2.3.3, item m).

6.7.2 With the exception of belt-driven units, the vendor shall provide a torsional analysis of all machines furnished. Torsional natural frequencies of the complete driver-compressor system (including couplings and any gear unit) shall not be within 10 % of any operating shaft speed and within 5 % of any multiple of operating shaft speed in the rotating system up to and including the tenth multiple.

6.7.3 For drive trains that include a turbine and gear, the requirements of API 611, API 612, API 613, and API 616, as applicable, shall govern in calculation and evaluation of critical speeds. For units requiring the use of a low-speed quill shaft and coupling, a separate lateral critical speed analysis shall be performed. Any lateral critical speed of a quill shaft shall be separated by at least 20 % from any operating speed of any shaft in the system.

6.7.4 When torsional resonances are calculated to fall within the margin specified in 6.7.2, 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 driver-compressor system. The assumptions and acceptance criteria for this analysis shall be agreed.

6.8 Compressor Cylinders

6.8.1 General

6.8.1.1 The maximum allowable working pressure (MAWP) of the cylinder shall be at least equal to the specified relief valve set pressure. If a set pressure is not specified, the MAWP of the cylinder shall exceed the maximum stage discharge gauge pressure by at least 10 % or 1.7 bar (25 psig), whichever is greater.

6.8.1.2 Unless otherwise specified, horizontal cylinders shall be used for compressing saturated gases or for gases carrying injected flushing liquids. All horizontal cylinders shall have bottom discharge connections. Other cylinder arrangements may be considered with the approval of the purchaser. In these cases, manufacturer shall provide the purchaser with an experience list for similar services.

NOTE Liquid in any form has detrimental effect on cylinder valve life and potentially on piston rod pressure packing and piston ring life.

6.8.1.3 Cylinders shall be spaced and arranged to permit access for operating and removal for maintenance of all components (including water jacket access covers, distance piece covers, packing, crossheads, pistons, valves, unloaders, or other controls mounted on the cylinder) without removing the cylinder, the process piping, or pulsation suppression devices.

6.8.1.4 Single-acting, step piston, or tandem cylinder arrangements may be provided if accepted by the purchaser at the time of purchase. For such cylinder arrangements, special consideration shall be given to ensure crosshead pin load reversal (see 6.6.4).

6.8.1.5 Unless otherwise specified, each cylinder shall have a replaceable dry-type liner, not contacted by the coolant. Liners shall be at least 9.5 mm ($^3/_8$ in.) thick for bore diameters up to and including 250 mm (10 in.). For bore diameters larger than 250 mm (10 in.), the minimum liner thickness shall be 12.5 mm ($^1/_2$ in.).

Liners shall be secured to prevent axial movement or rotation. The liner fit to the cylinder bore shall be designed to enhance heat transfer and dimensional stability.

NOTE 1 Liners may be replaced if damaged or worn during operation.

NOTE 2 Replaceable dry-type liners allow the use of alternate materials as a wear surface to maximize piston ring and rider band performance. See 6.8.1.8.

NOTE 3 Noncontacting vertical labyrinth type pistons do not necessarily need a replaceable liner.

6.8.1.6 The surface finish of the running bore of the cylinder liners and cylinders without liners shall be 0.1 µm to 0.6 µm (4 µin. to 24 µin.) Ra (arithmetic average roughness). The actual surface finish requirement is dependent on the choice of cylinder liner material, coatings, operating conditions, and the degree of lubrication.

● **6.8.1.7** If specified, the running bore of cylinders shall be honed using a hone surface of the same material as the rider bands and/or piston rings. The hone surface material and the method of application shall be mutually agreed.

NOTE During commissioning of cylinders, particularly nonlubricated cylinders, monitor excessive early rider band wear to prevent damage to the cylinder liner. After the initial run-in period, rider band wear normally decreases significantly.

6.8.1.8 The walls of cylinders without liners (see 6.8.1.5) shall be thick enough to provide for reboring to a total of 3.0 mm ($^1/_8$ in.) increase over the original diameter. The increase in piston diameter shall not affect the cylinder MAWP, the maximum allowable continuous gas load, and the maximum allowable continuous crosshead pin load.

NOTE 1 If a liner is not used, the piston wear surface is part of the pressure containment boundary.

NOTE 2 Unlined cylinders may be over-bored or may require replacement.

6.8.1.9 The use of tapped bolt 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 tapped holes.

6.8.1.10 Bolting shall be furnished as specified in 6.2.

6.8.1.11 Cylinder heads, stuffing boxes for piston rod pressure packing, clearance pockets, and valve covers shall be fastened with studs. The fastening configuration shall be designed so that these component parts can be removed without removing any studs.

6.8.1.12 Cylinder supports shall be designed to avoid misalignment and resulting excessive rod runout during the warm-up period and at actual operating temperature. The support shall not be attached to the outboard cylinder head, unless agreed. The cylinder support design shall be flexible in the direction of the piston rod center line to allow for the thermal growth and axial stretch of the cylinder along this line. The pulsation suppression devices shall not be used to support the compressor cylinder.

6.8.1.13 Where valve covers with radial captured O-rings are used, two extra-long studs 180 degrees apart shall be provided for each cover to ensure the cover O-ring clears the cylinder valve-port bore before the valve cover clears the studs. Extra-long studs shall be capable of having a full-threaded nut when the O-ring is clear of cylinder valve-port sealing bore.

6.8.1.14 Valve cage designs shall be of the cylindrical type held in place by a circular contact cover. Center-bolt design shall not be furnished (see Annex I for preferred approach).

6.8.1.15 The surface finish of valve port O-ring sealing surfaces shall not exceed an arithmetic average roughness Ra of 1.6 µm (64 µin.). Valve ports shall include an entering bevel for the O-ring.

6.8.1.16 Drain connections shall be supplied on external bottles used as clearance pockets.

6.8.2 Cylinder Connections

6.8.2.1 General

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

6.8.2.1.2 All connections shall be flanged or machined and studded, except where threaded connections are permitted by 6.8.2.1.5. All connections shall be suitable for the MAWP of the cylinder. Flanged connections may be integral with the cylinder or, for cylinders of weldable material, formed by butt-welded pipe nipple or transition piece and shall terminate with a welding-neck flange. Socket welded connections shall not be used.

6.8.2.1.3 Connections welded to the cylinder shall meet the material requirements of the cylinder, including impact values. All welding of connections shall be completed before the cylinder is hydrostatically tested (see 8.3.2).

6.8.2.1.4 Butt-welded connections, size DN 40 ($1^1/_2$ NPS) and smaller, shall be reinforced or gusseted.

6.8.2.1.5 For connections other than main process connections, threaded connections for pipe sizes not exceeding DN 40 ($1^1/_2$ NPT) may be used with purchaser's approval in the following cases:

a) on nonweldable materials, such as cast iron;

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

6.8.2.1.6 Pipe nipples screwed or welded to the cylinder should be no more than 150 mm (6 in.) long and shall be a minimum of Schedule 160 seamless for sizes DN 25 (1 NPS) and smaller and a minimum of Schedule 80 for DN 40 ($1^1/_2$ NPS).

6.8.2.1.7 The nipple and flange materials shall meet the requirements of 6.14.7.9.

● **6.8.2.1.8** Pipe threads, where permitted, shall be taper threads in accordance with ISO 7-1 or ASME B1.20.1 as specified. If ISO 7-1 has been specified, tapered or straight internal threads shall also be specified.

6.8.2.1.9 Threaded connections shall not be seal welded.

6.8.2.1.10 Threaded openings not to be connected to piping shall be plugged with solid, round-head steel plugs in accordance with ASME B16.11. As a minimum, these plugs shall meet the material requirements of the pressure casing (or cylinder). Plugs with the possibility of later removal shall be of a corrosion-resistant material. Plastic plugs shall not be used. A process compatible thread lubricant of proper temperature specification shall be used on all threaded connections. Thread tape shall not be used.

6.8.2.1.11 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. Studs and nuts shall be furnished installed.

6.8.2.1.12 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, except for noncircular cylinder connections described in 6.8.2.2.1, shall be approved by the purchaser. Unless otherwise specified, the vendor shall supply mating flanges, studs, and nuts for these nonstandard connections.

6.8.2.1.13 Studded connections shall be furnished with studs installed. Threads at both ends of each stud shall be removed to allow the stud end to bottom in the hole. Anaerobic adhesive or similar epoxy bonding agents shall not be used.

6.8.2.1.14 To minimize nozzle loading and facilitate installation of piping, each main flange shall be parallel to the plane shown on the general arrangement drawing to within 0.5 degrees. Studs or bolt holes shall straddle centerlines parallel to the main axes of the equipment.

6.8.2.1.15 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.

6.8.2.1.16 The finish of the gasket contact surfaces shall conform to ISO 7005-1 or ISO 7005-2 or ASME B16.5.

● **6.8.2.1.17** Each cylinder shall be provided with a DN 12 (NPT $^1/_2$) indicator tap at each end. If specified, each cylinder shall be provided with a flanged indicator tap at each end.

● **6.8.2.1.18** If specified, indicator valves shall also be provided. If indicator valves are not furnished, the tapped indicator holes shall be plugged in accordance with 6.8.2.1.10 and flanged connections shall be blinded.

● **6.8.2.1.19** Lube oil injection passages to the cylinder bore shall be drilled through a metal boss provided in the cylinder water jacket casting or weldment. If specified, cylinders for nonlubricated service shall not be drilled and tapped for lube oil injection.

6.8.2.2 Flanges

6.8.2.2.1 Flanges shall conform to ISO 7005-1 or ISO 7005-2 or ASME B16.1, ASME B16.5, ASME B16.42, or ASME B16.47 Series B as applicable, except as specified in 6.8.2.2.2 through 6.8.2.2.7 (see 6.8.2.1.16 for facing finish requirements). The details of any special connections, such as a lens joint, shall be submitted to the purchaser for review (see Annex E). For low-pressure cylinders, where noncircular connections are used, the vendor shall supply inlet and discharge transition pieces with the termination flange consistent with the agreed flange standards. The transition pieces shall be of the same grade of material as, or of a higher grade of material than the cylinder. The vendor shall supply all gaskets, studs, and nuts between the cylinder and transition piece.

6.8.2.2.2 Cast, ductile, and malleable iron flanges shall be flat faced and conform to the dimensional requirements of ASME B16.1 or ASME 16.42 or ISO 7005-2 as specified. PN 20 (Class 125) flanges shall have a minimum thickness equal to PN 50 (Class 250) for sizes DN 200 (NPS 8) and smaller.

6.8.2.2.3 Steel flanges shall conform to the dimensional requirements of IS0 7005-1, ASME B16.5, or ASME B16.47.

6.8.2.2.4 Nonferrous flanges shall conform to agreed standards.

6.8.2.2.5 Flat-face flanges with full raised face thickness are permitted on cylinders of all materials. Flanges in all materials that are thicker or have a larger outside diameter than required by the applicable flange standards are permitted. The dimensions of nonstandard (oversized) flanges shall be shown on the arrangement drawing in full detail.

NOTE Flat-faced flanges, in lieu of recessed or female face flanges, are typically needed to permit removal of the cylinder without removing or springing piping or pulsation suppression devices. Ring type joints and lens type joints should be discussed between the purchaser and the vendor on a special requirement basis.

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

6.8.2.2.7 The flange gasket contact surface shall not have mechanical damage that penetrates the root of the grooves for a radial length of more than 30 % of the gasket contact width.

6.8.3 External Forces and Moments

The vendor shall define the maximum allowable nozzle loads at the vendor interfaces. These loads shall be referred to a coordinate system as shown on a drawing.

6.9 Valves and Unloaders

6.9.1 Valves

6.9.1.1 Average valve gas velocity shall be calculated as shown in Equation (1):

In SI units

$$W = F \times c_m / f \tag{1}$$

where

W is the average gas velocity in m/s;

F is the effective area of the cylinder bore; the area of the cylinder bore nearest the compressor crankshaft is the area of the crank-end of the cylinder bore less the cross-sectional area of the compressor piston rod in cm^2;

f is the product of the valve geometric lift area and the number of inlet or discharge valve per cylinder in cm^2;

c_m is the average piston speed in m/s.

In USC units

$$V = 288 \times D / A$$

where

V is the average gas velocity in ft/min;

D is the piston displacement per cylinder in ft^3/min;

A is the product of the valve geometric lift area and the number of inlet or discharge valves per cylinder in $in.^2$

The valve lift used in Equation (1) shall be shown on the data sheets.

If the lift area is not the smallest area in the flow path of the valve, that condition shall be noted on the data sheet and the velocity shall be computed on the basis of the smallest area. Velocities calculated from Equation (1) should not be confused with effective velocities based on crank angle, degree of valve lift, unsteady flow, and other factors.

NOTE The velocity computed from Equation (1) is not necessarily a representative index for valve power loss or disk/plate impact.

6.9.1.2 Valve and unloader designs shall be suitable for operation with all gases specified. Each individual unloading device shall be provided with a visual indication of its position and its load condition (loaded or unloaded).

6.9.1.3 The valve design shall be such that valve assemblies cannot be inadvertently interchanged or reversed. For example, it shall not be possible to fit a suction valve assembly into a discharge port, nor a discharge valve assembly into a suction port, nor shall it be possible to insert a valve assembly upside down.

6.9.1.4 Valve assemblies (seat and guard) shall be removable for maintenance. Valve-to-cylinder gaskets shall be solid metal. Valve-cover-to-cylinder sealing may be achieved with gaskets (either solid metal, flexible graphite type, or metal jacketed) or with O-ring type seals.

6.9.1.5 The valve and cylinder designs shall be such that neither the valve guard nor the assembly bolting can fall into the cylinder even if the valve assembly bolting breaks or unfastens. Hanging-guard type valves require purchaser approval.

6.9.1.6 All under-slung valves shall be provided with a retention device to hold the complete valve assembly in position while the cover is removed or installed.

6.9.1.7 The ends of coil-type valve springs shall be squared and ground to protect the plate against damage from the spring ends.

6.9.1.8 The vendor shall conduct a valve dynamic study to optimize the valve element motion, impacts, and efficiencies. The study shall include a review of all operating gas densities and load conditions. The report shall define the assumptions used in the study.

6.9.1.9 When nonmetallic valve plates or disks are furnished, flatness and surface finish shall be controlled so that adequate sealing occurs in operation. The vendor shall provide the properties of nonmetallic valve element materials. These properties shall include usable temperature range, chemical compatibility, and material type. Metal valve disks or plates, nonmetallic valve plates or disks, when furnished, shall be suitable for installation with either side sealing and shall be finished on both sides to an Ra of 0.4 µm (16 µin.) or better. Valve seats and sealing surfaces shall also be finished to an Ra of 0.4 µm (16 µin.) or better.

6.9.2 Unloaders

● **6.9.2.1** If cylinder valve unloading is required, the type of unloader provided (finger-, port-, or plug-type) shall be specified. Valve assembly lifters shall not be used. When finger-type valve unloaders are used for capacity control, all inlet valves of the cylinder end involved shall be so equipped. Use of less than a full complement of suction valve finger-type unloaders requires the purchaser's approval.

6.9.2.2 Where plug-type unloaders are used for capacity control, the number of unloaders is determined by the area per plug opening, the total of which shall be equal to or greater than half of the total geometric lift area of all suction valves on that end. The unloader assembly shall positively guide the plug to the seat.

6.9.2.3 When unloaders are used only for start-up and not for capacity control, consideration should be given to using a reduced number of unloaders.

● **6.9.2.4** Unloaders shall be pneumatically, hydraulically, or electromechanically actuated as specified. Individual hand-operated unloaders or manual overrides on actuated unloaders shall not be used. The vendor shall provide the user with information regarding the proper sequencing for unloader operation. See 7.8.2.4.

NOTE Malfunctioning and/or incorrect sequencing of unloaders can result in compressor damage.

6.9.2.5 For turbine-driven, geared applications, cylinder unloaders shall be provided on each cylinder end for emergency shutdown.

6.9.2.6 Unloaders shall be designed so that the operating fluid used for unloading cannot mix with the gases being compressed, even in the event of failure of the diaphragm or another sealing component. A threaded gas vent connection shall be provided at the stem packing.

6.9.2.7 Unloader sliding push rods exposed to atmospheric conditions shall be of corrosion-resistant material.

6.10 Pistons, Piston Rods, and Piston Rings

6.10.1 Connection of Piston-to-Piston Rod

Pistons that are removable from the rod shall be attached to the rod by a shoulder and nut(s) design or a multi-through-bolt design. Other proven attachment methods may be used, and in such cases, they shall be noted in the proposal. Mechanical or hydraulic methods are acceptable for tightening piston nuts. Slugging (hammer) wrenches shall not be used for this procedure.

As a basic requirement, the manufacturer's tightening procedure shall ensure a minimum preload in the connection of 1.5 times the maximum allowable continuous gas loading.

6.10.2 Connection of Piston Rod to Crosshead

6.10.2.1 Piston rods shall be connected to the crosshead by the following:

a) a direct connection, where the rod is threaded into the crosshead (e.g. jam nut design or a multi-jackbolt jam nut design), or

b) an indirect connection, where the rod is not threaded into the crosshead.

The attachment method shall be described in the proposal. Mechanical or hydraulic methods are acceptable for tightening. Slugging wrenches for this procedure shall not be used.

6.10.2.2 Positive locking of the nut shall be provided for direct connection methods. Where preload is achieved by hydraulic or multi-jackbolt tensioning methods, which ensure the proper preload, positive locking is not required.

6.10.2.3 The manufacturer's tightening procedure shall ensure a minimum preload in the connection equal to 1.5 times the maximum allowable continuous pin load minus the inertial effects of the crosshead.

6.10.3 Pistons

6.10.3.1 Hollow pistons (single piece or multi-piece) shall be continuously self-venting; i.e. they shall depressure when the cylinder is depressurized. Acceptable methods of venting include a hole located in the head-end face of the piston in the form of a single hole 3 mm ($^1/_8$ in.) in diameter, a hole at the bottom of the piston ring groove, or a spring-loaded relief plug in the outer-end face of the piston.

6.10.3.2 All pistons shall be supplied with nonmetallic rider bands. Rider bands shall be designed to prevent them acting as piston rings.

NOTE Vertical cylinders with labyrinth pistons may not require rider bands.

● **6.10.3.3** Piston ring grooves shall be wear-resistant.

6.10.3.4 For nonlubricated, horizontal cylinders, the bearing load calculated from Equation (2) on rider bands shall not exceed 0.035 N/mm^2 (5 lbf/in.^{2}) based on the mass of the entire piston assembly plus half the mass of the rod divided by the projected area of a 120° arc of all rider bands [see Equation (2)].

For lubricated horizontal cylinders, the bearing load calculated from Equation (2) on rider bands, if used, shall not exceed 0.07 N/mm^2 (10 lbf/in.^{2}).

$$L_B = \frac{M_{PA} + (M_R/2)}{(0.866 \times D \times W)} \quad (2)$$

where

L_B is the bearing load on rider band in N/mm^2 (lbf/in.^{2});

M_{PA} is the weight of piston assembly in N (lbf);

M_R is the weight of piston rod in N (lbf);

D is the cylinder bore diameter in mm (in.);

W is the total width of all rider bands in mm (in.).

NOTE When meeting the bearing load requirement results in an excessively wide rider band, multiple rider bands are preferred.

6.10.3.5 Rider bands shall not overrun single-hole valve ports or liner counter-bores by more than half the width of the rider band. When the cylinder configuration leads the rider band to overrun the valve ports by more than half the band width, the port design shall be of the multiple-drilled-hole type to provide sufficient support for the rider band.

6.10.4 Piston Rods

6.10.4.1 Unless otherwise specified, all piston rods, regardless of base material, shall be coated with a wear-resistant material. The material and surface treatment of piston rods shall be chosen to maximize rod and piston rod pressure packing life and shall be proposed by the vendor at the time of purchase for the purchaser's acceptance. Coatings shall comply with 6.10.4.2. Piston rod base material and coatings for use in corrosive environments shall be suitable for the service and operating conditions specified.

Uncoated piston rod may be proposed when the expected life equals or exceeds that of a coated rod for the specified operating conditions. Uncoated piston rods shall be surface-hardened in the packing area to a hardness of at least Rockwell C50 and shall be inspected for cracking by magnetic particle examination.

6.10.4.2 When coatings are used, piston rods shall be continuously coated from the piston rod packing through the oil wiper travel areas. The coating material shall be properly sealed to prevent corrosion of the base material at the interface of the coating. Techniques that require temperatures high enough to permanently affect the mechanical characteristics of the base material shall not be used. High-velocity and high-impact thermal coating processes are acceptable for the coating of piston rods. Metal spray techniques requiring roughening of the surface of the base metal shall not be used. Use of a subcoat (other than a binder layer) under the main coating shall not be used.

Piston rods that have been previously induction-hardened shall not be coated with a wear-resistant material over the induction-hardened case.

6.10.4.3 The base material of piston rods used in H_2S service shall be in accordance with NACE MR0103 (see 6.14.1.9). When this requirement results in insufficient surface hardness for wear resistance, a proven surface treatment or coating shall be proposed for purchaser's approval.

6.10.4.4 Tolerances for finished rods shall be 12.5 µm (0.0005 in.) for roundness and 25 µm (0.001 in.) for diametral variation over the length of the rod.

The surface finish in the packing areas for lubricated and nonlubricated services shall be 0.15 µm to 0.4 µm (6 µin. to 16 µin.) Ra.

NOTE Smoother finishes can be considered for high pressures or for particular material combinations where experience indicates that such finishes can result in improved performance.

6.10.4.5 Piston rods with threads shall be furnished with rolled threads having a polished thread relief area.

6.10.4.6 The vendor shall state in the proposal the rod material and type of connection (see Figure F.5, Figure F.6, and Figure F.7).

6.10.4.7 Threads shall be rolled after heat treatment. If NACE MR0103 is applied, the rod material will be considered acceptable as long as the base hardness and yield strength remain within the specified NACE values. An increase in hardness around thread surface due to thread rolling is acceptable as long as the base hardness meets NACE requirements.

6.10.4.8 The use of tail rods requires purchaser's written approval. When tail rods are deemed acceptable, tail rod packing assemblies shall be equal in design and quality to packing assemblies for piston rods. Tail rod surface treatment and finish shall be the same as for the piston rod. Tail rod design shall include a device to positively prevent the tail rod from being ejected in the event that it becomes disconnected from the piston/piston rod. Rod runout measured at the tail rod packing assembly shall not exceed the limits defined in 6.3.1.

6.11 Crankshafts, Bearings, Connecting Rods, Crossheads, and Crankcases

6.11.1 Crankshafts

For compressors above 150 kW (200 hp), crankshafts shall be forged in one piece and shall be heat treated and machined on all working surfaces and fits. The use of removable counterweights is acceptable. For compressors less than or equal to 150 kW (200 hp), ductile iron is acceptable for crankshafts. The crankshafts shall be free of sharp corners. Main and crankpin journals shall be ground to size. Drilled holes or changes in section shall be finished with generous radii and shall be highly polished. Forced lubrication passages in crankshafts shall be drilled. See 8.2.2.3.2 for ultrasonic testing of crankshafts.

6.11.2 Bearings

6.11.2.1 For compressors above 150 kW (200 hp), replaceable, precision-bored shell (sleeve) crankpin bearings and main bearings shall be used. For compressors equal to or less than 150 kW (200 hp), tapered roller type bearings are acceptable for main bearings. Cylindrical, roller, or ball type bearings may be used only with the purchaser's approval.

NOTE The use of rolling element bearings can affect the service life of the compressor.

6.11.2.2 When rolling element bearings are allowed, they shall be supplied in compliance with 6.11.2.3 and 6.11.2.4.

6.11.2.3 Rolling element bearing's basic rating life, L_{10h}, shall be at least 50,000 hours with a continuous operation at rated conditions, and at least 32,000 hours at maximum radial and axial loads at rated speed. The basic rating, L_{10h} life, shall be calculated in accordance with ISO 281.

6.11.2.4 Rolling element bearings shall be secured to the shaft by a shrink fit and fitted into housings in accordance with the vendor recommendations.

6.11.3 Connecting Rods

6.11.3.1 For compressors above 150 kW (200 hp), connecting rods shall be forged steel with removable caps on the crankpin end. For compressors less than or equal to 150 kW (200 hp), ductile iron, steel plate, or cast steel connecting rods are acceptable.

6.11.3.2 Connecting rods shall be free of sharp corners. Forced lubrication passages shall be drilled. Drilled holes or changes in section shall be finished with generous radii and shall be highly polished.

6.11.3.3 Crosshead pin bushings shall be of the replaceable precision-bored type and shall be securely locked in place.

6.11.3.4 Connecting rod bolts shall have rolled threads.

6.11.4 Crossheads

6.11.4.1 Crossheads shall be made of steel or ductile iron.

6.11.4.2 The crosshead top and bottom shoes shall be replaceable. Facilities shall be provided for the adjustment of crosshead clearance and alignment. Field machining for adjustment of clearances shall not be used. Crossheads without replaceable or adjustable shoes shall be approved by the purchaser.

6.11.4.3 Adequate openings shall be provided to service crosshead assemblies.

6.11.5 Crankcases

● If specified, the crankcase shall be provided with one or more device(s) to protect against rapid pressure rise. These devices shall incorporate a flame-arresting mechanism and a rapid closure device to minimize reverse flow and be directed away from the personnel area. Sizing criteria shall be agreed considering crankcase environments, oil mist only or hydrocarbon gas, and potential pressure rise within the crankcase.

When not an integral part of the frame, crosshead housings shall be attached to the crankcase with studs. A metal-to-metal joint, prepared with suitable sealant, shall be used between the crosshead housing and crankcase, the crosshead housing and distance piece, and the distance piece and cylinder.

6.12 Distance Pieces

6.12.1 Distance Piece Types

● **6.12.1.1** The purchaser shall specify the type of distance piece to be supplied. The types are listed in 6.12.1.2 through 6.12.1.5 (see Figure F.2).

6.12.1.2 Type A—Short, single-compartment distance piece used only for lubricated service when oil carryover (at the wiper packing and piston rod pressure packing) is acceptable. In this application, part of the piston rod may alternately enter the crankcase (crosshead housing) and the piston rod pressure packing. This arrangement shall not be used when cylinders are lubricated with oils not compatible with the crankcase oil (see 7.5.3.1.11).

NOTE Type A distance pieces are used only for nonflammable or nonhazardous gases.

6.12.1.3 Type B—Long single-compartment distance piece used for nonlubricated service or for lubricated service where oil carryover is not acceptable. No part of the piston rod shall alternately enter the crankcase (crosshead housing) and the piston rod pressure packing. The piston rod shall be fitted with an oil slinger of spark resistant material and of a split design for easy access to the piston rod pressure packing.

● **6.12.1.4** Type C—Long/long two-compartment distance piece designed to contain flammable, hazardous, or toxic gases. No part of the piston rod shall alternately enter the wiper packing and partition packing or the partition packing and piston rod pressure packing. The piston rod shall be fitted with a frame-end compartment oil slinger of spark resistant material and of a split design for easy access to the packing. A segmental packing shall be provided between the two compartments. If necessary, provisions for lubrication of the partition packing shall be furnished by the vendor. If specified, provisions for the injection of buffer gas shall also be provided.

NOTE The Type C distance piece with two oil slingers, one in each compartment, is not normally used on process compressors. This type of distance piece is used only for special services such as oxygen service. This distance piece design causes the overall length of the gas end assembly to become excessively large, thus causing the overall width of the compressors to become large and therefore increasing foundation requirements. Uses of such distance pieces can cause piston-rod diameters to increase because of the column effect of excessively long piston rods.

● **6.12.1.5** Type D—Long/short two-compartment distance piece designed to contain flammable, hazardous, or toxic gases. No part of the piston rod shall alternately enter the wiper packing and the intermediate partition packing. The rod shall be fitted with a frame-end compartment oil slinger of spark resistant material and of a split design for easy access to the packing. Segmental packing shall be provided between the two compartments. Provisions for lubrication of this segmental packing, if necessary, and, if specified, for the injection of buffer gas shall be furnished by the vendor.

NOTE The buffer gas should be a nonflammable, nonreactive, or inert gas such as nitrogen.

6.12.2 Distance Piece Requirements

● **6.12.2.1** Access openings of adequate size shall be provided in all distance pieces to permit removal of the assembled piston rod pressure packing case. On Type D, two-compartment distance pieces, the compartment adjacent to the cylinder (the outboard compartment) may be accessible through a removable partition. Distance piece compartments shall be equipped with gasketed solid metal covers. If specified, screened safety guards or louvered weather covers may be used for nonflammable or nonhazardous gases.

6.12.2.2 Distance piece design shall be such that the packing rings can be removed and replaced without removal of the piston rod.

NOTE In the case of small compressors, it can be easier to remove the piston rod.

6.12.2.3 For distance pieces with solid metal covers, the distance piece, partitions, covers, bolting, and partition packing shall be designed for a minimum of 3 bar (45 psig) MAWP. For Types C and D, each compartment shall be capable of the full MAWP independently. The vendor shall indicate the MAWP of the distance piece.

6.12.2.4 The purchaser shall specify the maximum operating pressure on the vent system. Vendor shall propose corrective measures if the distance piece MAWP is lower than the specified maximum operating vent pressure.

● **6.12.2.5** Each distance piece compartment shall be provided with the following connections (see Figure F.2):

a) top vent connection at least DN 40 (NPT $1^1/_2$);

b) bottom drain connection;

c) if specified, a purge or vacuum connection;

d) a piston rod pressure packing vent connection below the piston rod to facilitate liquid draining of the piston rod pressure packing case;

e) when required, piston rod pressure packing lubrication;

f) where piston rod pressure packing case cooling is required or specified, inlet and outlet connections on the distance piece suitably arranged to facilitate draining and venting.

See Annex H for vent and purge system schematics. Closed, sealed, or purged distance pieces not utilizing the DN 40 (NPT $1^1/_2$) free vent connection shall be equipped with a relief device. The vendor shall provide the sizing criteria for the vent connection.

6.12.2.6 Double compartment distance pieces shall be equipped with a buffer gas connection on the inboard distance piece. The inboard distance piece shall preferably be buffered with a pressure of at least 0.5 bar (7 psi) above the outboard distance piece pressure to avoid leakage of toxic or hazardous gas toward inboard compartment.

The buffer gas purge pressure shall be limited to the maximum allowable pressure for the distance piece components (see 6.12.2.3). Some buffer gas will flow into the compressor frame. Frame venting shall allow an outlet for this flow.

6.12.2.7 All external connections, except the top vent, shall be at least DN 25 (NPT 1).

6.12.2.8 Distance piece compartments with internal reinforcing ribs shall have internal drain provisions through the ribs.

6.12.2.9 Unless otherwise specified, all external drain, vent, and purge piping and equipment shall be provided by the purchaser.

6.12.2.10 For Type A and Type B distance pieces with solid metal covers, positive seal rings shall be provided at the wiper packing. For Type C and Type D distance pieces with solid metal covers, positive seal rings shall be provided at both the wiper packing and the intermediate partition packing. These seal rings shall be of the segmental type that effectively seal at atmospheric pressure (without purge) to prevent contamination of the crankcase oil by leakage from the piston rod pressure packing (see 6.13.1.5).

6.13 Packing Cases and Piston Rod Pressure Packing

6.13.1 General

● **6.13.1.1** All oil-wiper packing, partition packing, and piston rod pressure packing shall be segmental rings with garter springs of a nickel chromium alloy (such as Inconel 600 or X750). If specified, shields shall be provided in the crosshead housings over the oil return drains from the wiper-packing stuffing boxes to prevent splash flooding.

6.13.1.2 Packing case flanges shall be bolted to the cylinder head or to the cylinder with no less than four bolts. Flanges shall be of steel for flammable, hazardous, or toxic gas service. Packing cases shall be pressure rated at least to the MAWP of the cylinder. Packing case assemblies shall have positive alignment features to align all stationary components (e.g. pilot fits, body-fitted tie bolts).

6.13.1.3 For flammable, hazardous, toxic, or wet gas service, the piston rod pressure packing case shall be provided with a common vent and drain, below the piston rod, piped by the vendor to the lower portion of the distance piece. See Annex F.

6.13.1.4 Adequate radial clearance shall be provided between the piston rod and all adjacent stationary components to prevent contact when the maximum allowable wear occurs on the piston rider bands.

6.13.1.5 Oil wiper packing shall be supplied to effectively minimize oil leakage from the crankcase. Oil wiper leakage shall not exceed 5 drops per minute.

6.13.1.6 Unless otherwise specified, the manufacturer shall provide suitable devices and instructions to enable the piston rod to be passed through the completely assembled piston rod pressure packing without damage.

NOTE There is a risk of packing damage when using entering sleeves. However, when the outside diameter of the entering sleeve is equal to the outside diameter of the rod, the risk is reduced when the manufacturer's instructions are followed.

6.13.1.7 Unused connections in the packing cases shall be plugged with threaded steel plugs.

6.13.2 Piston Rod Pressure Packing Case Cooling Systems

6.13.2.1 Unless otherwise specified, the criteria given in 6.13.2.2 through 6.13.2.9 shall be followed for the cooling of piston rod pressure packing cases.

6.13.2.2 Packing cases shall be designed for liquid cooling with totally enclosed cooled cups for the following applications:

a) all nonlubricated packing rings above 17 bar (250 psig);

b) lubricated nonmetallic rings, when the cylinder MAWP is above 35 bar (500 psig);

c) all materials, lubricated or nonlubricated, when the cylinder MAWP is above 100 bar (1500 psig).

6.13.2.3 When liquid cooled packing cases are furnished:

a) O-rings shall be used to seal coolant passages between cups;

b) O-rings shall be fully captured in grooves, both on the inside and outside diameter of the O-ring; a small relief recess of 0.5 mm to 1 mm (0.015 in. to 0.030 in.) shall be provided around the captured O-ring to detect gas leakage; O-rings that encircle the piston rod are not allowed;

c) cases are to be tested for leakage on the coolant side to a gauge pressure not less than 8 bar (115 psig).

6.13.2.4 When the packing case is cooled by forced circulation, the vendor shall supply internal tubing and fittings of austenitic stainless steel.

6.13.2.5 When cooling of piston rod pressure packing is required, the vendor shall be responsible for determining and informing the purchaser of minimum requirements such as flow, pressure, pressure drop, and temperature, as well as any filtration and corrosion protection criteria. The inlet packing case coolant temperature should not exceed 35 °C (95 °F). The coolant pressure drop through the packing case shall not exceed 1.7 bar (25 psig).

NOTE Packing efficiency increases with low coolant temperature.

● **6.13.2.6** If specified, the vendor shall supply a closed liquid cooling system.

NOTE See Figure F.1 and Figure F.3 for typical drawing on packing case cooling systems.

● **6.13.2.7** If specified, and for all sour or toxic gas services, this system shall be separate from the cylinder jacket cooling system.

6.13.2.8 A coolant filter having a 125 µm (125 microns) nominal rating or better and located external to the distance piece shall be provided. If external tubing is provided by the vendor, it shall be austenitic stainless steel.

● **6.13.2.9** If specified, the packing vent temperature shall be monitored.

6.13.3 Buffer Gas System

● **6.13.3.1** If specified, a buffer gas system shall be supplied to reduce process gas emissions. The buffer gas should be a nonflammable, nonreactive, or inert gas such as nitrogen. The buffer system scope and design shall be agreed.

● **6.13.3.2** If specified, the piston rod pressure packing shall include venting and buffer gas cups with side-loaded packing rings in the adjacent sealing cups. The packing vent/drain shall be routed to a liquid collection pot.

NOTE See the arrangement in Figure H.7.

6.13.3.3 The piston rod pressure packing buffer gas supply pressure shall be at least 1 bar (15 psi) higher than the vent system pressure at connection points A or G in Annex F, Figure F.2 (in the outboard distance piece), whichever is higher.

● **6.13.3.4** A liquid collection pot shall be supplied. The purchaser shall specify the vent and drain locations and conditions. The collection pot shall not be combined with the distance piece drains.

● **6.13.3.5** If specified, intermediate partition packing shall be buffered in addition to the piston rod pressure packing.

● **6.13.3.6** If specified, the distance piece shall be buffered. On dual compartment distance pieces, the purchaser shall specify which compartment shall be buffered and which compartment shall be vented.

● **6.13.3.7** If specified, the distance piece vent pressure shall be monitored.

6.14 Materials

6.14.1 General

6.14.1.1 Unless otherwise specified, the materials of construction shall be selected by the manufacturer based on the operating and site environmental conditions specified.

NOTE Table G.1 lists material typically used.

6.14.1.2 The materials of construction for 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. Where international standards are not available, internationally recognized national standards (such as AISI or ASTM) or other standards may be used. When no such designation is available, the vendor's material specification, giving physical properties, chemical composition, and test requirements shall be included in the proposal.

6.14.1.3 Copper and copper alloys shall not be used for parts of compressors or auxiliaries in contact with corrosive gas or with gases capable of forming explosive copper compounds. Nickel-copper alloys (UNS N04400 Monel or its equivalent), bearing babbitt, bearings, and precipitation-hardened stainless steels, are excluded from this requirement. Where agreed, copper-containing materials may be used for packing on lubricated compressors or other specific purposes.

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

● **6.14.1.4** The vendor shall specify the tests and inspection required to ensure that materials selected are satisfactory for the service intended. Such tests and inspections shall be listed in the proposal. Additional tests and inspections shall be specified by the purchaser.

NOTE Additional tests and inspections can be specified, especially for materials used in critical components or in critical services.

6.14.1.5 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.

● **6.14.1.6** The purchaser shall specify the presence of any agents (including trace quantities) in the motive and process fluids and in the site environment that may cause corrosion.

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

NOTE 2 If amines are present, refer to API 945 for information on amine cracking and its prevention.

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

When the purchaser has specified the presence of chlorides in any fluid, materials exposed to that fluid shall be selected and processed in accordance with the requirements of API 571. Chloride concentrations greater than 50 ppm may require alternate material selection.

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

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

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

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

● **6.14.1.9** All materials exposed to H_2S gas service shall be in accordance with the requirements of NACE MR0103. Ferrous materials not covered by NACE MR0103 shall not have a yield strength exceeding 620 N/mm^2 (90,000 psi) nor a hardness exceeding Rockwell C22. When there are trace quantities of wet H_2S known to be present, or if there is any uncertainty about the amount of wet H_2S that may be present, the purchaser shall note on the data sheets that materials resistant to sulfide stress corrosion cracking are required.

Hardness requirements for valve seats and piston rod surface can be in excess of NACE provisions (see 6.10.4.3). Similar exceptions can be made for valve plates, springs, and unloader components, where greater hardness has been proven necessary. Agreement shall be reached on requirements for alternative alloys or special heat treatment.

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

6.14.1.10 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 tensile strength and ductility requirements and, when required, hardness and impact requirements.

6.14.1.11 On multiple service and multistage machines, NACE requirements shall apply to all fasteners and other interchangeable parts of all cylinders to avoid possible inadvertent interchange of parts.

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

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

6.14.1.13 Low-carbon steels can be notch sensitive and susceptible to brittle fracture at ambient or lower temperatures. Therefore, only steels made to fine-grain practice are acceptable. Steel made to a coarse austenitic grain size practice (such as ASTM A515) shall not be used.

6.14.1.14 O-ring materials shall be compatible with all specified services. O-rings for high-pressure services shall not be damaged upon 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.

6.14.1.15 Bolting shall be in accordance with ASTM A193 Grade B7 or Grade B7M. Carbon steel nuts such as ASTM A194, Grade 2H shall be used.

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

6.14.2 Pressure-containing Parts

6.14.2.1 Materials for pressure-containing cylinder parts shall be used in conjunction with the MAWP in Table 3. All material selections shall be subject to review by the purchaser.

NOTE Higher design pressures can be permitted based on detailed engineering analysis.

Table 3—Maximum Gauge Pressures for Cylinder Materials

Material	Maximum Allowable Working Pressure	
	barg	psig
Gray cast iron	70	1000
Ductile iron	100	1500
Cast steel	180	2500
Forged steel	No limitation	
Fabricated steel	85	1250

6.14.2.2 Steel compressor cylinders shall be equipped with steel heads.

6.14.2.3 The use of fabricated cylinders shall be stated in the proposal and shall be approved by the purchaser.

6.14.3 Castings

6.14.3.1 General

6.14.3.1.1 Castings shall be free from porosity, hot tears, shrink holes, blowholes, cracks, scale, blisters, and similar injurious defects. Surfaces of castings shall be cleaned by sandblasting, shot-blasting, chemical cleaning, or other standard methods. Mold-parting fins and the remains of gates and risers shall be chipped, filed, or ground flush. Castings shall not be impregnated or surface sealed.

6.14.3.1.2 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.

6.14.3.1.3 Fully enclosed cored voids, which become fully enclosed by methods such as plugging, welding, or assembly, shall not be used.

6.14.3.1.4 Pressure-retaining castings of gray iron shall be produced in accordance with ASTM A278.

6.14.3.1.5 Pressure-retaining castings of steel shall be produced in accordance with ASTM A216.

6.14.3.2 Ductile Iron Castings

6.14.3.2.1 Pressure-retaining castings of ductile iron shall be produced in accordance with ASTM A395. The production of these castings shall conform to the conditions specified in 6.14.3.2.2 through 6.14.3.2.4. Ductile iron castings for non-pressure-retaining components, such as crossheads, shall be produced in accordance with either ASTM A395 or ASTM A536.

6.14.3.2.2 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 12 J (9 ft-lb) and the mean of the three specimens shall not be less than 14 J (10 ft-lb) at room temperature.

6.14.3.2.3 The keel or Y-block cast at the end of the pour shall have a thickness not less than the thickness of critical sections of the main casting. 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 ASTM A247.

6.14.3.2.4 Brinell hardness readings shall be made on the actual castings at feasible critical sections such as section changes, flanges, and other accessible locations such as the cylinder bore and valve ports. Sufficient surface material shall be removed before hardness readings are made to eliminate any skin effect. Readings shall also be made at the extremities of castings at locations that represent the sections poured first and last. These readings shall be made in addition to Brinell readings on the keel and Y-blocks.

6.14.4 Forgings

Pressure-containing forgings shall be in accordance with ASTM A668.

6.14.5 Fabricated Cylinders and Cylinder Heads

6.14.5.1 When fabricated cylinders are allowed, they shall be designed based on an infinite fatigue life. The vendor shall conduct an engineering analysis that addresses the applicable loads, materials, weldments, and the geometry of the cylinder. The analysis shall ensure that the alternating stresses are limited to values that preclude the propagation of an existing internal defect.

6.14.5.2 Gas pressure-containing parts of cylinders and cylinder heads made of wrought materials or combinations of wrought and cast materials shall conform to the conditions specified in 6.14.5.3 through 6.14.5.13.

6.14.5.3 Plate subjected to alternating pressure loads used in cylinders and cylinder heads shall be subjected to the procedures in 6.14.5.4 through 6.14.5.6 after being cut to shape and before weld joint preparation.

6.14.5.4 If the plate is loaded in tension in the through-thickness direction, the piece shall be 100 % ultrasonically inspected in the area one plate-thickness on each side of the load-imposing member (see Figure 1).

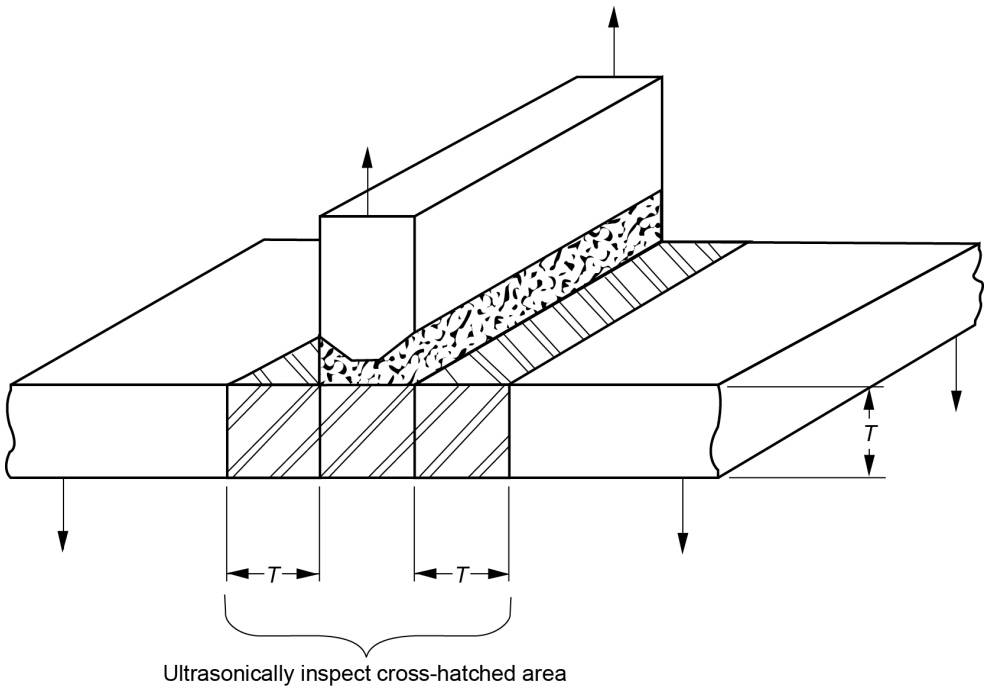

Figure 1—Plate Loaded in Tension in the Through-thickness Direction and Its Area Requiring Ultrasonic Inspection

6.14.5.5 If the plate is loaded in bending, the piece shall be 100 % ultrasonically inspected in the area one plate-thickness on each side of the load-imposing member (see Figure 2).

NOTE These procedures are intended to discover laminations or inclusions that can affect the load-carrying ability of the components.

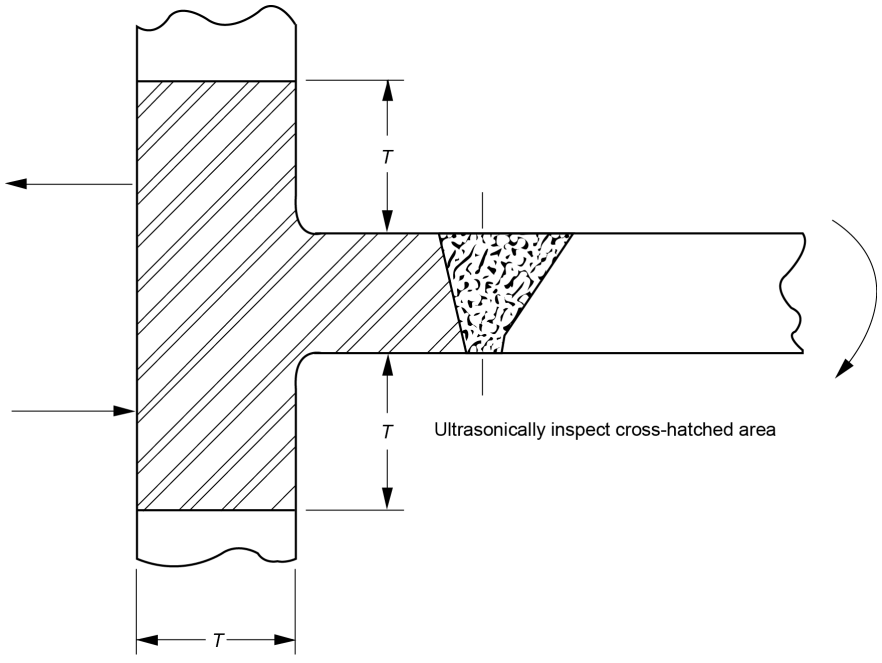

Figure 2—Plate Loaded in Bending and Its Area Requiring Ultrasonic Inspection

6.14.5.6 If the plate is axially loaded, ultrasonic inspection is not required (see Figure 3).

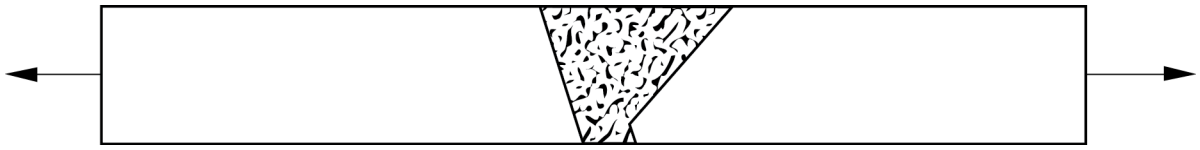

Figure 3—Axially Loaded Plate

6.14.5.7 Before welding, plate edges shall be examined by the magnetic particle method to confirm the absence of laminations.

● **6.14.5.8** Accessible surfaces of welds shall be inspected by magnetic particle or liquid penetrant examination after chipping or back-gouging and again after post-weld heat treatment. If specified, the quality control of welds that will be inaccessible on completion of the fabrication shall be agreed prior to fabrication.

6.14.5.9 Pressure-containing welds, including welds to horizontal- and vertical-joint flanges, shall be full-penetration (complete-joint) welds.

6.14.5.10 All fabricated cylinders and cylinder heads shall be post-weld heat treated, regardless of thickness (see 6.14.7.7).

6.14.5.11 All butt welds on the inner barrel of welded cylinders shall be 100 % examined radiographically. Other welds to the inner barrel shall be inspected radiographically where possible. If radiography is not possible, other methods such as ultrasonic examination shall be approved.

● **6.14.5.12** If specified, in addition to the requirements of 6.14.7.1, specific welds shall be subjected to 100 % radiography, magnetic particle inspection, or liquid penetrant inspection.

● **6.14.5.13** If specified, proposed cylinder, cylinder-head, and connection designs shall be made available for review and approval by the purchaser before fabrication. The drawings shall show weld designs, size, materials, and preweld and post-weld heat treatments.

6.14.6 Repairs to Castings and Forgings

6.14.6.1 Major repairs to pressure-containing parts, all repairs to moving parts subject to load reversals, and all repairs to crankshafts shall be undertaken only with the purchaser's written authorization. This requirement applies, but is not necessarily limited to, cylinder parts, piston and rod assembly components, and crosshead assembly components.

6.14.6.2 A major repair, for the purpose of purchaser notification, is any defect that equals or exceeds any of the following criteria:

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

b) any situation where the total area of all repairs to the part under repair exceeds 10 % of the surface area of the part;

c) any repairs to pressure-containing parts carried out after hydrostatic testing.

6.14.6.3 Before performing major repairs to pressure-containing parts, the vendor shall submit the following for the purchaser's written approval:

a) sketches or photographs showing the defective area;

b) proposed method of repair;

c) materials to be used;

d) welding procedure;

e) proposed extent of testing or re-testing to prove the effectiveness of the repair.

All such repairs shall be properly documented for the purchaser's permanent record.

6.14.6.4 For non-pressure-containing components, the vendor shall make repairs in accordance with their internal quality procedures. These procedures shall be available for review by the purchaser at the manufacturer's plant.

When repairs of non-pressure-containing components are done, they shall be documented by the vendor. No repair is to be made without written approval of the vendor's engineering, quality-control, and manufacturing departments.

● **6.14.6.5** If specified, the purchaser shall be given notice of repairs to other major components, such as distance pieces, and crankcase.

6.14.6.6 Pressure-containing castings shall not be repaired by peening, or burning-in, or impregnating. Pressure-containing castings and forgings shall not be repaired by welding, plating, or plugging except as specified in 6.14.6.7 through 6.14.6.8.

6.14.6.7 Weldable grades of steel castings and forgings may be repaired by welding using a qualified welding procedure (see 6.14.7.3). After major weld repairs but before hydrostatic testing, the complete casting or forging shall be given a post-weld heat treatment to ensure stress relief and continuity of mechanical properties of both weld and parent metals.

6.14.6.8 Gray cast iron or ductile iron may be repaired by plugging within the limits specified in the applicable material standard such as ASTM A278 or ASTM A395, but shall not be repaired by welding.

Plugs shall not be used in the gas-pressure-containing wall sections of cylinders, in particular in the bore under the liner, unless approved by the purchaser.

When plugs are allowed, the holes drilled for plugs shall be carefully examined, using liquid penetrant, to ensure that all defective material has been removed.

6.14.6.9 Damaged threaded holes in castings may be mechanically repaired by use of threaded inserts or bushings when approved by the purchaser.

6.14.7 Welding

6.14.7.1 Welding of piping, pressure-containing parts, rotating parts and other highly stressed parts, weld repairs, and any dissimilar-metal welds shall be performed and inspected by procedures and operators qualified in accordance with the specified pressure design code or internationally recognized standards such as ASME *BPVC* Section VIII, Division 1, and ASME *BPVC* Section IX.

6.14.7.2 Welding of non-pressure-containing components such as cylinder supports, pulsations suppression device supports, baseplates, nonpressure ducting, lagging, and control panels shall be performed by welders qualified in accordance with an appropriate recognized standard such as AWS D1.1 or ASME *BPVC* Section IX or other purchaser-approved welding standard.

6.14.7.3 The vendor shall ensure that repair welds are properly heat treated and nondestructively examined.

Repairs shall be nondestructively tested by the same method used to detect the original flaw. The minimum level of inspection after the repair shall be by the magnetic particle method in accordance with 8.2.2.4 for magnetic material and by the liquid penetrant method in accordance with 8.2.2.5 for nonmagnetic material.

6.14.7.4 Connections welded to pressure-containing parts shall be installed as specified in 6.14.7.5 through 6.14.7.9.

● **6.14.7.5** If specified, in addition to the requirements of 6.14.7.1, specific welds shall be subjected to 100 % radiography or magnetic particle inspection or liquid penetrant inspection of welds.

● **6.14.7.6** If specified, proposed connection designs shall be submitted to the purchaser for acceptance before the start of fabrication. The drawings shall show weld designs, size, materials, and preweld and post-weld heat treatments.

6.14.7.7 All welds shall be heat treated in accordance with the specified pressure vessel code or an internationally recognized standard such as the ASME *BPVC* Section VIII, Division 1, Sections UW-10 and UW-40. For steels in H_2S service, heat treatment shall also be in accordance with NACE MR0103.

6.14.7.8 If post-weld heat treatment is required, it shall be carried out after all welds, including piping welds, have been completed.

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

6.14.7.10 Flux-core welding may be used for equipment in hydrogen service, upon written agreement of the purchaser after submission of weld procedures.

6.14.8 Low-temperature Service

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

NOTE Normally, this will be the lower of the minimum surrounding ambient temperature or minimum inlet gas temperature. The purchaser may specify a minimum design metal temperature based on properties of the process gas, such as auto-refrigeration at reduced pressures.

6.14.8.2 To avoid brittle failures, materials and construction for low temperature service shall be suitable for the minimum design metal temperature 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.

NOTE Design practices for low temperature services include the selection of fabrication methods, welding procedures, and materials for steel pressure-retaining parts to ensure that the ductile-to-brittle transition temperature is suitable for the service. The published design-allowable stresses for many materials in internationally recognized 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 course-grain practices.

6.14.8.3 All carbon and low-alloy steel pressure-containing components, including nozzles, flanges, and weldments, shall be impact tested in accordance with the requirements of ASME *BPVC* Section VIII, Division 1, Sections UCS-65 through 68, or the specified pressure design code. High-alloy steels shall be tested in accordance with ASME *BPVC* Section VIII, Division 1, Section UHA-51, or the specified pressure design code. For materials and thicknesses not covered by ASME *BPVC* Section VIII, Division 1 or the specified pressure design code, testing requirements shall be as specified by the purchaser.

NOTE Impact testing of a material may be omitted depending on material selection; the minimum design metal temperature; thermal, mechanical, and cyclic loading; and the governing thickness. Refer to requirements of ASME *BPVC* Section VIII, Division l, Section UG-20F, for example.

6.14.8.4 The governing thickness used to determine impact testing requirements shall be the greater of the following:

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

b) the largest nominal section for pressure containment, excluding:

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

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

c) one-fourth of the nominal flange thickness (recognizing that the predominant flange stress is not a membrane stress).

The results of the impact testing shall meet the minimum impact energy requirements of ASME *BPVC* Section VIII, Division l, Section UG-84, or the specified pressure design code.

6.15 Nameplates and Rotation Arrows

6.15.1 A nameplate shall be securely attached at a visible location on the compressor crankcase, on each compressor cylinder, and on any major piece of auxiliary equipment.

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

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

6.15.4 The following data shall be clearly stamped or engraved on the compressor crankcase nameplate:

a) vendor’s name;

b) serial number;

c) frame size and model;

d) rated speed;

e) stroke;

f) purchaser item number or other reference.

6.15.5 Nameplates on compressor cylinders shall include the following data:

a) vendor’s name;

b) serial number;

c) bore, stroke, model number;

d) MAWP;

e) hydrostatic test pressure;

f) maximum allowable working temperature;

g) cold piston end-clearance setting for each end;

h) minimum allowable temperature [required if the material is rated for a minimum allowable temperature below −30 °C (−20 °F)].

7 Accessories

7.1 Drivers

7.1.1 General

● **7.1.1.1** Unless otherwise specified, the compressor vendor shall furnish the driver and power transmission equipment. The type of driver shall be as specified by the purchaser.

7.1.1.2 The driver shall be sized to meet the maximum specified operating conditions, including external power transmission 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 proposal.

7.1.1.3 The driver shall be capable of driving the compressor with all stages at full flow, rated suction pressure, and discharging at the relief valve set pressure.

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

● **7.1.1.5** The purchaser shall specify anticipated process variations that can affect the sizing of the driver (such as changes in the pressure, temperature or properties of the fluid handled, and special plant start-up conditions).

● **7.1.1.6** The purchaser shall specify the starting conditions for the driven equipment. The starting procedure shall be agreed by the purchaser and the vendor. The driver's starting-torque capabilities shall exceed the starting-torque requirements of the driven equipment from zero to operating speed.

7.1.1.7 The inertial characteristics of the rotating parts of the compressor and of the drive train shall be such that rotational oscillations will be minimized. Undesirable oscillations include those that cause damage, undue wear of parts or interference with the governor or governing system of the driver and those that result in harmful torsional and/or electrical system disturbances. For initial design purposes and other than motor drivers, peak-to-peak speed oscillation of the rotating system shall be limited to 1.5 % of rated speed at full load and partial cylinder loads if step unloading is specified.

The compressor vendor shall inform the driver manufacturer of the nature of the application, including the torque variation characteristics, and shall obtain confirmation from the driver manufacturer that the driver is suitable for this service.

7.1.1.8 For purposes of sizing flywheels and couplings for gear drives, the peak-to-peak torque variation at the gear shall not exceed 25 % of the torque corresponding to the maximum compressor load and in no case shall there be any torque reversal in the gear mesh.

7.1.1.9 For belt-driven compressors the peak-to-peak speed variation shall not exceed 3 % of rated compressor speed at any operating condition (see 7.4).

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

7.1.2 Motor Drivers

7.1.2.1 Motor drives shall conform to API 541, API 547, or API 546 or other standards as approved by the purchaser. Motors that are below the power scope of API 541, API 547, or API 546 shall be in accordance with IEEE 841 or IEC 60034.

● **7.1.2.2** The type of motor supplied and its characteristics and accessories, including, but not limited to, the following, shall be as specified by the purchaser:

a) type of motor (synchronous or induction);

b) bearing and coupling arrangement;

c) line voltage and frequency.

If belt drives are required, see 7.4.3.

7.1.2.3 For motor-driven units, the motor rating shall be not less than 110 % of the greatest power required (including power transmission losses) for any of the specified operating conditions. In addition, the motor rating shall be not less than 105 % of the power required (including power transmission losses) for the relieving operation specified in 7.1.1.3.

● **7.1.2.4** If specified, single bearing motors shall be provided with a temporary inboard support device to facilitate erection and alignment.

● **7.1.2.5** The motor starting-torque shall be sufficient to start the compressor without the need to depressurize any stage from the compressor suction pressure as long as all cylinder ends are unloaded or all stages are 100 % bypassed. Special agreement may be necessary in the following circumstances: high suction pressure; high settling-out gas pressure specified by the purchaser; high-pressure unloaded starts; or alternate gas unloaded starts.

7.1.2.6 The combined inertia of rotating parts of synchronous motor-compressor installations shall be sufficient to limit motor current variations to a value not exceeding 66 % of the full load current for all specified loading conditions, including unloaded operation with cylinders pressurized to their normal suction pressures. The electrical system data necessary for proper design shall be provided by the purchaser.

NOTE The power supply for some installations can require tighter control of current pulsation to protect other equipment in the electrical system. Standard motor performance data are based on steady-state load conditions and may not reflect actual performance under the variable-torque conditions encountered when driving reciprocating compressors. With induction-motor drivers, the effects of variable torque and resultant current pulsation are more pronounced and require closer evaluation (see 6.7.4 and 7.1.1.7).

For this reason, high-efficiency induction motors with their lower slip factors can experience higher current pulsation and consequently draw higher average current and higher power than standard efficiency motors when driving reciprocating compressors.

7.1.2.7 When the motor is supplied by the purchaser, the compressor vendor shall furnish the purchaser with the following:

a) compressor data required by the motor manufacturer to calculate the inertia necessary to satisfy the current pulsation limits;

b) starting-torque requirements;

c) coupling details.

7.1.2.8 The rotor of a single bearing motor driver shall be mounted on a shaft extension with a keyed interference fit. The shaft extension shall be rigidly coupled to the crankshaft, with forged flanges integral with the shaft extension and crankshaft. Split or clamped hubs shall not be used. The interference fit shall carry the maximum transmitted torque by itself; the key shall not be relied on to carry any of the torque. Side clearance for the key shall be 0.025 mm (0.001 in.) at maximum. Top clearance for the key shall be adequate to prevent overstressing of the keyway. Keyless interference fits are acceptable only if accepted by the purchaser. Keys and keyways shall be machined with smooth, generous radii to minimize the effects of stress concentration. An outboard bearing shall be provided by the vendor to support the end of the shaft extension.

7.1.2.9 Unless otherwise specified, the necessary motor starting apparatus shall be supplied by the purchaser.

7.1.2.10 Cantilevered (overhung) motors shall not be supplied.

7.1.2.11 For single bearing motors, the motor manufacturer's drawing shall show the allowable tolerance for setting the air gap. All sections of the motor (and rotary exciter, if applicable) stator shall be doweled after internal alignment is completed to ensure maintenance of the proper air gap. The exciter housing (if applicable) shall be mounted with sufficient lateral and axial rigidity to prevent excessive motion of the stator relative to the rotor.

● **7.1.2.12** The bearing of motors rigidly coupled to a compressor shall be of the same generic type (hydrodynamic or rolling element) as the main bearings of the driven compressor. The use of a rolling element bearing in other cases shall be subject to the purchaser's approval. The design of direct coupled motors shall be such, that the bearing can be inspected, removed, and replaced in situ.

Hydrodynamic bearings shall be self-lubricated (e.g. oil-ring and sump) or, if specified, shall receive lubricating oil from the compressor frame lubrication system.

7.1.3 Steam Turbine Drivers

● **7.1.3.1** Steam turbine drivers shall conform to API 611 or API 612. The turbine power rating shall be not less than 110 % of the power required (including power transmission losses) for the relieving operation specified in 7.1.1.3 with the specified normal steam conditions. In addition, the turbine continuous power rating shall be no less than 120 % of the greatest power required (including any power transmission losses) when operating at any of the specified operating conditions, with the specified normal steam conditions.

NOTE 1 The 120 % factor includes an allowance for the cyclic torque load of reciprocating compressors.

NOTE 2 The 120 % is a design criterion. After testing, this margin might not be available due to performance tolerances of the driven equipment.

● **7.1.3.2** If specified, a separate special-purpose lube oil system in accordance with API 614 shall be furnished for a turbine drive train.

7.2 Couplings and Guards

7.2.1 Couplings

7.2.1.1 A flexible coupling shall be supplied, except where a single bearing motor is supplied as defined in 7.1.2.8. The coupling shall be supplied by the manufacturer of the driven equipment.

7.2.1.2 Unless otherwise specified, the coupling shall be of the all-steel, nonlubricated, flexible membrane, torsionally rigid, spacer-type. Couplings may be of the elastomeric type where necessary to avoid torsional resonance problems. The coupling type, manufacturer, model, and mounting arrangement shall be agreed.

NOTE For information on torsional damping couplings and resilient couplings see API 671, Annex A.

● **7.2.1.3** If specified, special-purpose couplings shall conform to and be mounted in accordance with API 671.

7.2.1.4 For compressors rated at 1500 kW (2000 hp) or more and driven by a double-reduction gear, the low-speed coupling can be a quill shaft. In such cases, the quill shaft shall be directly coupled to the compressor flywheel, shall pass through the hollow low-speed gear shaft, and shall couple with the low-speed shaft on the side opposite the compressor.

7.2.1.5 Information on shafts, keyway dimensions (if any) and shaft end movements due to end play and thermal effects shall be supplied.

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

7.2.1.7 Couplings shall be mounted in accordance with the requirements of 7.2.1.8 through 7.2.1.9.

7.2.1.8 Flexible couplings shall be keyed to the shaft. Keys and keyways and their tolerances shall conform to AGMA 9002, Commercial Class.

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

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

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

7.2.1.10 Coupling hubs shall be furnished with tapped puller holes at least 10 mm (0.375 in.) diameter to facilitate removal.

7.2.1.11 Coupling spacer shall be long enough to allow removal of the flywheel or coupling hub without removing the driver.

7.2.2 Guards

7.2.2.1 Guards shall be provided by the vendor for each coupling, auxiliary drive coupling, and all exposed moving parts. Guards shall be removable without disturbing the coupled elements and shall meet the requirements of 7.2.2.2 through 7.2.2.5.

7.2.2.2 Coupling and flywheel guards shall enclose the coupling, flywheel, and the shafts to prevent personnel from contacting moving parts or accessing the space between the guard and such moving parts during operation of equipment train. Allowable access dimensions shall comply with specified standards, such as ISO 14120 or ANSI B11.19.

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

7.2.2.4 Guards shall be fabricated from solid sheet or plate with no openings. Guards fabricated from expanded metal or perforated sheets may be used if the size of the openings does not exceed 10 mm (0.375 in.). Guards of woven wire shall not be used. Guards shall be constructed of steel, brass, aluminum, or nonmetallic (polymer) materials. If specified, nonsparking guards of agreed material shall be supplied.

Guards shall be removable without disassembly of the compressor, piping, instrumentation, or driver. Openings with removable covers shall be provided in flywheel guards for barring-over the machine and for access to flywheel locking devices, indicator timing marks, wheel center (if available), and to any other parts that can require attention.

7.2.2.5 For outdoor installations, guards over belt and chain drives shall be weatherproofed and properly ventilated to prevent excessive heat buildup.

7.3 Reduction Gears

● **7.3.1** Gear units shall conform to API 677. If specified, gear units shall confirm to API 613.

7.3.2 Gears lubricated by an integral pump shall be provided with an electrically driven standby pump arranged for automatic start. The system shall be arranged to prevent starting unless the oil pressure has reached the minimum permissible level.

7.4 Belt Drives

7.4.1 Belt drives shall be used only for equipment of 150 kW (200 hp) or less and require purchaser approval. All belts shall be of the static-conducting type and shall be oil resistant. The drive service factor shall not be less than 1.75 based on the driver nameplate power rating.

7.4.2 The vendor shall provide a positive belt-tensioning device on all belt drives. This device shall incorporate a lateral adjustable base with guides and hold-down bolts, two belt-tensioning screws, and locking devices. All bearing lubrication points shall be accessible.

7.4.3 When a belt drive is used, the vendor who has unit responsibility shall inform other manufacturer(s) of the connected equipment. The other manufacturer(s) shall be provided with the radial load resulting from the belt drive and, the torque variation characteristics. The drive manufacturer shall take into account the radial load and torque variation conditions and shall provide bearings with a life at least equivalent to that specified in 6.11.2.2.

7.4.4 The belt drive system design shall be the responsibility of the vendor and shall meet the following requirements:

a) the distance between the centers of the sheaves shall be at least 1.5 times the diameter of the larger sheave;

b) the belt wrap (contact) angle on the smaller sheave shall be at least 140 degrees;

c) the shaft length on which the sheave hub is fitted shall be greater than or equal to the width of the sheave hub;

d) the length of a shaft key, if used, to mount a sheave shall be equal to the length of the sheave bore;

e) unless otherwise specified, each sheave shall be mounted on a tapered adapter bushing;

f) to reduce the overhang moment on shafts due to belt tension the sheave overhang distance from the adjacent bearing shall be minimized;

g) sheaves, and mounting hardware, shall meet the balance requirements of ISO 1940-1.

7.5 Lubrication

7.5.1 General

For compressors 150 kW (200 hp) and above, the frame lubrication system shall be a pressurized system as defined in API 614. The additional following requirements also apply.

7.5.2 Compressor Frame Lubrication

7.5.2.1 General

7.5.2.1.1 Compressors below 150 kW (200 hp) with rolling element bearings and a pressurized lube oil system shall be supplied with an API 614 system as described in Table 2, Class I-P0-R0-H1-BP0-C1F2-C0-PV0-TV1-BB0. Splash lubrication systems may be supplied with approval of the purchaser.

7.5.2.1.2 The crankcase oil temperature shall not exceed 70 °C (160 °F) for pressurized oil systems and 80 °C (180 °F) for splash systems. Cooling coils shall not be used in crankcases or oil reservoirs.

● **7.5.2.1.3** Pressure lubrication systems shall be designed and furnished in accordance with API 614, Table 2 except as modified below.

7.5.2.1.4 If specified, critical pressure lubrication systems (reference API 614, 4.4) shall be designed and furnished in accordance with API 614, Table 2 for other drive train equipment.

NOTE Critical service oil systems in accordance with API 614 are typically applied only to reciprocating compressor trains involving a large turbine driver and gear unit.

7.5.2.1.5 The following instruments shall be provided:

a) one level indicator (on the crankcase or reservoir) (see 7.5.2.7);

b) one pressure transmitter for low pressure alarm and auxiliary pump start;

c) one low frame oil level transmitter for alarm;

d) one filter high differential pressure transmitter for alarm;

e) one pressure transmitter for low pressure shutdown.

See Figure F.4 for a typical schematic drawing of a lube oil system.

7.5.2.1.6 The system design pressure of the frame lubrication system shall be not less than 10 bar (150 psig) (this is a system design criterion only; the manufacturer's recommended bearing supply pressure may be significantly less). The pressure limiting valve setting shall be no greater than the sum of the normal bearing supply pressure, the equipment and piping pressure losses upstream of the filter, and the cartridge collapsing differential pressure drop at a minimum oil temperature of 27 °C (80 °F) at the normal flow rate to the bearings.

7.5.2.1.7 The oil reservoir shall be equipped with an oil-level sight glass. The maximum and minimum operating levels shall be permanently indicated.

7.5.2.1.8 Oil return lines to the crankcase shall be located above the maximum operating level.

7.5.2.1.9 To prevent the oil from being contaminated if the cooler fails, the oil-side operating pressure shall be higher than the water-side operating pressure.

7.5.2.1.10 Unless otherwise specified, crankshaft-driven oil pumps shall be manufactures' standard design. Sizing shall be in accordance with API 614.

7.5.2.2 Auxiliary Pump

For each unit having a nominal frame rating of more than 150 kW (200 hp) and/or hydrodynamic bearings, the vendor shall provide a separate, independently driven, full-capacity, full-pressure auxiliary oil pump with an automatic start feature activated by low lube oil pressure and include provisions for post-lubrication after shutdown. Auxiliary oil pump shall be designed and furnished in accordance with API 614.

7.5.2.3 Cooler

Lube oil coolers shall be designed and furnished in accordance with API 614.

7.5.2.4 Filters

Lube oil filters shall be designed and furnished in accordance with API 614. Each filter shall be equipped with valved vent and drain connections. If applicable, both clean- and dirty-side drain connections shall be valved.

7.5.2.5 Heater

Lube oil heaters shall be designed and furnished in accordance with API 614.

7.5.2.6 Pressure Limiting Valve

Each lube oil pump pressure limiting valve shall be individually piped back to the crankcase reservoir. A relief valve serving the main oil pump may have a cast iron or nodular iron body if it is located inside the crankcase; otherwise, it shall be steel. If specified, the relief valve for the crankcase-driven pump shall be mounted outside the crankcase. Continuously operating flowing oil return lines shall enter the sump or an external reservoir in a way to avoid adverse effect on pump suction and electrostatic discharge.

7.5.2.7 Oil Temperature Regulator

Oil temperature regulators shall be designed and furnished in accordance with API 614.

7.5.3 Cylinder and Packing Lubrication

7.5.3.1 General

● **7.5.3.1.1** For compressors with lubricated cylinders, the vendor shall supply either a divider block or a single plunger-per-point (pump-to-point) lubricator system for compressor cylinder and packing lubrication, as specified.

7.5.3.1.2 Vendor shall define the normal operating lubrication rates per point.

NOTE Higher rates can be required for initial start-up when metallic sealing elements are supplied.

● **7.5.3.1.3** Lubricators shall be driven independently or by the crankshaft, as specified. Lubricators shall be separate from the frame lubrication pump(s) and complete with necessary tubing or piping (see 7.9.3.1). Ratchet lubricator drives shall not be used.

7.5.3.1.4 Pumps shall be sized to permit a 25 % increase and a 25 % decrease in normal operating lubrication rate. The pumps shall be designed to allow adjustments to the lubrication rate while the compressor is operating.

7.5.3.1.5 A lubricator reservoir heating device with thermostatic control shall be provided. The heat density of the device shall be limited to 2.3 W/cm^2 (15 W/in.^{2}). The size of heating system and temperature control instrumentation shall be as agreed. When an internal heater is used, it shall be fully immersed even at minimum reservoir level (see 7.5.3.3.2). A low-level device is recommended in the reservoir, placed above the heating element to alarm before level drops below the heating element. Electric immersion heaters shall be interlocked to be de-energized when the oil level drops below the minimum operating level.

7.5.3.1.6 Lubricators shall have provisions for prelubrication of the compressor prior to compressor start-up.

7.5.3.1.7 Each lubrication system shall be provided with a system failure alarm (see 7.5.3.2 and 7.5.3.3.2).

7.5.3.1.8 At least one lubrication point shall be provided for each compressor cylinder bore and packing.

7.5.3.1.9 A stainless steel integral double-ball check valve shall be provided as close as possible to each lubrication point. Check valve, tubing, and fittings shall be rated for the MAWP of the lubricator. The check valve and tubing shall be arranged such that the outlet of the check valve is always immersed in oil.

NOTE The immersion in oil will aid in the valve sealing against gas pressure and will isolate the check valve ball/seat from contamination introduced from cylinder gases.

7.5.3.1.10 Tubing connections shall be match tagged for identification at the disassembly points for all compressor components in order to facilitate reassembly.

● **7.5.3.1.11** If specified, the compressor cylinders shall be lubricated by synthetic lubricants. The lubricant specifications shall be mutually agreed. Interior surfaces and nonmetallic components of the lubricating system coming into contact with synthetic lubricant shall be of compatible materials. Interior surfaces coming in contact with synthetic lubricant shall be left unpainted. In those cases where other interior surfaces (of distance pieces, or frames, for example) require painting, a synthetic lubricant-resistant coating shall be used.

NOTE The concerns with the use of synthetic lubricants are the contamination of conventional crankcase oil by synthetic cylinder lubricating oil, and synthetic oil attack of paint coatings in the crankcase and distance pieces.

7.5.3.1.12 Lubricator reservoir capacity shall be adequate for a minimum of 30 hours of operation at normal operating lubrication rates. All reservoirs shall have a low point drain to remove water contamination.

● **7.5.3.1.13** If specified, automatic float-type fill devices shall be provided for make up to the lubricator reservoir.

7.5.3.2 Divider Block Lubrication

Divider block systems shall be provided with protection and indicating devices to protect the system from overpressure and to allow monitoring of the system.

As a minimum, the following requirements shall be met:

a) each outlet of the primary divider block shall be equipped with a resettable spring-loaded indicator pin to signal that the outlet is plugged;

b) a check valve shall be used at each outlet of each divider block assembly;

c) the system shall be protected from overpressure with a relief device located downstream of the pump(s), with return to tank;

d) a pressure gauge shall be provided indicating pump discharge pressure;

e) for protection against loss of flow, a cycle monitor shall be provided and shall be equipped with an alarm indicating low flow;

f) the cycle monitor shall be driven by a proximity switch mounted on the primary divider block; a visual cycle indicator is recommended on the primary divider block for visual indication and troubleshooting of system;

g) balancing valves shall be included when pressure differential between outlets of a divider block assembly is greater than 55 bar (800 psi);

h) a filter upstream of the pump(s) shall be used to allow for particulate and air removal;

i) a 10-micron polishing filter shall be supplied between the pump and primary divider block;

j) if specified, automatic float-type fill devices shall be provided for make up to the lubricator reservoir.

7.5.3.3 Pump-to-point Lubrication

7.5.3.3.1 Lubricators shall have a sight flow indicator for each lubrication point.

7.5.3.3.2 Protection against loss of cylinder and packing lubrication shall consist of a low pressure alarm connected to the discharge of an extra plunger pump that circulates oil through an orifice and back to the lubricator reservoir. The plunger pump shall have its suction tube shortened so that it will lose suction when the lubricator reservoir oil drops below 30 % of full level. When more than one reservoir compartment is used, each compartment shall be so protected.

NOTE This basic system does not provide electronic monitoring of each individual lubrication point. To achieve this, individual electronic flow meters would have to be added. The typical system provided only low reservoir monitoring and shaft rotation.

7.6 Cylinder Jacket Water Systems

7.6.1 Unless otherwise specified, cylinders shall be supplied with jackets. Noncooled or air-cooled cylinders shall not be furnished unless approved by the purchaser.

7.6.2 Design of cylinder jackets shall prevent leakage between jacket water and gas cavities due to the failure of a gasket or seal. When cooling of cylinder heads is provided, separate noninterconnecting jackets are required for cylinder bodies and cylinder heads.

7.6.3 Static-filled Systems

Static-filled systems (see Figure F.1, Plan A) may be supplied where cylinders are not required to operate fully unloaded for extended periods of time, the expected maximum discharge temperature is less than 90 °C (190 °F), and the adiabatic gas temperature rise (difference between suction temperature and discharge temperature based on isentropic compression) is less than 85 K (150 °F).

7.6.4 Thermosiphon Systems

7.6.4.1 Atmospheric thermosiphon systems (see Figure F.1, Plan B) may be supplied when cylinders are not required to operate fully unloaded for extended periods of time and either

a) the expected maximum discharge temperature is 100 °C (210 °F) or

b) the adiabatic gas temperature rise is less than 85 K (150 °F).

7.6.4.2 A pressurized thermosiphon system may be used where the expected maximum gas discharge temperature is not to exceed 105 °C (220 °F). In such cases, the system shall be supplied with a thermal relief valve set at a gauge pressure of 1.7 bar (25 psig) maximum.

7.6.4.3 If condensable constituents may be present in the gas, a heater or other provision shall be provided to maintain the water temperature at least 5 K (10 °F) above the dew point temperature of the inlet gas in order to prevent gas condensation.

7.6.5 Jacket Water Systems

7.6.5.1 A self-contained, forced circulation, closed jacket water system (see Figure F.1, Plan D) shall be provided when cylinders are operated while unloaded for extended periods of time or

a) the expected maximum discharge temperature is above 100 °C (210 °F) or

b) the adiabatic gas temperature rise is 85 K (150 °F) or greater.

The jacket water system shall meet the requirements of 7.6.5.2 to 7.6.5.13.

7.6.5.2 Vendor to specify either series or parallel flow through the cylinders.

7.6.5.3 Jacket water velocities should be sufficient to prevent solids suspended in the cooling media from depositing and causing the fouling of jackets and passages.

7.6.5.4 Jacket water shall be supplied to each cylinder with an inlet temperature at least 5 K (10 °F) above the inlet gas temperature to prevent gas condensation in the suction passage under all operating conditions including start-up with no heat addition from the compressor.

NOTE 1 Lower inlet water temperatures can cause condensation of gas constituents, which can be detrimental to the life of cylinder valves, piston rings, and packing.

NOTE 2 For most applications, the inlet gas temperature is considered to be equal to the dew point. In applications where it is known that the gas dew point is substantially below the gas inlet temperature and remains that way at all times during operation, a lower coolant inlet temperature can be considered as long as condensation is avoided.

7.6.5.5 Jacket water exit temperatures shall not be higher than 17 K (30 °F) above gas inlet temperature.

NOTE Excessively high exit temperatures can result in loss of capacity and efficiency.

● **7.6.5.6** If specified, a horizontal reservoir shall be supplied. The reservoir shall be sized to allow rundown of all compressors serviced on the system and not exceed the maximum fill level.

NOTE This allows draining of liquid when shut down.

● **7.6.5.7** If specified, a vertical reservoir shall be supplied. The reservoir normal level shall be above the highest point of the cylinder jacket water piping to maintain a liquid full condition at all times.

● **7.6.5.8** Purchaser shall specify mounting location of the reservoir, either on the jacket water system baseplate or at close proximity to the system.

7.6.5.9 Reservoir shall be equipped with the following minimum items:

a) heater(s);

b) vent;

c) level gauge;

d) purge connection;

e) fill connection;

f) return line connection;

g) pump suction line(s) connections;

h) clean out/inspection port;

i) drain connection.

7.6.5.10 Heaters shall be electric, hot water, or steam, as specified. They shall be sized accounting for heat losses of surface areas of the reservoir, cylinders, pipe, and fittings at the minimum ambient temperature specified.

● **7.6.5.11** Electric immersion heaters shall be installed in a manner that allows the heater(s) to be removed during operation.

● **7.6.5.12** If specified, in-line heaters shall be supplied.

7.6.5.13 Coolers shall have vents and drains on both shell and tube side.

7.6.5.14 A once-through jacket water system (see Figure F.1, Plan C) may be provided when a suitable external source of jacket water is available. This system shall meet the requirements of 7.6.5.2 to 7.6.5.5 and 7.6.5.10 to 7.6.5.12.

7.7 Mounting Plates

7.7.1 General

● **7.7.1.1** The equipment shall be furnished with a baseplate, soleplates, or rails as specified.

NOTE See Annex K for typical mounting plate and soleplate arrangements.

7.7.1.2 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. A leveling screw shall be provided near each anchor bolt. If the equipment and mounting plates are too heavy to be lifted using leveling screws, alternate methods shall be provided by the equipment vendor. The design of the alternate method shall be included in the proposal.

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

d) Bottom corners of components that are in contact with grout shall be radiused or chamfered.

e) All machinery mounting surfaces that are not to be grouted shall be treated with a rust preventive immediately after machining.

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

7.7.2 Machined Surfaces

The upper and lower surfaces of mounting plates and any separate pedestals mounted thereon shall be machined parallel. The surface finish shall be 3.2 µm (125 µin.) Ra or better. Surfaces shall be:

a) machined after the baseplate is fabricated;

b) flat and parallel to all other mounting surfaces within 0.15 mm/m (0.002 in./ft).

7.7.3 Leveling, Alignment, and Lifting

7.7.3.1 Mounting plates shall have jackscrews conforming to the following.

a) The compressor parts (such as a crankcase or a crosshead frame) shall be equipped with vertical jackscrews.

b) The feet of the drive equipment shall be equipped with vertical jackscrews.

c) When the drive equipment mass exceeds 225 kg (500 lb), the drive train mounting plates shall be furnished with horizontal jackscrews (axial and lateral) the same size as, or larger than, the vertical jackscrews. The lugs holding the jackscrews shall be attached to the mounting plates so that they do not interfere with the installation or removal of the drive equipment, jackscrews, or shims.

d) Vertical jackscrews shall be located outside of the shimming areas in the equipment feet to prevent damaging of the shimming surfaces.

e) Jackscrews shall be treated for rust resistance.

f) Jackscrews shall be supplied for leveling soleplates.

g) The vendor having unit responsibility shall supply all jackscrews.

h) 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 shall be proposed for equipment that is too heavy to be lifted or moved horizontally using jackscrews.

7.7.3.2 Anchor bolts shall not be used to fasten drive train equipment to mounting plates. Anchor bolts shall not be used to fasten compressors through baseplates. Anchor bolts may be used to fasten compressors through soleplates or rails.

7.7.3.3 The vendor shall furnish stainless steel shim packs between the drive equipment feet and the mounting plates. The shims shall be in accordance with API 686 and shall straddle the hold-down bolts and vertical jackscrews and be at least 5 mm ($^1/_4$ in.) larger on all sides than the equipment feet.

7.7.3.4 Hold-down bolts for attaching the components to the mounting plates shall be supplied by the vendor.

● **7.7.3.5** If specified, steel chock blocks shall be supplied by the vendor.

7.7.3.6 The purchaser shall provide anchor bolts. If specified anchor bolts shall be furnished by the vendor. Scope of supply of anchor bolts shall be mutually agreed.

7.7.3.7 The vendor shall provide anchor bolt projection, anchor bolt hole diameter in component, layout, and required hold-down force per bolt.

7.7.3.8 The drive equipment feet shall be drilled with pilot holes that are accessible for use in final doweling.

7.7.3.9 Unless otherwise specified, epoxy grout shall be used for machines mounted on concrete foundations. The vendor shall blast-clean in accordance with ISO 8501, Grade SA2 or SSPC SP 6, all grout contact surfaces of the mounting plates and coat those surfaces with a mutually agreed compatible primer in preparation for epoxy grout.

● **7.7.3.10** If specified, leveling plates shall be supplied. Leveling plates (see Figure K.1) shall be steel plates at least 19 mm ($^3/_4$ in.) thick. Plates shall be hardened and have round corners and roughened bottom.

NOTE These requirements supersede the requirements of API 686.

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

7.7.4 Baseplates

● **7.7.4.1** When a baseplate is specified, major equipment to be mounted on it shall be as specified by the purchaser. 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 to ensure accurate field reassembly, and provisions for a sufficient number of optical leveling targets to record and repeat the required level in the field.

NOTE A baseplate may have to be fabricated in multiple sections because of shipping restrictions.

7.7.4.2 When a baseplate(s) is provided, it shall extend under the drive-train components to contain and drain any leakage. Details of the drain and containment system shall be mutually agreed.

7.7.4.3 Baseplates shall be of welded construction. Abutting beams shall be welded on both sides. Flanges of load-bearing members shall not be spliced. Contact between webs at perpendicular joints shall be a minimum of one-third of the depth of the smallest member.

7.7.4.4 The compressor crankcase, crosshead guide, cylinder supports, and drive equipment shall be supported on load-bearing structural members.

7.7.4.5 Sufficient anchor bolt locations shall be provided on external load-bearing structural members to ensure that forces and moments are properly transmitted to the foundation.

7.7.4.6 Baseplates shall be designed and built to adequately support the weight of the compressor, driver, and accessories and to avoid resonance with any possible excitation frequency. The baseplate shall be able to transmit all forces and moments generated by the compressor and driver to the foundation.

7.7.4.7 The baseplate shall be provided with lifting lugs for at least a four-point lift. Lifting lugs attached to the equipment shall be designed using a maximum allowable stress of one-third of the specified minimum yield strength of the material. Welding applied to lifting lugs shall be full penetration, continuous welds and be in accordance with AWS D1.1. The welds shall be 100 % tested using nondestructive examination in accordance with the applicable code. Lifting the baseplate complete with all equipment mounted shall not permanently distort or otherwise damage the baseplate or the equipment mounted on it.

● **7.7.4.8** If specified, the baseplate shall be designed for column mounting (i.e. shall have sufficient rigidity to be supported at specified points) without continuous grouting under structural members. The purchaser and the vendor shall agree on the baseplate design.

● **7.7.4.9** If specified, the baseplate shall be designed to facilitate the use of optical, laser-based instruments or other methods for accurate leveling in the field. The purchaser and vendor shall agree on the details of such provisions. When the requirements are met by providing leveling pads and/or targets, these shall be accessible with the baseplate on the foundation and the equipment mounted. Removable protective covers shall be provided. For column mounted baseplates (see 7.7.4.8), leveling pads and/or targets shall be located close to the support points. For non-column mounted baseplates, a pad or target should be located, as a minimum, at each corner. For baseplates longer than 6 m (20 ft), additional pads shall be located at intermediate points.

7.7.4.10 The bottom of the baseplate between structural members shall be open. When the baseplate is installed on a concrete foundation, accessibility shall be provided for grouting under all load-bearing structural members. The members shall be shaped to lock positively into the grout. Open cavities may be either completely filled with grout, sealed, or provided with drains to prevent accumulation of foreign material.

7.7.4.11 The underside mounting surfaces of the baseplate shall be in one plane to permit use of a single-level foundation. When multi-section baseplates are provided, the mounting pads shall be in one plane after the baseplate sections are doweled and bolted together.

7.7.4.12 Nonskid decking covering all walk and work areas shall be provided on the top of the baseplate.

7.7.4.13 All joints, including deck plate to structural members, shall be continuously seal-welded on both sides to prevent crevice corrosion. Stitch welding, top or bottom, is unacceptable.

7.7.4.14 Supports, braces, and auxiliary equipment shall be mounted on load-bearing structural members.

● **7.7.4.15** If specified, a dynamic analysis of the baseplate, including a modal analysis and forced response analysis, shall be performed. The modal analysis shall establish that mechanical natural frequencies of the baseplate are separated from the significant excitation frequencies by at least 20 %. The following loads, accounting for magnitude, phase, and frequency shall be considered:

a) forces and moments due to reciprocating and rotating machinery;

b) acoustic-pulsation shaking forces in vessels and piping;

c) forces due to driver torque.

The forced response analysis shall demonstrate that the calculated vibration levels at any particular forcing frequency at any point on the baseplate shall not exceed the following:

a) for a vibration frequency less than or equal to 10 Hz, a maximum displacement of 100 µm 0 to peak (4 mil 0 to peak);

b) for a vibration frequency greater than 10 Hz, a maximum velocity of 4.5 mm/s RMS (0.175 in./s RMS).

If specified, a written report of the analysis shall be provided.

NOTE This type of analysis is typically performed for equipment mounted offshore, platforms, or equipment mounted on steel columns. For equipment mounted on solid concrete foundations, dynamic skid analysis may be omitted.

7.7.5 Soleplates and Rails

● **7.7.5.1** When soleplates or rails are specified, they shall be provided by the vendor, and they shall meet the requirements of 7.7.1.2 and 7.7.2 in addition to those of 7.7.3.1.

NOTE See Annex K for a typical sketch.

7.7.5.2 Adequate working clearance shall be provided at the bolting locations to allow the use of standard socket or box wrenches and to allow the equipment to be moved using the horizontal and vertical jackscrews.

7.7.5.3 Soleplates shall be steel plates thick enough to transmit the expected loads from the equipment feet to the foundation and to facilitate grouting. In no case shall they be less than 40 mm ($1^1/_2$ in.) thick.

7.8 Controls and Instrumentation

7.8.1 General

7.8.1.1 Control systems, instrumentation, electrical systems, and their installation shall conform to the purchaser's specifications and, unless otherwise specified, shall comply with the requirements of API 614 and API 670, except as modified by the following sections.

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

● **7.8.1.3** The vendor shall provide all instrumentation as specified. The proposal shall include a list of all instrumentation being supplied by the vendor.

7.8.1.4 All instrumentation furnished by the vendor shall be approved by the purchaser.

7.8.1.5 Instrumentation, panel, and gauge board mounting details shall be agreed.

7.8.1.6 All instrumentation shall be securely supported to eliminate vibration and undue force on instrument piping and to prevent damage during shipment, storage, operation, and maintenance.

7.8.1.7 When controls are shipped loose for field installation, each device shall be individually tagged with the appropriate identification information. The vendor shall provide a listing of these devices and documentation indicating location and instructions for installation. See 8.4 for shipment.

7.8.1.8 All tubing connections dismantled for shipment shall have matched stainless steel tags (initiation point, intermediate sections, and application point) attached by stainless steel wire.

7.8.2 Control Systems

● **7.8.2.1** The compressor can be controlled on the basis of inlet pressure, discharge pressure, flow, or some combination of these parameters. This can be accomplished by suction throttling, valve unloaders, clearance pockets, speed variation, or a cooled bypass from discharge to suction. The control system can be mechanical, pneumatic, hydraulic, electric or electronic, or any combination thereof.

The following shall be as specified by the purchaser:

a) the type of control system;

b) the control signal;

c) the control range;

d) control equipment to be furnished by the vendor.

● **7.8.2.2** The configuration of the control system shall be Arrangement 1, 2, or 3, in accordance with API 614 or as specified by the purchaser.

7.8.2.3 The vendor shall describe the complete control system (including alarms and shutdowns) in this scope of supply by means of logic diagrams in accordance with IEC 60848. When the control system is supplied by others, the vendor shall provide logic diagrams of the critical functions associated with the compressor operation (starting, stopping, capacity control, shutdowns, etc.).

● **7.8.2.4** The purchaser shall specify the method of capacity control for start-up and continuous operation. For constant-speed units, this is typically achieved by suction valve unloading, clearance pockets, cooled recycle, or a combination of methods. Capacity control on adjustable-speed units is typically accomplished by speed control but may be used with a combination of methods. The vendor and the purchaser shall agree on the modes and duration of unloaded and partially loaded compressor operation. The vendor shall be responsible for the loading/unloading sequence.

NOTE Reciprocating compressors are usually specified for constant-speed operation.

● **7.8.2.5** If specified, automatic immediate unloading shall be supplied to permit re-acceleration of the motor after a temporary electric power failure of an agreed maximum duration.

7.8.2.6 The purchaser shall specify the load steps required from the capacity control system. Five-step suction valve unloading shall provide nominal capacities of 100 %, 75 %, 50 %, 25 %, and 0 %; three-step suction valve unloading shall provide nominal capacities of 100 %, 50 %, and 0 %; and two-step suction valve unloading shall provide capacities of 100 % and 0 %.

7.8.2.7 For variable speed control the speed of the compressor shall vary linearly with the control signal and an increase in signal shall increase speed. Unless otherwise specified, the full range of the purchaser's signal shall correspond to the required operating range of the compressor for all specified operating conditions.

7.8.2.8 Clearance pockets shall normally be of the fixed type (pocket either open or closed). The use of variable volume clearance pockets requires purchaser's approval. Each added clearance volume shall be included in the data sheets to indicate the clearance it adds to the cylinder.

7.8.2.9 When a machine-mounted capacity control system is specified, the vendor shall provide a panel complete with the following:

a) a master selector device (one for each service on multi-service compressors) to provide the specified load steps such as positive-detent-type selector, push buttons, or HMI activated;

b) indicators to show at which step the machine is operating.

7.8.3 Instrument and Control Panels

Interconnecting shop-fabricated piping, tubing, and wiring for controls and instrumentation, when furnished and installed by the vendor, shall be disassembled only as necessary for shipment.

7.8.4 Instrumentation

● **7.8.4.1 General**

Instruments shall be furnished and mounted locally or on a panel, as specified. Instrument mounting details shall be mutually agreed.

● **7.8.4.2 Speed Indication**

If specified, a phase reference transducer shall be provided. The purchaser shall specify single or dual probes.

A tachometer shall be provided for adjustable speed units. The purchaser shall specify the type, range, and indicator provisions of the tachometer. Unless otherwise specified, the tachometer shall be supplied by the driver vendor and shall be furnished with a minimum range of 0 % to 125 % of maximum continuous speed.

7.8.4.3 Temperature Measurement

7.8.4.3.1 Dial type temperature gauges shall be heavy duty and corrosion resistant. They shall be at least 125 mm (5 in.) diameter, bimetallic or liquid-filled types and, unless otherwise agreed, shall have black marking on a white background.

● **7.8.4.3.2** Main bearing temperature detectors shall be supplied. If specified, packing, and/or valve temperature detectors shall be supplied. Details of the monitoring requirements and auxiliary equipment to be furnished (thermocouples, resistance temperature detectors, intrinsically safe systems, etc.) shall be jointly agreed.

7.8.5 Relief Valves

Relief valves shall be set to operate at not more than the MAWP, but not less than the values listed in Table 4.

Table 4—Relief Valve Settings

Rated Discharge Gauge Pressure (Each Stage)		Minimum Relief Valve Set Pressure Margin Above Rated Discharge Gauge Pressure
bar	psig	
≤ 10	≤ 150	1 bar (15 psig)
> 10 to 170	> 150 to 2500	10 %
> 170 to 240	> 2500 to 3500	8 %
> 240 to 345	> 3500 to 5000	6 %
> 345	> 5000	See footnote [a]

[a] For rated discharge gauge pressures above 345 bar (5000 psig), the relief valve setting shall be agreed on by the purchaser and the vendor.

7.8.6 Alarms and Shutdowns

● **7.8.6.1** If specified, an alarm/shutdown system shall be provided. The alarm/shutdown system 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.

● **7.8.6.2** The purchaser shall specify the alarms and shutdowns required. Minimum recommendations are listed in Table 5.

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

● **7.8.6.4** The purchaser shall specify whether alarm and shutdown circuits shall be designed to open (de-energize) or to close (energize) to initiate alarms and shutdowns.

● **7.8.6.5** If specified, crossheads shall be equipped with a high crosshead pin temperature sensor. The type of system shall be agreed.

Table 5—Minimum Alarm and Shutdown Recommendations

Condition	Alarm	Shutdown
High gas discharge temperature for each cylinder	X	—
Low gas suction pressure for each stage	X	—
Low frame lube oil pressure	X	X
Low frame lube oil level	X	—
Cylinder lubricator system failure	X	—
High oil-filter differential pressure	X	—
High frame vibration	X	X
High crosshead vibration	X	X
High level in separator	X	X
Jacket water system failure	X	—

NOTE The “X” indicates when the condition occurs, alarm or shutdown is recommended; “—” indicates when the condition occurs, alarm or shutdown is not recommended.

7.8.6.6 It is recommended that start-up permissives (interlocks) be used for barring/locking device, low lube oil temperature, low lube oil pressure, cylinder lubricator, frame oil level, and separator level. A trip function is required in the event that the barring device become disengaged from the rest position. The purchaser shall specify who is to supply sensing devices for these.

7.8.7 Vibration and Position Detectors

● **7.8.7.1** If specified, the vendor shall furnish and mount vibration transducers.

Devices and mounting shall conform to API 670. Ball-and-seat or magnetic-type switches shall not be supplied. The type, number, and location of the devices shall be agreed.

● **7.8.7.2** If specified, the vendor shall furnish and mount piston rod drop detectors of the noncontacting type to measure the vertical movement of each piston rod (piston rod drop). The probe and the associated oscillator-demodulator and connecting cable shall be installed and calibrated in accordance with API 670.

● **7.8.7.3** A one-event-per-revolution machined mark on the crankshaft and a phase-reference transducer shall be supplied. If specified, a redundant phase-reference transducer shall be provided. The transducer(s) shall be supplied, installed, and calibrated in accordance with API 670.

7.8.7.4 Contacting-type piston rod drop detectors (such as a mechanical roller or fuse metal plug) if used shall be approved by the purchaser.

7.8.8 Temperature Monitoring Systems

If specified, the vendor shall supply a temperature monitoring system installed and calibrated in accordance with API 670. The temperatures monitored shall be as specified by the purchaser and may include, but are not limited to, the following:

a) main bearing temperatures;

b) valve cover temperatures;

c) packing temperatures.

7.9 Piping

7.9.1 General

7.9.1.1 Piping shall comply with the requirements of API 614, except as modified by the following sections.

7.9.1.2 The extent of process and auxiliary piping to be supplied by the vendor shall be specified.

7.9.1.3 If special flanges, not in accordance with the specified standards, are unavoidable at the purchaser connection, the vendor shall supply a welding neck companion flange, bolting, and gaskets to be installed by others. The purchaser shall be advised of this situation in the proposal.

NOTE Cylinder connections are discussed in 6.8.2.

7.9.1.4 If specified, piping, pulsation suppression devices and knockout vessels shall have provisions for heat tracing and/or insulation.

7.9.1.5 The compressor piping system shall be designed to flow liquids to a collection device. Low points shall be drainable.

7.9.1.6 Termination of piping connections shall be mutually agreed. All piping supplied by the vendor shall be prefabricated. Any piping that cannot be shipped in the assembled state shall be preserved, match marked, and tagged to facilitate field assembly.

7.9.1.7 Manifolded component vents and drains shall be considered piping systems and comply with the requirements of API 614.

7.9.1.8 Internals of piping and components shall be accessible through openings or by dismantling for complete visual inspection and cleaning.

7.9.1.9 Branch-connections DN 50 (2 NPS) and smaller shall be designed to minimize overhung weight. Connections shall be forged fittings or shall be braced back to the main pipe in at least two planes to avoid breakage due to pulsation-induced vibration.

7.9.1.10 All pipe flanges mating with cast iron compressor flanges shall be flat faced and utilize full-faced gaskets.

NOTE For the purposes of this section, the term “compressor flanges” does not include faced and studded bosses.

7.9.1.11 Threaded piping joints shall not be used for flammable or toxic fluids in accordance with 6.8.2.1.5. Where threaded joints are permitted, they shall not be seal welded unless approved by the purchaser.

NOTE 1 Threaded joints are typically only allowed for connections to nonweldable materials such as cast iron, instruments, or locations that are disassembled for maintenance.

NOTE 2 Hazardous situations can arise from the incompatibility between parallel and tapered-type thread standards.

7.9.1.12 Control valves shall have flanged ends.

7.9.1.13 Except where ring type joints are required or specified, pipe flange gaskets shall be flat, asbestos-free material up to and including ANSI Class 300 pressure ratings, and spiral wound gaskets for higher ratings. Spiral wound gaskets shall have external centering rings and windings of austenitic stainless steel or other suitable corrosion-resistant materials (Monel, Inconel, etc.) depending on the fluids handled.

7.9.1.14 Flared type tubing connections shall not be used.

● **7.9.1.15** Special requirements for piping, flanges, valves, and other appurtenances in services such as hydrogen, hydrogen sulfide, or other toxic services shall be specified by the purchaser.

7.9.1.16 Inert gas purge systems shall be stainless steel downstream of the filters.

7.9.1.17 Lap-joint or slip-on flanges shall not be used.

NOTE Slip-on flanges are not used on piping and appurtenances around reciprocating compressors due to their insufficient fatigue life.

7.9.2 Frame Lubrication Oil Piping

7.9.2.1 The vendor shall specify the maximum piping distance between the main frame and any auxiliary oil console, and the required elevation difference.

7.9.2.2 Unless otherwise specified, oil piping (with the exception of cast-in-frame lines or passages) and tubing, including fittings, shall be stainless steel.

7.9.2.3 After fabrication, oil lines shall be thoroughly cleaned per API 614.

7.9.3 Forced-feed Lubricator Tubing

7.9.3.1 Oil feed lines from force-feed lubricators to cylinder and packing lubrication points shall be at least 6 mm ($^1/_4$ in.) outside diameter with a minimum wall thickness of 1.5 mm (0.065 in.). Tubing shall be seamless austenitic stainless steel. Fittings shall be austenitic stainless steel. See 7.5.3.1.9 for check valves. Tubing rating shall meet or exceed the MAWP of the lubricator system.

7.9.3.2 Tubing shall be grouped together where possible. If winterization is specified per 6.1.21, the tubing shall stand off from the machine to allow insulation to fully enclose the tubing.

7.9.4 Jacket Water Piping

7.9.4.1 The vendor shall supply piping with a single inlet and a single outlet connection on each cylinder requiring external water circulation (see Figure F.1).

7.9.4.2 Both the water inlet and outlet lines to each compressor cylinder shall be provided with an isolation valve. A flanged globe valve shall be provided on the main outlet line from each cylinder. A sight flow indicator shall be installed in the water outlet line from each cylinder. Where more than one water inlet and outlet point exists on a cylinder, one sight flow indicator and a globe valve shall be provided for each water outlet point on each cylinder. Cylinder water piping shall be equipped with valved water vents and drains (see Figure F.1).

● **7.9.4.3** If specified, the vendor shall supply a piping system for all equipment mounted on the compressor or compressor base. Each water circuit operating at different inlet temperature level shall have a separate inlet connection. All water circuits shall be connected to a common outlet. Series-type circuits shall have the necessary valved bypasses to provide temperature control.

7.9.4.4 Where a thermosiphon or a static system is provided (see 7.6.3 and 7.6.4), the vendor shall furnish piping with a drain valve at its lowest point and an expansion tank (complete with fill-and-vent connections and level indication) sized to prevent overflow of water (see Figure F.1, Plans A and B). A temperature indicator is required for a thermosiphon system.

7.9.5 Instrument Piping

Initial connections for pressure instruments and test points shall comprise a branch and an isolation valve conforming to the same requirements as the system to which it is connected. Beyond the initial isolation valve, a minimum of DN 15 (NPS $^1/_2$) piping or 10 mm ($^3/_8$ in.) tubing shall be used. A common primary connection may be used for remotely mounted instruments that measure the same pressure. Such common connections shall not be smaller than DN 15 (NPS $^1/_2$) and separate secondary isolation valves shall be provided for each instrument. Where a pressure gauge is to be used for testing pressure alarm or shutdown devices, common connections are required for the pressure gauge and associated devices.

7.9.6 Process Piping

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

7.9.6.2 When compressor process inlet piping and pulsation suppression equipment are furnished by the vendor, provisions shall be made for the insertion of temporary start-up screens just upstream of the suction pulsation suppression device. The design of the piping system, the suction pulsation suppression device and the temporary start-up screens shall afford easy removal and reinsertion of the screens without the necessity of pipe springing.

7.9.6.3 Temporary start-up screens shall be supplied by the vendor. The design, location, and orientation of the screens shall be agreed.

● **7.9.6.4** If specified, the vendor shall supply the removable spool pieces that accommodate temporary start-up screens. Sufficient pressure taps to allow monitoring of the pressure drop across the screen shall be provided.

● **7.9.6.5** If specified, a final stage discharge check valve shall be supplied. Valve type, size, and location shall be agreed.

NOTE Swing type check valves are not recommended for pulsating service.

7.9.7 Distance Piece Vent and Drain Piping

7.9.7.1 The vendor shall supply distance piece vent and drain piping to the extent and requirements specified. See Annex H for a typical distance piece vent and drain system.

7.9.7.2 Drain and vent piping serving individual cylinders shall not be less than DN 25 (NPS 1). Drain and vent tubing serving individual cylinders shall not be less than 20 mm ($^3/_4$ in.) outside diameter. Drain and vent headers shall not be less than DN 50 (NPS 2). Vent connections in the packing case and interconnecting tubing within a distance piece shall be of austenitic stainless steel and of at least 6 mm ($^1/_4$ in.) outside diameter with a minimum wall thickness of 1.24 mm (0.049 in.).

7.10 Intercoolers, Aftercoolers, and Separators

7.10.1 Intercoolers and Aftercoolers

● **7.10.1.1** If specified, the vendor shall furnish an intercooler between each compression stage.

● **7.10.1.2** If specified, aftercoolers shall be furnished by the vendor.

● **7.10.1.3** Coolers shall be air cooled or water cooled as specified.

7.10.1.4 Intercoolers and aftercoolers shall be furnished in accordance with the specified pressure design code.

7.10.1.5 Water-cooled shell-and-tube intercoolers and aftercoolers shall be designed and constructed in accordance with TEMA Class C or R, as specified. When TEMA Class R has been specified, the heat exchanger shall be in accordance with API 660.

7.10.1.6 When air coolers are specified, they shall be in accordance with API 661.

7.10.1.7 Unless otherwise specified, the water side of heat exchangers shall be designed in accordance with 6.1.8.

7.10.1.8 The choice of water on the tube or shell side of shell and tube heat exchangers shall be agreed, with due consideration to pulsations, pressure levels, corrosion, and maintainability.

● **7.10.1.9** If specified, the vendor shall furnish the fabricated piping between the compressor stages and the intercoolers and aftercoolers.

7.10.2 Separators

● **7.10.2.1** If specified, liquid separation and collection facilities in accordance with 7.10.2.2 through 7.10.2.8 shall be provided upstream of the compressor and after every intercooler.

NOTE Intercooling may result in condensation.

7.10.2.2 The design of a compressor piping system, separator, and equipment location should consider the following factors:

— operation with a gas at or near saturation;

— liquid separator close to the compressor suction;

— sufficient separator volume to handle incoming slugs;

— sufficient gas velocity in the line from the separator to the cylinder to minimize liquid dropout;

— elimination of low points between the separator and cylinder;

— slope of lines to allow liquids to flow to a collection device;

— insulation to minimize heat loss;

— heat tracing to maintain the gas at or above the dew point.

7.10.2.3 The type of liquid separation device and whether it is to be arranged in a separate vessel, or integral with the pulsation suppression device, or integral with the intercooler, shall be agreed upon by the vendor and purchaser. In the case of cylinders handling gases that are or can become saturated or are within 10 °C (20 °F) of any anticipated dew point temperature a standalone separator should be used. An integral moisture removal section is permitted if the gas is more than 10 °C (20 °F) away from any anticipated dew point. Special attention should be paid to integral separators in pulsation suppression devices to avoid mechanical vibration in the separator pack.

NOTE 1 Moisture removal sections of pulsation suppression devices have demonstrated a low separation efficiency when oscillating flow effects were not considered.

NOTE 2 Drain sumps on pulsation suppression devices can lead to longer cylinder connection nozzles and can result in high vibrations on the drain sump instrumentation.

7.10.2.4 The liquid separation device shall remove 99 % of all droplets of 10 microns or larger over the entire flow range. Pressure drop shall be as defined in 7.11.8.1.

7.10.2.5 Integral moisture removal sections shall have a drain sump or boot extending below the device shell into which the separated liquid is directed.

NOTE Drain sumps on pulsation suppression devices can lead to longer cylinder connection nozzles and can result in high vibrations on the drain sump instrumentation.

7.10.2.6 The capacity of the sump or boot of an integral separator, or lower part of the standalone separation vessel, shall be sufficient to contain the maximum expected liquid flow from any specified operating condition for not less than 15 minutes, without activating any alarm.

7.10.2.7 The liquid separation device shall be equipped with a drain connection of not less than DN 25 (NPS 1), level indication connections, and a high-level shutdown device connection. The capacity of the vessel or boot between the alarm and shutdown levels shall be equivalent to the maximum expected liquid flow for not less than 5 minutes. The connections shall be flanged and fitted with blinds.

● **7.10.2.8** If specified, an automatic drainage system shall be provided. For air or inert gas service, this automatic drainage system may comprise a float-operated trap with a manual bypass. In all other cases, the drainage system shall comprise a separate level control valve with a manual bypass, operated by a level controller of an agreed type.

● **7.10.2.9** If specified, the drain sump or boot or lower part of the standalone separation vessel shall be provided with a level indicator and alarm and shutdown devices.

7.11 Pulsation and Vibration Control

7.11.1 General

7.11.1.1 Refer to API 688 for guidance on the application of pulsation and vibration control requirements.

NOTE API 688 contains information on design of pulsation suppression, piping and support layout, sizing of acoustic filters, and shaking forces that were part of API 618, Fifth Edition.

7.11.1.2 The basic techniques used for control of detrimental pulsations and vibrations are the following:

a) system design based on analysis of the interactive effects of pulsations and the attenuation requirements for satisfactory levels of piping vibration, compressor performance, valve life, and operation of equipment sensitive to flow pulsation;

b) utilization of pulsation suppression devices such as pulsation filters and attenuators; volume bottles, with or without internals; choke tubes; orifice systems; and selected piping configurations;

c) mechanical restraint design, specifically including such things as type, location, and number of pipe and equipment clamps and supports.

● **7.11.1.3** If specified for preliminary sizing, pulsation suppression devices shall have minimum suction surge volume and minimum discharge surge volume (not taking into account liquid collection chambers), as determined from Equations (3), (4), and (5), but in no case shall either volume be less than 0.03 m^3 (1 ft^3).

In SI units

$$V_s = 8.1 \times \mathrm{PD}\left(\frac{kT_s}{M}\right)^{\frac{1}{4}} \tag{3}$$

$$V_d = 1.6 \times \left(\frac{V_s}{r^{\frac{1}{k}}}\right) \tag{4}$$

$$V_s \text{ and } V_d \geq 0.03 \tag{5}$$

In USC units

$$V_s = 7 \times \mathrm{PD}\left(\frac{kT_s}{M}\right)^{\frac{1}{4}}$$

$$V_d = 1.6 \times \left(\frac{V_s}{r^{\frac{1}{k}}}\right)$$

$$V_s \text{ and } V_d \geq 1.0$$

where

V_s is the minimum required suction surge volume in m^3 (ft^3);

V_d is the minimum required discharge surge volume in m^3 (ft^3);

k is the isentropic compression exponent at average operating gas pressure and temperature;

R is the stage pressure ratio at cylinder flanges (absolute discharge pressure divided by absolute suction pressure);

T_s is the absolute suction temperature in K (°R);

M is the molecular weight;

PD is the total net displaced volume per revolution of all compressor cylinders to be manifolded in the surge volume in m^3 (ft^3).

The internal diameter of the surge volume shall be based on the minimum surge volume overall length required to manifold the compressor cylinders. For a single-cylinder surge volume, the ratio of surge volume length to internal diameter shall not exceed 4.0. The inside diameter of spherical volumes shall be calculated directly from the volumes determined by Equations (3), (4), and (5).

NOTE 1 Equations (3), (4), and (5) are intended to ensure that reasonably sized pulsation suppression devices are included with the compressor vendor's proposal. The sizes can be altered according to the simulation analysis employed by Design Approaches 2 and 3. Sizing requirements can be substantially influenced by operating parameters, interaction among elements of the overall system, and mechanical characteristics of the compressor system. The magnitude of the effects of these factors cannot be accurately predicted at the outset.

NOTE 2 Some compressor applications require the use of properly designed low-pass acoustic filters that can affect preliminary sizing.

7.11.1.4 When acceptance criteria defined in 7.11.7 and 7.11.8 cannot be met, the purchaser and the vendor shall agree on acceptable limits and control methods.

● **7.11.1.5** The purchaser shall specify if the analysis is to be performed by the vendor or a third party. If a third party is selected to perform the analysis, the compressor vendor shall provide the necessary information required for the third-party vendor to complete the analysis.

● **7.11.2 Alternate Operating Conditions**

7.11.2.1 Analysis shall be performed for all specified alternative gases, operating conditions, and loading steps. For compressor systems with extensive alternate operating conditions, the extent of the analysis shall be defined in the proposal.

NOTE It may be impractical or unnecessary to analyze every combination of operating conditions. The number of analysis points may be reduced based on experience.

7.11.2.2 When a compressor is to be operated on two or more gases of dissimilar molecular weights (e.g. hydrogen and nitrogen), pulsation levels shall be optimized for the gas on which the unit will operate for the greater length of time.

7.11.3 Multiple Unit Additive Effects

7.11.3.1 The scope of the analysis shall be based on agreement between the purchaser and the vendor.

● **7.11.3.2** The purchaser shall specify when multiple compressors are to be operated in parallel.

● **7.11.3.3** The purchaser shall specify when the compressor is to be operated in conjunction with existing compressor units and their associated piping systems. Modifications to an existing system to obtain acceptable pulsation levels shall be mutually agreed upon.

NOTE In some cases, it may be necessary to impose tighter limits for each new compressor than those defined in 7.11.7 in order for the combined system to achieve acceptable pulsation levels.

7.11.4 Design Approaches

Table 6 shall be utilized to determine the design approach.

NOTE Design Approach 1 has been removed, and the sizing equations are used for initial sizing as defined in 7.11.1.3.

Table 6—Design Approach Selection

Discharge Pressure	Rated Power per Cylinder		
	kW/cyl < 55 (hp/cyl < 75)	55 < kW/cyl < 220 (75 < hp/cyl < 300)	220 < kW/cyl (300 < hp/cyl)
P < 35 barg (P < 500 psig)	2	2	2
35 barg < P < 70 barg (500 psig < P < 1000 psig)	2	2	3
70 barg < P < 200 barg 1000 psig < P < 3000 psig)	2	3	3
P > 200 barg (P > 3000 psig)	3	3	3

7.11.5 Design Approach 2—Acoustic Simulation and Piping Restraint Analysis

7.11.5.1 General

Design Approach 2 is pulsation control through the use of pulsation suppression devices and proven acoustic techniques in conjunction with mechanical review of pipe runs and anchoring systems (clamp design and spacing) to achieve control of vibrational response. This approach includes the evaluation of acoustic interaction between the compressor, pulsation suppression devices, and associated piping, including pulsation effects on compressor performance and an evaluation of acoustic shaking forces in the pulsation suppression devices. The evaluation is accomplished by modeling the compressor system and the piping and then performing an acoustic simulation to determine the response. See Annex L for flowchart.

7.11.5.2 Compressor System Model

Pulsation suppression devices are analyzed using acoustic simulation. The compressor system model shall include piston and valve motion, cylinder passages, pulsation suppression device(s), and terminates at the line-side nozzle flange. This model is only used for the acoustic simulation. There is no mechanical modeling of the compressor system to evaluate mechanical resonances in Design Approach 2.

7.11.5.3 Piping System Model

When the layout and sizing of the piping system is completed, an acoustic simulation of the complete system shall be performed to confirm compliance with the requirements of 7.11.7 or to identify changes necessary to achieve compliance.

7.11.5.4 Prestudy

For applications where the piping system is not defined, the acoustic simulation can be performed with the piping system initially modeled with an infinite length, acoustically nonreflective line. When the acoustic simulation is performed prior to completion of the piping system model, the maximum allowable pressure pulsation level at the pulsation suppression device line-side nozzle flange shall be 70 % of the allowable value defined by Equation (8). Pressure drop requirements in 7.11.8.1 and shaking force requirements in 7.11.7.4.3 shall apply.

NOTE 1 The 70 % limit may not ensure Equation (7) pulsation allowable levels will be met in the final design without use of other acoustical measures (orifices, increased diameters, piping modifications, etc.).

NOTE 2 In order to meet contract delivery, all parties should cooperate to schedule the design of the pulsation suppression device, the pulsation analysis, and piping design. Ordering components after the prestudy can facilitate the procurement of long delivery components of the pulsation suppression devices such as end caps, nozzles, and cylindrical sections. However, the final length, nozzle orientation, and need for vessel internals cannot be optimized until the piping system is added to the acoustic model.

NOTE 3 If the pulsation suppression devices are fabricated prior to finalizing the piping configuration, the only remaining system design optimization methods available to the designer are the installation of orifices, piping modifications, and stiffening of the piping system.

7.11.5.5 Mechanical Review and Piping Restraint Analysis

A mechanical review shall be performed using span and basic vessel mechanical natural frequency calculations to avoid mechanical resonance. This review shall result in a table of various pipe sizes that indicates the maximum allowable span (based on the maximum compressor operating speed) between piping supports as a function of pipe diameter and the separation margin requirements of 7.11.8.2.

7.11.6 Design Approach 3—Acoustic Simulation and Piping Restraint Analysis Plus Mechanical Analysis

7.11.6.1 General

7.11.6.1.1 This acoustic simulation approach is identical to Design Approach 2, with the addition of a mechanical analysis of the compressor mechanical model, pulsation suppression devices and associated piping systems, including interaction between acoustic and mechanical system responses. Forced mechanical response is included when necessary. See Annex L for flowchart.

7.11.6.1.2 If specified, an analysis of the stresses found in the pulsation suppression device internals shall be completed in accordance with 7.12.1.23 and 7.12.1.24.

7.11.6.2 Step 3a—Mechanical Natural Frequency Analysis of the Compressor and Piping System

An analysis of the compressor and piping system shall be done to predict the mechanical natural frequencies. The mechanical and acoustic system shall be designed to meet the separation margin criteria of 7.11.8.2, and the shaking forces shall not exceed the limits found in 7.11.7.4.

The starting point of the compressor mechanical model shall be the crosshead guide-to-crankcase interface. This location shall be relatively rigid when compared to the rest of the compressor mechanical model, and it shall be accurately described by a 6 degree of freedom spring. The compressor mechanical model end point shall be the second rigid pipe clamp on the suction and discharge piping moving away from the line side nozzles of the pulsation suppression devices.

NOTE The intent is to avoid mechanical resonance of the compressor, pulsation suppression devices, and piping system at frequencies where high shaking forces also exist.

7.11.6.3 Step 3b1—Forced Mechanical Response Analysis of the Compressor Mechanical Model

7.11.6.3.1 When the excitation frequency separation margins or the shaking force amplitude guidelines for pulsation suppression devices cannot be met, a forced mechanical response analysis of the compressor mechanical model to the pulsation-induced forces and cylinder-gas forces shall be performed. The allowable cyclic stress criteria in 7.11.7.6 shall apply.

NOTE It is not intended that analysis of the cyclic stresses in the compressor components be included in this design approach. The compressor components are included in the model only for the purpose of enabling the analysis of the effects of their flexibility and dynamic movement on the pulsation suppression devices.

7.11.6.3.2 The compressor vendor shall supply the allowable vibration limits for compressor components such as cylinders, distance pieces, and crankcases.

NOTE 1 European Forum for Reciprocating Compressors (EFRC) guidelines can be used if the allowable vibration limits are not supplied by compressor vendor.

NOTE 2 The allowable compressor vibration levels are generally the limiting design criteria.

7.11.6.4 Step 3b2—Forced Mechanical Response of the Piping System Model

When the excitation frequency separation margin and the shaking force amplitude guidelines for the piping system cannot be met, a forced mechanical response analysis of the piping system to acoustic shaking forces shall be performed. The allowable vibration and cyclic stress limits in 7.11.7.5 and 7.11.7.6, respectively, shall apply. The piping system model end points shall be defined by the analyst in agreement with the purchaser. The piping system model should include all of the piping that was included in the acoustic simulation.

When forced mechanical response analysis of the piping system is performed without doing a forced mechanical response analysis of the compressor mechanical model, the starting point of the piping system is at the compressor cylinder flanges, which are assumed to be rigid.

NOTE As with Step 3b1, the vibration is generally the limiting design consideration because when the vibration levels are within the recommended allowable limits, the allowable stress levels are usually not approached. The exception is where high stress concentrations occur at large diameter reductions such as nozzle connections and weldolets for small piping on significantly larger piping.

7.11.7 Design Criteria

7.11.7.1 General

Pulsation suppression devices and techniques applied in accordance with Design Approaches 2 and 3 shall satisfy the basic criteria in 7.11.7.2 and the other criteria in 7.11.8.

7.11.7.2 Allowable Compressor Cylinder Flange Pressure Pulsation

Unless other criteria (such as loss of compressor efficiency) are specified, the unfiltered peak-to-peak pulsation level at the compressor cylinder flange, as a percentage of mean absolute line pressure, shall be limited to the lesser of 7 % or the value computed from Equation (6).

$$P_{cf} = 3R\% \tag{6}$$

where

P_{cf} is the maximum allowable unfiltered peak-to-peak pulsation level, as a percentage of mean absolute line pressure at the compressor cylinder flange;

R is the stage pressure ratio.

7.11.7.3 Allowable Pulsation Levels at and Beyond Line-side Connections of Pulsation Suppression Devices

7.11.7.3.1 Based on normal operating conditions, the peak-to-peak pulsation levels in the initial suction, interstage, and final discharge piping systems beyond pulsation suppression devices shall satisfy the requirements specified in items a) and b).

a) For systems operating at absolute line pressures above 3.5 bar (50 psia), the peak-to-peak pulsation level of each individual frequency component shall be limited to that calculated by Equation (7).

In SI units

$$P_1 = \sqrt{a/(350)}\left(\frac{400}{(P_L \times D_1 \times f)^{0.5}}\right) \tag{7}$$

In USC units

$$P_1 = \sqrt{a/(1150)}\left(\frac{300}{(P_L \times D_1 \times f)^{0.5}}\right)$$

where

P_1 is the maximum allowable peak-to-peak level of each individual frequency component expressed as a percentage of mean absolute line pressure;

a is the speed of sound for the gas in m/s (ft/s);

P_L is the mean absolute line pressure in bara (psia);

D_I is the inside diameter of line pipe in mm (in.);

f is the pulsation frequency in Hz.

The pulsation frequency f is derived from Equation (8).

$$f = \frac{N \times z}{60} \tag{8}$$

where

N is the shaft speed in r/min;

z is the 1, 2, 3,…, corresponding to the fundamental frequency and higher order frequencies.

b) For absolute pressures less than 3.5 bara (50 psia), Equation (7) shall be multiplied by Equation (9).

In SI units

$$\sqrt{P_L / 3.5} \tag{9}$$

In USC units

$$\sqrt{P_L / 50}$$

● **7.11.7.3.2** If pulsation levels exceed the limits defined by 7.11.7.2 and 7.11.7.3, the shaking force (7.11.7.4) or vibration levels (7.11.7.5) or cyclic stress levels (7.11.7.6) shall be approved by the purchaser.

7.11.7.3.3 Flow pulsations in elements sensitive to such phenomena (e.g. check valves, cyclone separators) shall be limited to mutually agreed criteria.

7.11.7.4 Allowable Acoustic Shaking Force

7.11.7.4.1 General

The allowable nonresonant peak-to-peak shaking force based on the design vibration guideline shall be determined from Equation (10).

$$\mathrm{SF_k} = k_{\mathrm{eff}} \times V \tag{10}$$

where

$\mathrm{SF_k}$ is the nonresonant peak-to-peak force guideline relative to static structural stiffness in N (lbf);

k_{eff} is the effective static stiffness along the piping or pulsation suppression device axis where the shaking force acts in N/mm (lbf/in.) (see API 688 for a detailed discussion of k_{eff});

V is the design peak-to-peak vibration guideline in mm (in.) (see Figure 4).

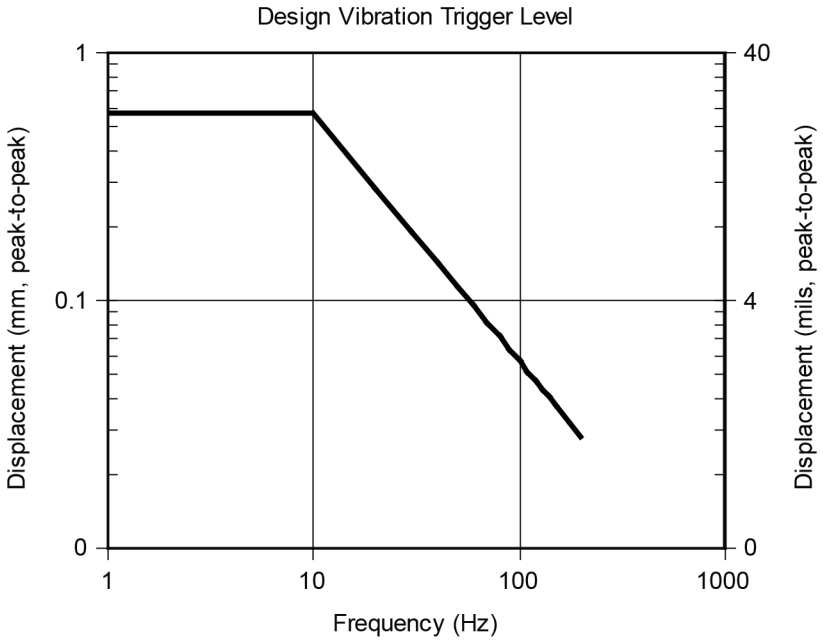

Figure 4—Piping Design Trigger Level at Discrete Frequencies

The shaking force guideline (SF_k) applies to nonresonant vibration. Shaking forces near resonance shall be reduced well below the above shaking force guideline. This guideline is simplified from a complex analysis, contains many inherent assumptions, and should be applied with care.

Various support types provide ranges of support stiffness as follows:

— elevated unbraced rack supports: 900 N/mm to 2700 N/mm (5000 lbf/in. to 15,000 lbf/in.);

— grade-level typical supports and clamps: 2700 N/mm to 27,000 N/mm (15,000 lbf/in. to 150,000 lbf/in.);

— grade-level heavy supports and clamps: 27,000 N/mm to 45,000 N/mm (150,000 lbf/in. to 250,000 lbf/in.).

7.11.7.4.2 Allowable Piping System Nonresonant Acoustic Shaking Force

The allowable piping nonresonant peak-to-peak shaking forces shall be the lower of the values calculated from Equation (10) or from Equation (11).

In SI units

$$SF_{p\,max} = 45 \times NPS \tag{11}$$

In USC units

$$SF_{p\,max} = 250 \times NPS$$

where

$SF_{p\,max}$ is the maximum piping nonresonant peak-to-peak shaking force guideline based on support strength in N (lbf);

NPS is the nominal pipe size in mm (in.).

7.11.7.4.3 Allowable Cylinder Mounted Pulsation Suppression Device Nonresonant Shaking Force

The allowable nonresonant peak-to-peak shaking forces for cylinder mounted pulsation suppression devices shall be the lower of the values calculated from Equation (10) or from Equation (12). For Design Approach 2, since the shaking force levels are not evaluated using Equation (10), the maximum allowable level shall be 10 % of Equation (12). For frequencies within ±20 % of the calculated pulsation suppression device mechanical natural frequency, the allowable level shall be 1 % of Equation (12).

In SI units

$$SF_{d\,max} = 45{,}000 \tag{12}$$

In USC units

$$SF_{d\,max} = 10{,}000$$

where

$SF_{d\,max}$ is the maximum pulsation suppression device nonresonant peak-to-peak shaking force guideline based on structural strength in N (lbf).

NOTE The shaking force criteria are intended as design criteria for shaking forces that act along the pulsation suppression device axis.

7.11.7.5 Piping Design Vibration Criteria

The predicted piping vibration magnitude for each discrete frequency shall be limited to the design level in Figure 4. These design levels are according to the design levels (Zone A) of the EFRC's *Guidelines for Vibrations in Reciprocating Compressor Systems*. The diagram in Figure 4 is based on the following:

a) a constant allowable vibration amplitude of 0.57 mm peak-to-peak (22.5 mils peak-to-peak) for frequencies below 10 Hz;

b) a constant allowable vibration velocity of approximately 36 mm/s peak-to-peak (1.41 in./s peak-to-peak) for frequencies between 10 Hz and 200 Hz.

The limits in Figure 4 are intended as a design trigger level for analysis in accordance with 7.11.6.4.

NOTE 1 Field acceptance criteria may differ from the design levels. Refer to EFRC Zone B for field acceptance criteria.

NOTE 2 The requirements in this subsection are considered to be conservative. There are, however, situations in which high stress risers and un-braced small diameter attached piping can pose a problem even though the main pipe exhibits acceptable vibration limits. There are no criteria conservative enough to be used without a significant understanding of vibrational mechanics.

7.11.7.6 Allowable Cyclic Stress

7.11.7.6.1 For Design Approach 3, Steps 3b1 and 3b2, pulsation and/or mechanically induced vibration shall not cause a cyclic stress level in the piping and pulsation suppression devices in excess of the endurance limits of materials used for components subject to these cyclic loads. For carbon steel with an operating temperature below 370 °C (700 °F), the peak-to-peak cyclic stress shall be less than 180 N/mm^2 (26,000 psi) considering all stress concentration factors present and with all other stresses within applicable code limits. Endurance limits for materials other than carbon steel shall be as defined in the specified pressure vessel code.

● **7.11.7.6.2** If specified, a piping system flexibility analysis that predicts forces, moments and stresses resulting from thermal gradients, thermal transients, pipe and fitting weights, static pressure, and bolt-up strains shall be performed. The specified piping code shall provide the design criteria.

Modeling should include the effects of thermal expansion, pressure and dead weight on the compressor frame, pulsation suppression devices, heat exchangers, and other equipment within the system.

7.11.8 Other Criteria

7.11.8.1 Allowable Pressure Drop

Allowable pressure drop through the pulsation control devices for each suction and discharge system of each compression stage is defined below.

a) Steady flow pressure drop shall not exceed 0.5 % of mean absolute line pressure at pressure ratios less than or equal to 1.4. At pressure ratios greater than 1.4, the value shall be determined by Equation (13). The allowable limits shall be increased by a factor of two when the pressure drop is calculated using the total flow, where total flow is the sum of the steady-state and dynamic flow components, provided that the steady flow component still meets the above criteria.

$$\Delta P = 1.67\left(\frac{R-1}{R}\right)\% \tag{13}$$

where

ΔP is the allowable pressure drop based on steady flow through devices installed for pulsation control, expressed as a percentage of mean absolute line pressure;

R is the stage pressure ratio.

b) When a moisture separator is an integral part of the pulsation suppression device, steady flow pressure drop shall not exceed 0.6 % of mean absolute line pressure at pressure ratios less than or equal to 1.4. At pressure ratios greater than 1.4, the value shall be determined by Equation (14). The allowable limits shall be increased by a factor of two when the pressure drop is calculated using the total flow, where total flow is the sum of the steady-state and dynamic flow components, provided that the steady flow component still meets the above criteria.

$$\Delta P = 2.17\left(\frac{R-1}{R}\right)\% \tag{14}$$

NOTE Pressure drops specified in this section can be exceeded by mutual agreement between purchaser and vendor, when this is the consequence of the preferred pulsation control.

7.11.8.2 Separation Margins

The guidelines described below are to be used to avoid coincidence of excitation frequencies with mechanical natural frequencies of the compressor, pulsation suppression devices, and piping system.

a) The minimum mechanical natural frequency of any compressor or piping system element shall be designed to be greater than 2.4 times the fundamental frequency at maximum rated speed, and

NOTE The intent is to be above twice running speed because there is generally sufficient excitation energy at the first and second orders to excite resonances to an unacceptable level.

b) The predicted mechanical natural frequencies shall be designed to be separated from significant excitation frequencies by at least 20 %.

NOTE Significant excitation sources include cylinder gas loads (stretch) and can also include pulsation shaking forces at frequencies above second order.

7.11.8.3 Flow Measurement Error

For flow meters located in the piping system, the maximum flow measurement error caused by flow pulsations shall not exceed the following:

a) for noncustody transfer meters: 1.00 % error;

b) for custody transfer meters: 0.125 % error.

7.11.9 Documentation Requirements

A written report on the control of pulsation and vibration shall be furnished to the purchaser. Compliance with the requirements of 7.9 for the specified design approach shall be documented. The report shall define the analysis scope, including analysis guidelines, compressor configuration, load steps, gas composition, and extent of the piping system analyzed. The report shall include the recommendations resulting from the analysis. The documentation shall also present results applicable to each type of analysis performed. Acoustic simulation results include cylinder nozzle and piping pulsation, acoustic shaking forces and flow pulsation at equipment sensitive to this in spectrum form. Separation margin analysis results include natural frequencies and mode shapes. Forced mechanical response results include vibration and cyclic stress. The format of the results presentation should permit easy comparison with the analysis guidelines.

7.12 Pulsation Suppression Devices

7.12.1 General

● **7.12.1.1** Pulsation suppression equipment shall be designed and fabricated in accordance with the specified pressure vessel code. If specified, the pulsation suppressors shall be stamped with the symbol as required by the specified pressure vessel code (e.g. ASME *BPVC*) and registered with the required jurisdiction.

7.12.1.2 The MAWP for any component shall not be less than the set pressure of the relief valve serving that component and, in any case, shall not be less than a gauge pressure of 4 bar (60 psig).

7.12.1.3 Suction pulsation suppression devices shall be rated for individual stage discharge pressure.

7.12.1.4 All materials in contact with process gases shall be compatible with the gases being handled. The corrosion allowance for shells and internals of carbon-steel pulsation suppression equipment shall be a minimum of 3 mm ($^1/_8$ in.) unless otherwise specified.

Regardless of materials, all shells, heads, baffles, and partitions shall have a minimum thickness of 10 mm ($^3/_8$ in.). Welding procedures shall be provided [see “Vendor Drawing and Data Requirements” section in Annex E, item 17)].

● **7.12.1.5** If specified, all butt welds shall be 100 % radiographed.

7.12.1.6 All flanged branch connections shall be reinforced so that the reinforcement provides a metal area equal to the cut-away area removed from the shell or head regardless of the metal thickness in the branch connection wall. Stress concentration factors shall be considered to ensure compliance with 7.11.7.6.

7.12.1.7 Suction pulsation suppression devices, not provided with an integral moisture removal section, shall be designed to prevent trapping of liquid.

● **7.12.1.8** If specified, the suction pulsation suppression device(s) shall include a moisture removal section as an integral part of the vessel. This device shall be equipped as detailed in 7.10.

7.12.1.9 The nozzle length from the shell of the pulsation suppression device to the cylinder flange shall be adequate to allow for maintenance of the cylinder including insulation. The nozzle area shall be at least equal to the area for the nominal compressor cylinder flange size.

NOTE The thermal flexibility and pulsation study can affect the nozzle length.

7.12.1.10 The orientation of the pulsation suppression devices and their nozzles shall be approved by the purchaser. Ratings, types, and arrangements of all connections shall be agreed.

● **7.12.1.11** A DN 20 ($^3/_4$ NPS) pressure test connection shall be provided at each pulsation suppressor inlet and outlet nozzle. An external drain connection of at least DN 25 (1 NPS) shall be provided for each compartment. Circular notched openings in the baffles that are located at the low point of the vessel wall may be used with the purchaser's approval. Arrangement of internals shall ensure that liquids will flow to drain connections under all operating conditions.

NOTE Internal baffle drain may affect acoustical performance of the pulsation device.

7.12.1.12 Where discharge temperature instruments are mounted in the cylinder nozzle portion of the pulsation suppression device, two connection locations shall be provided to permit, without interference, the purchaser's installation of thermowells of at least DN 25 (NPS 1) for a high-temperature alarm or shutdown element and a dial thermometer. If specified, a thermowell connection of at least DN 25 (NPS 1) shall also be provided for the cylinder nozzle of each suction pulsation suppressor.

7.12.1.13 Flanged connections DN 40 (NPS 1.5) and smaller, shall be gusseted back to the pulsation suppression device or reinforcing pad in at least two planes. Maximum length shall be limited to that of a long weld-neck flange.

7.12.1.14 Main connections to the compressor cylinder(s) and to process line shall be weld-neck flanges. For nonstandard connections, see 6.8.2.2.1 and 6.8.2.1.12.

● **7.12.1.15** Pulsation suppression devices with an internal diameter equal to or greater than 450 mm (18 in.) shall have studded pad-type inspection openings of at least 150 mm (6 in.) in diameter, complete with blind flanges and gaskets to provide access to each compartment. For pulsation suppressor devices with an internal diameter less than 450 mm (18 in.), 100 mm (4 in.) studded pad-type inspection openings may be used. Inspection openings shall be located in a position that provides maximum visual inspection capability of critical welds such as both sides of the baffles. The purchaser shall specify if larger or additional openings are required for inspection or cleaning.

7.12.1.16 Pulsation suppression device connections other than those covered by 7.12.1.14 and 7.12.1.15 shall be weld-neck flanges. When threaded fittings are provided, they shall have a minimum rating of Class 6000.

7.12.1.17 Flanges shall be in accordance with ISO 7005-1 or ASME B16.5; however, lap-joint and slip-on flanges shall not be used.

● **7.12.1.18** If specified, provisions shall be made for attaching insulation. All connections and nameplates shall be arranged to clear the insulation.

7.12.1.19 All internals of pulsation suppression devices shall be designed, fabricated, and supported considering the possibility of high acoustic shaking forces. Dished baffles in lieu of flat baffles shall be used. The same welding procedures as applicable to external welds shall be followed. Full penetration continuous welds shall be used for the attachment of the baffles to the pulsation suppressor shell.

7.12.1.20 All butt welds shall be full penetration welds.

● **7.12.1.21** If specified, internal surfaces of carbon steel pulsation suppression devices shall be covered with a coating of phenolic or vinyl resins that are suitable for the service conditions.

7.12.1.22 A stainless steel nameplate shall be provided on each pulsation suppression device. The manufacturer's standard data, purchaser's equipment item number, and purchase order number shall be included.

● **7.12.1.23** If specified, the dynamic and static stresses on the pulsation suppression device internals that result from pulsation-induced shaking forces and pressure-induced static forces shall be analyzed to confirm compliance with the specified pressure vessel code.

7.12.1.24 If required by the specified pressure vessel code, a low-cycle fatigue analysis shall be performed to predict the stresses from thermal gradients, thermal transients, and pressure cycles on the pulsation suppression devices and internal components.

7.12.2 Fabrication and Thermally Induced Stresses in the Pulsation Suppression Device

7.12.2.1 When two or more cylinders are to be connected to the same pulsation suppression device, the flanges shall be fitted up to aligned cylinders at the compressor vendor's shop and welded in place to ensure proper final alignment. An alignment fixture may be used if approved by the purchaser.

NOTE An alignment fixture may be necessary on larger, block-mounted units.

7.12.2.2 An acoustic and mechanical analysis of the pulsation suppression devices shall be conducted, taking into account stresses induced by thermal growth and by relative motion of the cylinders (e.g. cylinder stretch).

7.12.2.3 The forces induced by thermal expansion of the pulsation suppression devices shall be taken into account to avoid intolerable misalignment and excessive stresses during operation.

7.12.3 Supports for Pulsation Suppression Devices

Supports for the pulsation suppression devices shall be furnished by the vendor. The supports shall be designed considering static loading (including piping loads), acoustic shaking forces, and mechanical responses and shall not impose harmful stresses on the compressor, piping system, or pulsation suppression devices to which they are attached. In calculating stress levels, the compressor frame growth and the flexibilities of the frame, crosshead guide, distance piece, flange, and branch connection shall be considered. Compliant (resilient) supports having inherent vibratory dampening characteristics are preferred as they accommodate thermal expansion. Loading of compliant supports shall be adjustable. Noncompliant supports shall be designed to allow adjustment by the purchaser while in operation. Spring supports shall not be used unless specifically approved by the purchaser.

NOTE The foundation of the supports is typically integral with the compressor foundation.

7.13 Air Intake Filters

● **7.13.1** Unless otherwise specified, air compressors taking suction from the atmosphere shall be provided with a dry-type air intake filter-silencer suitable for outdoor mounting provided by the vendor. Special design details shall be as specified by the purchaser.

7.13.2 As a minimum, the following features should be considered in the design of the filter-silencer:

a) micron particle rating;

b) ease of cleaning during in-service conditions;

c) corrosion protection of filter and of internal surfaces of inlet piping;

d) avoidance of internal threaded fasteners;

e) connections for measuring pressure differential across the filter.

7.14 Special Tools

7.14.1 When 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 complete with instructions for their use. For multiple-unit installations, the requirements for quantities of special tools and fixtures shall be agreed but no less than one complete set of tools for three units. These special tools shall be used, and their use demonstrated, during shop assembly and post-test disassembly of the equipment.

● **7.14.2** Special tools for reciprocating compressors shall include, as a minimum:

a) mandrels for fitting solid rider bands on nonsegmental pistons;

b) a lifting and lowering device for removal and insertion of valve assemblies with a mass greater than 15 kg (35 lb);

c) a crosshead removal and installation tool;

d) sleeve/cone to enable piston rod to be passed through completely assembled packing (see 6.13.1.6);

e) hydraulic tensioning tools.

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

7.14.4 All compressors shall be provided with suitable means of barring for maintenance. For compressors with driver power equal to or greater than 750 kW (1000 hp), and for compressors with a peak bar-over torque requirement equal to or greater than 1600 Newton-meters (1200 ft-lb), a unidirectional power-driven barring device with automatic disengagement and a limit switch shall be furnished. The vendor shall furnish a complete description of the barring device including a procedure for reverse rotation, method of operation, lockout signals required, location, guards, and power required.

● **7.14.5** If specified, each compressor shall be fitted with a device to lock the shaft in position during maintenance. The device shall allow locking of the shaft in multiple positions, as necessary for maintenance. The device shall be fitted with a limit switch.

7.14.6 Barring device and shaft locking limit switches shall be permissive to start. A trip function is required in the event that the barring device become disengaged from the rest position.

8 Inspection and Testing

8.1 General

8.1.1 The extent of the purchaser’s participation in the inspection and testing shall be as specified.

● **8.1.2** If specified, the purchaser’s representative, the vendor’s representative, or both shall indicate compliance in accordance with the inspector’s checklist (see Annex J) by initialing, dating, and submitting the completed checklist to the purchaser before shipment.

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

8.1.4 The vendor shall notify subvendors of the purchaser’s inspection and testing requirements.

● **8.1.5** The expected dates of testing shall be communicated at least 30 days in advance of testing and the actual dates confirmed as agreed. The vendor shall give at least 5 working days’ advanced notification of a witnessed or observed inspection or test.

NOTE For an observed test, the purchaser should expect to be in the factory longer than is required for a witnessed test.

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

8.1.7 Prior to a witnessed mechanical running or performance test, confirmation of the successful completion of the applicable preliminary test shall be provided.

NOTE Confirmation of a successful preliminary test is expected prior to beginning of travel.

8.1.8 Equipment, materials, and utilities for the specified inspections and tests shall be provided by the vendor.

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

8.2 Inspection

8.2.1 General

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

a) necessary or specified certification of materials, such as mill test reports;

b) test data and results to verify that the requirements of the specification have been met;

c) fully identified records of all heat treatment whether performed in the normal course of manufacture or as part of a repair procedure;

d) results of quality control tests and inspections;

e) details of all repairs;

f) final assembly maintenance and running clearances;

g) other data specified or required by applicable codes and regulations (see 5.3 and E.3.1.1).

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

● **8.2.1.3** In addition to the requirements of 6.14.7.1, the purchaser shall specify the following:

a) parts that are to be subjected to surface and subsurface examination;

b) the type of examination required, such as magnetic particle, liquid penetrant, radiographic, and ultrasonic examination.

8.2.2 Material Inspection

8.2.2.1 General

● **8.2.2.1.1** When radiographic ultrasonic, magnetic particle, or liquid penetrant inspection of welds or materials is required or specified, the criteria in 8.2.2.2 through 8.2.2.5 shall apply unless other corresponding procedures and acceptance criteria have been specified. Cast iron may be inspected only in accordance with 8.2.2.4 and/or 8.2.2.5. Welds, cast steel, and wrought material shall be inspected in accordance with 8.2.2.2 through 8.2.2.5.

NOTE The material inspection of pressure-containing parts is covered in 8.3.2.

8.2.2.1.2 Defects that exceed the limits imposed in 8.2.2 shall be removed to meet the quality standards cited, as determined by the inspection method specified.

8.2.2.1.3 Acceptance standards for 8.2.2.2 through 8.2.2.5 shall be agreed.

8.2.2.2 Radiography

Radiography shall be performed in accordance with ASTM E94.

8.2.2.3 Ultrasonic Inspection

8.2.2.3.1 Ultrasonic inspection shall be performed in accordance with ASTM A609 (castings), ASTM A388 (forgings), or ASTM A578 (plate).

8.2.2.3.2 All crankshafts shall be ultrasonically tested in accordance with ASTM A503.

8.2.2.4 Magnetic Particle Inspection

8.2.2.4.1 Both wet and dry methods of magnetic particle inspection shall be performed in accordance with ASTM E709.

8.2.2.4.2 To prevent buildup of potential voltage in the equipment, all components shall be demagnetized to the free air gauss levels in Table 7 when measured with a calibrated Hall effect probe.

Table 7—Maximum Allowable Free Air Gauss Levels

Maximum Allowable Level	Component
±2 Gauss	Bearing and seal assemblies including all components
±4 Gauss	Casing and all stationary components except bearing and seal assemblies
±2 Gauss	Shaft and all rotating components

NOTE The free air gauss level is measured while suspending the component from a nonconductive strap with no influence from stray magnetic fields.

8.2.2.5 Liquid Penetrant Inspection

Liquid penetrant inspection shall be based upon the procedures of ASTM E165 and ASTM E1417.

8.2.3 Mechanical Inspection

8.2.3.1 During assembly of the equipment, each component (including integrally cast-in passages) and all piping and appurtenances shall be inspected to ensure they have been cleaned and are free of foreign materials, corrosion products and mill scale.

● **8.2.3.2** When the oil system is specified to be run in the manufacturer's shop, it shall meet the test screen cleanliness requirements specified in API 614.

● **8.2.3.3** If specified, the equipment and all piping and appurtenances shall be inspected for cleanliness before heads are welded onto vessels, openings in vessels or exchangers are closed, or piping is finally assembled.

● **8.2.3.4** If specified, the hardness of parts, welds, and heat-affected zones shall be verified as being within the allowable values by testing. The method, extent, documentation, and witnessing of the testing shall be agreed.

8.2.3.5 Unless otherwise specified, the equipment components or surfaces subject to corrosion shall be coated with the vendor's standard rust preventive immediately after inspection. Temporary rust preventive shall be easily removable with common petroleum solvents. The equipment shall be closed promptly upon the purchaser's acceptance thereof. See 8.4.3 for details.

8.3 Testing

8.3.1 General

8.3.1.1 Equipment shall be tested in accordance with 8.3.2 and 8.3.3. Other tests that may be specified are described in 8.3.4.

8.3.1.2 At least 6 weeks before the first scheduled running test the vendor shall submit to the purchaser, for their review and comment, detailed procedures for the mechanical running test and all specified running optional tests (see 8.3.4), including acceptance criteria for all monitored parameters.

8.3.1.3 Testing notification requirements are covered in 8.1.5. If the testing is rescheduled, the vendor shall notify the purchaser. A new date shall be agreed upon with 5 working days' advanced notification.

8.3.2 Hydrostatic and Gas Leakage Tests

8.3.2.1 Pressure-containing parts (including auxiliaries) shall be tested hydrostatically with liquid at a higher temperature than the nil-ductility transition temperature of the material being tested and at the following minimum test pressures:

a) cylinder gas passages and bore: $1^1/_2$ times MAWP, but not less than a gauge pressure of 1.5 bar (20 psig);

b) cylinder water jackets and packing cases: $1^1/_2$ times MAWP;

c) piping, pressure vessels, filters, and other pressure-containing components: $1^1/_2$ times MAWP or in accordance with the specified pressure code, but not less than a gauge pressure of 1.5 bar (20 psig).

The tests specified in items a) and b) shall be performed prior to the installation of the cylinder liner.

Compressor cylinders shall be tested as assembled components using the heads, valve covers, clearance pockets, and fasteners to be supplied with the finished cylinder.

NOTE For gas pressure-containing parts, the hydrostatic test is a test of the mechanical integrity of the component and is not a valid gas leakage test.

● **8.3.2.2** If specified, distance pieces shall be hydrostatically tested at 1.5 times MAWP.

NOTE See 6.12.2.3 for MAWP requirements.

8.3.2.3 The following gas test shall be performed to ensure that the components do not leak process gas. The leakage tests shall be conducted with the components thoroughly dried and unpainted. Compressor cylinders shall be leak-tested without liners, but with the following job components: heads, valve covers, clearance pockets, and fasteners.

a) Pressure-containing parts such as compressor cylinders and clearance pockets handling gases with a molecular weight equal to or less than 12 or gases containing a mol percentage of H_2S equal to or greater than 0.1 %, shall undergo, in addition to the hydrostatic test specified in 8.3.2.1, a pressure test with helium performed at the MAWP. Leak detection shall be by helium probe or by submergence in water. The water shall be at a higher temperature than the nil-ductility transition temperature of the material being tested. The internal pressure shall be maintained, while submerged, at the MAWP. Zero leakage is required (see 8.3.2.5). In the case of testing by helium probe, the procedure, the sensitivity of the instrument, and the acceptance criteria shall be by prior agreement.

b) Cylinders handling gases other than those described above in item a) shall undergo a gas leakage test as described in item a), with either air or nitrogen used as the test gas.

8.3.2.4 The chlorine content of liquids used to test austenitic stainless steel materials shall not exceed 50 ppm. 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.

8.3.2.5 Test duration shall be sufficient to allow complete examination of parts under pressure. The hydrostatic and gas leakage tests shall be considered satisfactory when neither leaks nor seepage through the pressure-containing parts or joints is observed for a minimum of 30 minutes. Large, heavy pressure-containing parts of complex systems can require a longer testing period to be agreed upon by the purchaser and the vendor.

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

8.3.3 Mechanical Running Test

8.3.3.1 The shop test of the compressor shall comprise a 4-hour continuous unloaded running test.

Pretests, intermediate stops, and inspections that are required prior to the 4-hour continuous test shall be defined in the test procedure.

● **8.3.3.2** If specified, packaged units, including integral auxiliary system packages, shall undergo a 4-hour mechanical running test prior to shipment. The test shall prove mechanical operation of all auxiliary equipment, as well as the compressor, reduction gear, if any, and driver as a complete unit.

The compressor need not be pressure-loaded for this test. The procedure for this running test shall be agreed.

8.3.3.3 All oil pressures, viscosities, and temperatures shall be within the range of operating values recommended in the vendor's operating instructions for the specific unit being tested.

8.3.3.4 Main bearing and packing temperature devices, if supplied by the vendor, shall be recorded during the running test.

8.3.3.5 Oil temperature, oil pressure (at the normal sensing point), speed, and piston rod temperature shall be recorded during the running test.

● **8.3.3.6** If specified, frame and cylinder vibration data shall be recorded during run test.

8.3.3.7 If replacement or modification of bearings, or dismantling to replace or modify other parts are required to correct mechanical or performance deficiencies, the initial test shall be deemed not acceptable and the final shop tests shall be run after these deficiencies are corrected.

Additional dismantling after evidence of malfunction is found shall be agreed.

● **8.3.3.8** Auxiliary equipment not integral with the unit, such as auxiliary oil pumps, oil coolers, filters, intercoolers, and aftercoolers, need not be used for any compressor shop tests unless specified. If specified, auxiliary system consoles shall receive both an operational test and a 4-hour mechanical running test prior to shipment. The procedure for this running test shall be as agreed.

8.3.4 Optional Tests

8.3.4.1 A bar-over test of the frame and cylinders shall be made in the vendor's shop to verify piston end clearances and rod runout. The final bar-over test shall be performed with all compressor cylinder valves in place to demonstrate no piston interference. Vertical and horizontal piston-rod runout (cold) at packing case flanges shall also be measured during this test (see 6.3.1 and 6.10.4.8). Bar-over test results shall become a part of the purchaser's records [see Annex E, item 59)].

● **8.3.4.2** If specified, all machine-mounted equipment, prefabricated piping, and appurtenances furnished by the vendor shall be fitted and assembled in the vendor's shop. The vendor shall be prepared to demonstrate that the equipment is free of harmful strains.

8.3.4.3 All compressor suction and discharge cylinder valves shall be leak-tested in accordance with the vendor's standard procedure.

● **8.3.4.4** If specified, the compressor shall be subject to a performance test in accordance with ISO 1217 or the applicable ASME power test code.

● **8.3.4.5** If specified, cylinder unloaders shall be installed and function tested.

8.4 Preparation for Shipment

● **8.4.1** Equipment shall be suitably prepared for the type of shipment specified, including blocking of the crankshaft. The preparation shall make the equipment suitable for 6 months of outdoor storage from the time of shipment. If storage for a longer period is specified, the purchaser will consult with the vendor regarding recommended procedures to be followed.

8.4.2 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 686.

NOTE It is recognized that failure to follow these instructions can jeopardize the successful operation of the equipment.

8.4.3 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 provisions of 8.4.4 through 8.4.20.

8.4.4 Equipment shall be completely free of water prior to any shipment preparation.

8.4.5 Except for mating machined surfaces, all exterior surfaces that may 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 Corrosion-resistant materials are typically not painted.

8.4.6 Exterior mating machined surfaces, except for corrosion-resistant material, shall be coated with a rust preventive.

8.4.7 The interior of the equipment, including pulsation suppression devices, shall be clean; free from scale, welding spatter, and foreign objects; and sprayed or flushed with a suitable rust preventive that is oil soluble or can be removed with solvent. In lieu of a soluble rust preventive, a permanently applied rust preventive may be used with prior approval by the purchaser.

NOTE Nonlubricated services can require special preservation procedures.

8.4.8 Internal areas of frames, bearing housings, and oil system equipment such as reservoirs, vessels, and piping shall be coated with an oil-soluble rust preventive or, with the purchaser's prior approval, a permanent rust preventive.

Rust preventive coatings shall be compatible with the lubricating oil.

8.4.9 Any paint exposed to lubricants shall be oil resistant. When synthetic lubricants are specified (see 7.5.3.1.11), the paint shall be compatible.

8.4.10 Flanged openings shall be provided with metal closures of a thickness equal to or greater than 5 mm ($^3/_{16}$ in.) with elastomer gaskets and at least four full-diameter bolts. For studded openings, all nuts needed for the intended services shall be used to secure closures.

8.4.11 Threaded openings shall be provided with steel caps or round-head steel plugs in accordance with ASME B16.11. The caps or plugs shall be of the same material as that of the pressure casing. Nonmetallic (such as plastic) caps or plugs shall not be used.

8.4.12 Openings that have been beveled for welding shall be provided with closures designed to prevent the entrance of moisture and foreign materials and damage to the bevel.

8.4.13 Lifting points and the center of gravity shall be clearly identified on the equipment package in English and the language of the country of destination. The vendor shall recommend the lifting arrangement.

● **8.4.14** The equipment shall be packed for domestic or export shipment as specified. Lifting, load-out, and handling instructions shall be securely attached to the exterior of the largest package in a well-marked weatherproof container. Where special lifting devices, such as spreader bars, are required, the supply of these shall be subject to agreement. Upright position, lifting points, weight, and dimensions shall be clearly marked on each package.

8.4.15 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.

8.4.16 Any cylinders, heads, packing cases, packing, pistons, rods, crossheads and shoes, crosshead pins, bushings, and connecting rods that are dismantled for the purpose of separate shipment, or that are shipped as spare parts, shall be sprayed with rust preventive, wrapped with moisture-proof sheeting and packed to prevent damage in shipment to, or storage at, the job site.

8.4.17 Exposed shafts and shaft couplings shall be protected from corrosion.

8.4.18 Auxiliary piping connections furnished with the purchased equipment shall be impression stamped or permanently tagged to agree with the vendor's connection table or general arrangement drawing. Service and connection designations shall be indicated.

8.4.19 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, 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 location shall be indicated by corrosion-resistant tags attached with stainless steel wire.

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

9 Vendor's Data

9.1 The purchaser may specify the content of proposals, meeting frequency, and vendor data content/format identified in Annex E. Annex E provides a general outline of information that potentially may be requested by the purchaser.

● **9.2** If specified, the information specified in Annex E shall be provided.

Annex A
(informative)

Data Sheets

DOCUMENT NUMBER: _____
CLIENT DOCUMENT NUMBER: _____

REVISION	0	1	2	3	4
DATE					
BY					
REV/APPR					

RECIPROCATING COMPRESSOR
DATA SHEET (API 618-6TH)
SI UNITS (kPa)

JOB NO. _____ ITEM NO. _____
PAGE 1 OF _____ REQUISITION NO. _____

APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ○ AS BUILT
VENDOR DATA, DRAWINGS AND NAMEPLATES, HARDWARE (INCLUDING FASTENERS), AND EQUIPMENT. SHALL BE IN:
LANGUAGE: ● ENGLISH ○ OTHER _____
UNITS OF MEASURE: ○ U.S. CUSTOMARY ○ SI ○ METRIC ○ OTHER _____
FOR USER _____ NUMBER REQUIRED _____
SITE / LOCATION _____ COMPRESSOR MANUFACTURER _____
SERVICE _____ TYPE MODEL NUMBER/S _____
UNIT _____ SERIAL NUMBER/S _____

NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ☒ PURCHASER OR MANUFACTURER AS APPLICABLE

☐ COMPRESSOR THROWS: TOTAL NUMBER _____ NUMBER WITH CYLINDERS _____
☐ NOMINAL FRAME RATING _____ (BkW) @ RATED RPM OF _____ (rpm)
☒ MAXIMUM ALLOWABLE SPEED _____ (rpm) ☐ MINIMUM ALLOWABLE SPEED _____ (rpm)
☐ DRIVER MANUFACTURER _____
☐ DRIVER NAMEPLATE POWER: _____ (kW) / OPERATING SPEED: _____ (rpm)
○ DRIVE SYSTEM (7.1.2.2): ○ DIRECT COUPLED ○ GEAR & COUPLED ○ BELT
○ TYPE OF DRIVER (6.1.12): ○ STEAM TURBINE ○ GAS TURBINE ○ ENGINE
○ INDUCTION MOTOR ○ SYNCHRONOUS MOTOR ○ OTHER _____
○ SINGLE BEARING
○ TEMPORARY SUPPORT (7.1.2.4)
○ CYLINDERS CONSTRUCTION: ○ LUBE ○ NON-LUBE ○ NOT DRILLED OR LUBED (6.8.2.1.19)
○ MAXIMUM ACCEPTABLE AVERAGE PISTON SPEED _____ (m/s)
○ UNINTERRUPTED CONTINUOUS OPERATION (6.1.1): _____ (hr)
○ STARTING CONDITION (7.1.1.6): ○ UNLOADED ○ LOADED ○ OTHER _____

OPERATING CONDITIONS

○ SERVICE						
○ STAGE						
○ NORMAL OR ALTERNATE CONDITION (6.1.4						
○ CERTIFIED POINT MARK ONE WITH X						
☒ MOLECULAR WEIGHT						
INLET CONDITIONS: AT INLET TO: ○ PULSE DEVICES ○ COMPRESSOR CYLINDER FLANGES						
○ PRESSURE (kPaA) @ PULS. SUPPRESSOR INLET						
☒ PRESSURE (kPaA) @ CYLINDER FLANGE						
○ TEMPERATURE (°C)						
○ REFERENCE SIDE STREAM TEMPERATURES (°C)						
○ DEW POINT (6.1.24) (°C)						
☐ COMPRESSIBILITY (Z_S)						
☒ Cp/Cv (K)(@ 65 °C) OR _____ (°C) (NOTE 2)						
NOTE: ○ SIDE STREAM TO _____ STAGE(S), THESE INLET PRESSURES ARE FIXED						
INTERSTAGE:						
○ INTERSTAGE ΔP INCLUDES: ○ PULSE DEVICES ○ PIPING ○ COOLERS ○ SEPARATORS ○ OTHER _____						
☒ ΔP BETWEEN STAGES, % / (kPa)						
DISCHARGE CONDITIONS: AT OUTLET FROM: ○ PULSE DEVICE ○ COMPRESSOR CYLINDER FLANGES ○ OTHER _____						
○ PRESSURE (kPaA) @ CYLINDER FLANGE						
○ PRESSURE (kPaA) @ PULS. SUPPRESSOR OUTLET						
☐ TEMPERATURE, ADIABATIC, (°C)						
☐ TEMPERATURE, PREDICTED,(6.5.1) (°C)						
☐ COMPRESSIBILITY (Z_2) OR (Z_{AVG})						
☒ Cp/Cv (K)(@ 65 °C) OR _____ (°C) (NOTE 2)						
CAPACITY AT INLET TO COMPRESSOR, NO NEGATIVE TOLERANCE (-0%) NOTE 1						
○ (kg/h) CAPACITY SPECIFIED IS ○ WET ○ DRY						
○ N(m³/h)/N(m³/h) (101.3 kPaA & 0°C DRY)						
MANUFACTURER'S RATED CAPACITY(AT INLET TO COMPRESSOR) & (BkW) @ CERTIFIED TOLERANCE OF ±3% FOR CAPACITY & ±3% FOR (BkW) NOTE 1						
☐ (kg/h) CAPACITY SPECIFIED IS ○ WET ○ DRY						
☐ INLET VOLUME FLOW (m³/h)						
☐ N(m³/h)/N(m³/h) (101.3 kPaA & 0°C DRY)						
☐ (BkW) /STAGE						
☐ TOTAL (BkW) @ COMPRESSOR SHAFT						
☐ TOTAL (kW) INCLUDING V-BELT & GEAR LOSSES						

REMARKS: NOTE 1: CAPACITY FOR NNT: MANUFACTURER'S = REQUIRED ÷ 0.97, THEREFORE REQUIRED = MANUFACTURER'S x 0.97
NOTE 2: IF GAS ANALYSIS IS GIVEN, MANUFACTURER SHALL SUPPLY DATA, OTHERWISE DATA SHALL BE SUPPLIED BY USER

DOCUMENT NUMBER: _____
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RECIPROCATING COMPRESSOR
DATA SHEET (API 618-6TH)
SI UNITS (kPa)

JOB NO. _____ ITEM NO. _____
PAGE 2 OF _____ REQUISITION NO. _____

NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ◯ PURCHASER OR MANUFACTURER AS APPLICABLE

GAS ANALYSIS AT OPERATING CONDITIONS
MOLE % (BY VOLUME) ONLY

○ SERVICE / ITEM NUMBER							
○ STAGE							
○ NORMAL OR ALTERNATE							
		(MW)					
AIR		28.966					
OXYGEN	O_2	32.000					
NITROGEN	N_2	28.016					
WATER VAPOR	H_2O	18.016					
CARBON MONOXIDE	CO	28.010					
CARBON DIOXIDE	CO_2	44.010					
HYDROGEN SULFIDE	H_2S	34.076					
HYDROGEN	H_2	2.016					
METHANE	CH_4	16.042					
ETHYLENE	C_2H_4	28.052					
ETHANE	C_2H_6	30.068					
PROPYLENE	C_3H_6	42.078					
PROPANE	C_3H_8	44.094					
I-BUTANE	C_4H_{10}	58.120					
n-BUTANE	C_4H_{10}	58.120					
I-PENTANE	C_5H_{12}	72.146					
n-PENTANE	C_5H_{12}	72.146					
HEXANE PLUS							
AMMONIA	NH_3	17.031					
HYDROGEN CHLORIDE	HCl	36.461					
CHLORINE	Cl_2	70.914					
CHLORIDES - TRACES							
CALCULATED MOL WEIGHT							

APPLICABLE SPECIFICATIONS

- ● API-618-RECIPROCATING COMPRESSORS FOR PETROLEUM, CHEMICAL AND GAS INDUSTRY SERVICES
- ○ NACE MR-0103 (6.10.4.3)
- ○ VENDOR HAVING UNIT RESPONSIBILITY: _____
- ○ GOVERNING SPECIFICATION (IF DIFFERENT): _____
- ○ _____
- ○ _____
- ○ _____
- ○ _____
- ○ _____
- ○ _____

NOISE SPECIFICATIONS:

- ○ MAXIMUM ALLOWABLE SOUND PRESSURE LEVEL _____ (dBA)
- ○ APPLICABLE TO MACHINE:
  SEE SPECIFICATION _____
- ○ APPLICABLE TO NEIGHBORHOOD:
  SEE SPECIFICATION _____

NOTES

IF CORROSIVE AGENTS, REACTIVE AGENTS,
WATER VAPOR AND / OR CHLORIDES ARE PRESENT,
EVEN MINUTE TRACES, IN THE GAS BEING COMPRESSED,
IT MUST BE INCLUDED TO THE LEFT.

REMARKS / SPECIAL REQUIREMENTS:

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CLIENT DOCUMENT NUMBER: _____

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RECIPROCATING COMPRESSOR
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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ◯ PURCHASER OR MANUFACTURER AS APPLICABLE

PART LOAD OPERATING CONDITIONS

CAPACITY CONTROL **(NOTE 1, NOTE 2)**

BY: ○ MANUFACTURER'S CAPACITY CONTROL ○ PURCHASERS BY-PASS ○ BOTH
○ OTHER _____

○ SEE DATA SHEET PAGE 2 FOR DETAILS ○ IN INSTRUMENT & CONTROL PANEL ○ SEPARATE MACHINE MOUNTED PANEL
○ SEPARATE FREE STANDING PANEL
○ PNEUMATIC ○ ELECTRIC ○ ELECTRONIC ○ HYDRAULIC
○ PROGRAMMABLE CONTROLLER

○ INSTRUMENT & CONTROL PANEL ○ ONE FOR EACH UNIT ○ ONE COMMON TO ALL UNITS ○ MACHINE MOUNTED ○ FREE STANDING (OFF UNIT)
○ BUFFER GAS CONTROL PANEL ○ ONE FOR EACH UNIT ○ ONE COMMON TO ALL UNITS ○ MACHINE MOUNTED ○ FREE STANDING (OFF UNIT)

FOR: ○ PART LOAD CONDITION ○ START-UP ONLY ○ BOTH
WITH: ○ AUTOMATIC LOADING-DELAY INTERLOCK ○ AUTOMATIC IMMEDIATE UNLOADING (7.8.2.5)
USING: ○ VOLUME POCKET: ○ FIXED ○ VARIABLE
○ SUCTION VALVE UNLOADERS(6.9.2.1): ○ FINGER ○ PLUG ○ OTHER _____
○ ACTION: ○ DIRECT (AIR-TO-UNLOAD) ○ REVERSE (AIR-TO-LOAD/FAIL SAFE)
○ NUMBER OF STEPS: ○ ONE ○ THREE ○ FIVE ○ OTHER _____
○ RAIN COVER REQUIRED OVER UNLOADERS

ALL UNLOADING STEPS BASIS MANUFACTURERS CAPACITY SHOWN ON PAGE 1.

INLET AND DISCHARGE PRESSURE ARE ○ AT CYLINDER FLANGES ○ PULSATION SUPPRESSOR FLANGES

○ SERVICE OR ITEM NUMBER						
◯ STAGE						
◯ NORMAL OR ALTERNATE CONDITION						
○ PERCENT CAPACITY						
○ WEIGHT FLOW, (kg/h)						
◯ N(m³/h)/N(m³/h) (101.3 kPaA & 0°C DRY)						
☐ POCKETS / VALVES OPERATION *						
☐ POCKET CLEARANCE ADDED %						
☐ TYPE UNLOADERS, PLUG / FINGER						
◯ INLET TEMPERATURE (°C)						
◯ INLET PRESSURE (kPaA)						
◯ DISCHARGE PRESSURE (kPaA)						
☐ DISCHARGE TEMPERATURE, ADIABATIC (°C)						
☐ DISCHARGE TEMPERATURE, PREDICTED (°C)						
☐ VOLUMETRIC EFFICIENCY, % HE						
☐ VOLUMETRIC EFFICIENCY, % CE						
☐ CALCULATED GAS LOAD (kN) , C **						
☐ CALCULATED GAS LOAD (kN) , T **						
◇ CROSSHEAD PIN LOAD (kN) C (GAS & INERTIA)						
◇ CROSSHEAD PIN LOAD (kN) T (GAS & INERTIA)						
◇ LOAD REVERSAL, DEGREES MIN @ X-HD PIN ***						
☐ (BkW)/Stage						
☐ TOTAL (BkW) @ COMPRESSOR SHAFT						
☐ TOTAL (kW) INCLUDING V-BELT & GEAR LOSSES						

* SHOW OPERATION WITH THE FOLLOWING SYMBOLS:

HE = HEAD END OR CE = CRANK END } - { S = SUCTION VALVE(S) UNLOADED OR F = FIXED POCKET OPEN
{ OR V = VARIABLE POCKET OPEN

EXAMPLE: HE-F/CE-S = HEAD END FIXED POCKET OPEN / CRANK END SUCTION VALVE(S) UNLOADED.

** C = COMPRESSION
** T = TENSION
*** X-HD = CROSSHEAD

☐ MINIMUM PRESSURE REQUIRED TO OPERATE CYLINDER UNLOADING DEVICES, _____ (kPaG)
○ CYLINDER UNLOADING MEDIUM: ○ AIR ○ NITROGEN ○ OTHER _____
○ PRESSURE AVAILABLE FOR CYLINDER UNLOADING DEVICES: MAXIMUM: _____ (kPaG) / MINIMUM: _____ (kPaG)

REMARKS, SPECIAL REQUIREMENTS, AND / OR SKETCH **NOTE 1: SEE INSTRUMENTATIONSCOPE DATA SHEETS FOR DETAILS OF PANEL,**
ADDITIONAL REMARKS, AND INSTRUMENTATION DETAILS.
NOTE 2: ALL TUBING, WIRING, & CONNECTIONS BETWEEN OFF-UNIT FREE STANDING PANELS AND COMPRESSOR UNIT BY PURCHASER.

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RECIPROCATING COMPRESSOR
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SI UNITS (kPa)

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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ◎ PURCHASER OR MANUFACTURER AS APPLICABLE

◎ **CYLINDER DATA AT FULL LOAD CONDITION**

SERVICE/ITEM NUMBER							
STAGE							
INLET PRESSURE, AT CYLINDER FLANGES	(kPaA)						
DISCHARGE PRESSURE, AT CYLINDER FLANGES	(kPaA)						
CYLINDERS PER STAGE							
SINGLE OR DOUBLE ACTING (SA OR DA)							
BORE,	(mm)						
STROKE,	(mm)						
RATED RPM:	(rpm)						
MAXIMUM ALLOWABLE RPM	(rpm)						
RATED PISTON SPEED:	(m/s)						
MAXIMUM ALLOWABLE PISTON SPEED	(m/s)						
CYLINDER LINER, YES/NO (6.8.1.5)							
LINER NOMINAL THICKNESS, (6.8.1.5)	(mm)						
PISTON DISPLACEMENT	(m^3/h)						
CYLINDER DESIGN CLEARANCE, % AVERAGE							
VOLUMETRIC EFFICIENCY, % AVERAGE							
QUANTITY OF INLET VALVES PER CYLINDER							
QUANTITY OF DISCHARGE VALVES PER CYLINDER							
TYPE OF VALVES							
VALVE LIFT, INLET	(mm)						
VALVE LIFT, DISCHARGE,	(mm)						
VALVE VELOCITY, SUCTION VALVE(S)	(m/s)						
VALVE VELOCITY, DISCHARGE VALVE(S)	(m/s)						
ROD DIAMETER,	(mm)						
MAXIMUM ALLOWABLE CROSSHEAD PIN LOADING,							
COMPRESSION	(kN)						
TENSION	(kN)						
CALCULATED GAS LOAD,							
COMPRESSION	(kN)						
TENSION	(kN)						
CROSSHEAD PIN LOAD (GAS + INERTIA),							
COMPRESSION	(kN)						
TENSION	(kN)						
LOAD REVERSAL, DEGREES MIN. AT CROSSHEAD							
RECIP WT. (PISTON, ROD, CROSSHEAD & NUTS),	(kN)						
MAXIMUM ALLOWABLE WORKING PRESSURE(6.8.1.1)	(kPaG)						
MAXIMUM ALLOWABLE WORKING TEMPERATURE	(°C)						
MINIMUM DESIGN METAL TEMPERATURE	(°C)						
HYDROSTATIC TEST PRESSURE,	(kPaG)						
GAS LEAKAGE TEST PRESSURE,	(kPaG)						
INLET FLANGE SIZE							
INLET FLANGE RATING							
INLET FLANGE FACING							
DISCHARGE FLANGE SIZE							
DISCHARGE FLANGE RATING							
DISCHARGE FLANGE FACING							
DISCHARGE RELIEF VALVE SETTING DATA AT INLET PRESSURES GIVEN ABOVE:							
RECOMMENDED SETTING,	(kPaG)						
GAS LOAD,							
COMPRESSION	(kN)						
TENSION	(kN)						
CROSSHEAD PIN LOAD,							
COMPRESSION	(kN)						
TENSION	(kN)						
LOAD REVERSAL, DEGREES MIN. AT CROSSHEAD							
NOTE 1							
○ SETTLE-OUT GAS PRESSURE							
(DATA REQUIRED FOR STARTING)							

REMARKS / SPECIAL REQUIREMENTS: NOTE 1: CALCULATED AT INLET PRESSURES GIVEN ABOVE & RECOMMENDED SETTING.

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RECIPROCATING COMPRESSOR
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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ☑ PURCHASER OR MANUFACTURER AS APPLICABLE

○ FABRICATED CYLINDER, HEADS, & CONNECTION SKETCHES FOR DESIGN REVIEW BY PURCHASER

☑ CONSTRUCTION FEATURES

SERVICE ITEM NUMBER						
STAGE						
CYLINDER SIZE (BORE DIAMETER) (mm)						
ROD RUN-OUT: NORMAL COLD VERTICAL (PER APPENDIX)						
DN 12 INDICATOR TAP AT EACH END OF CYLINDER	○	○	○	○	○	○
CYLINDER INDICATOR VALVES REQUIRED	○	○	○	○	○	○
INDICATOR CONNECTIONS ABOVE 34470 kPa	○	○	○	○	○	○
RUNNING BORE SHALL BE HONED (6.8.1.7)	○	○	○	○	○	○
FLUOROCARBON SPRAYED CYLINDER	○	○	○	○	○	○
NON COOLED OR AIR COOLED CYLINDER	○	○	○	○	○	○

○ PREFERRED TYPE OF CYLINDER COOLING **(NOTE 1)**
- ○ FORCED _____ STAGE / CYLINDERS
- ○ THERMOSYPHON _____ STAGE /CYLINDERS
- ○ STATIC STAND-PIPE _____ STAGE / CYLINDERS
- ○ CYLINDER COOLANT PIPING BY ○ PURCHASER ○ SUPPLIER
  - ○ MATCH MARKED
- ○ SINGLE INLET/OUTLET MANIFOLD & VALVES ○ SIGHT GLASSES
- ○ INDIVIDUAL INLET/ OUTLET PER CYLINDER ○ VALVES
- ○ CLOSED SYSTEM WITH PUMP, COOLER, SURGE TANK, & PIPING

☑ MATERIALS OF CONSTRUCTION

CYLINDER(S)						
CYLINDER LINER(S)						
PISTON(S)						
PISTON RINGS						
WEAR BANDS ○ REQUIRED						
PISTON ROD(S): MATERIAL (6.10.4.1)						
PISTON ROD(S): YIELD (MPa)						
THREAD ROOT STRESS @ MAX ALLOWABLE CROSSHEAD PIN LOAD						
PISTON ROD HARDNESS, BASE MATERIAL, Rc						
PISTON ROD COATING ○ REQUIRED						
COATING HARDNESS, Rc						
VALVE SEATS						
SEAT PLATE						
VALVE SEAT MIN HARDNESS, Rc						
VALVE GUARDS (STOPS)						
VALVE DISCS						
VALVE SPRINGS						
ROD PRESSURE PACKING RINGS						
ROD PRESSURE PACKING CASE						
ROD PRESSURE PACKING SPRINGS						
SEAL / BUFFER PACKING, DISTANCE PIECE						
SEAL / BUFFER PACKING, INTERMEDIATE						
WIPER PACKING RINGS						
MAIN JOURNAL BEARINGS, CRANKSHAFT						
CONNECTING ROD BEARING, CRANKPIN						
CONNECTING ROD BUSHING, CROSSHEAD END						
CROSSHEAD PIN BUSHING						
CROSSHEAD PIN						
CROSSHEAD						
CROSSHEAD SHOES						
INSTRUMENTATION IN CONTACT WITH PROCESS GAS						
COLD SIDE						
HOT SIDE						

☑ COUPLING(S)

	○ LOW-SPEED Between Compressor & Driver or Gear	○ HI-SPEED Between Driver & Gear
◇ MANUFACTURER		
◇ MODEL		
◇ TYPE		

○ KEY-LESS DRIVE ○ QUILL SHAFT
○ KEYED DRIVE ○ OTHER
API-671 APPLIES ○ YES ○ NO

☑ FLYWHEEL LOCKING DEVICE (7.14.5)
○ PROVIDED BY:

☑ REDUCTION GEARS (7.3)
○ PROVIDED BY:
○ STANDARD (7.3.1)
○ API 613 ○ API 677 ○ OTHER:
○ SEE DATA SHEET:

☑ CRANKCASE RAPID PRESSURE RELIEF DEVICE(S)(6.11.5)
○ PROVIDED BY:

○ **SPECIAL CORROSION PROTECTION:** ○ NO ○ YES
○ MFR'S STANDARD ○ OTHER

REMARKS / SPECIAL REQUIREMENTS: NOTE 1: MANUFACTURER SHALL RECOMMEND TYPE OF COOLING AFTER FINAL ENGINEERING REVIEW OF ALL OPERATING CONDITIONS

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RECIPROCATING COMPRESSOR
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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ◯ PURCHASER OR MANUFACTURER AS APPLICABLE

CONSTRUCTION FEATURES (CONTINUED)

◯ **DISTANCE PIECE(S):(REFERENCE FIGURE F-3)**(6.12.1.1)
○ TYPE: ○ A ○ B ○ C ○ D
○ COVERS (6.12.2.1): ○ SOLID METAL ○ SCREEN ○ LOUVERED
○ HIGHER PARTITION DIFFERENTIAL PRESSURE ○ YES ○ NO
PRESSURE: (kPaG)
○ CYLINDER COMPARTMENT: ○ VENTED TO (kPaG)

(Outboard Distance Piece)
○ PURGED AT (kPaG)
○ PRESSURIZED TO (kPaG)
○ WITH RELIEF VALVE

○ FRAME COMPARTMENT: ○ VENTED TO (kPaG)
(Inboard Distance Piece)
○ PURGED AT (kPaG)
○ PRESSURIZED TO (kPaG)
○ WITH RELIEF VALVE

○ VENT SYSTEM MAX PRESSURE (6.12.2.4): (kPaG)
☐ DISTANCE PIECE MAWP (kPaG)

◯ **COMPRESSOR CYLINDER ROD PACKING**
○ FULL FLOATING PACKING
○ VENTED TO: ○ FLARE @ (kPaG) ○ ATMOSPHERE
○ SUCTION PRESSURE @ (kPaG)
○ FORCED LUBRICATED ○ NON-LUBE
◯ WATER COOLED, STAGE(S), (m³/h) REQUIRED
◯ OIL COOLED, STAGE(S), (m³/h) REQUIRED
○ WATER FILTER ○ PROVISION FOR FUTURE WATER/OIL COOLING
○ VENT / BUFFER GAS SEAL PACKING ARRANGEMENT
REF: ANNEX H, FIGURES H-1, H-2, H-3, H-4
○ OIL WIPER PACKING PURGE
○ INTERMEDIATE PARTITION PURGE (6.12.1.4, 6.12.1.5)
○ INERT BUFFER PURGE GAS: ○ N_2 ○ OTHER
○ VENT, DRAIN, PURGE PIPING BY MANUFACTURER ○ NO ○ YES
○ DISPOSAL SYSTEM ○ CONSTANT ○ VARIABLE
○ BUFFER GAS PRESSURE, (kPaG)
○ SPLASH GUARDS FOR WIPER PACKING (6.13.1.1)

○ **BASEPLATE (7.7.4)**
○ BASEPLATE FOR:
○ ANCHOR BOLTS BY (7.7.3.6) ○ PURCHASER ○ SUPPLIER
○ SOLEPLATE ○ RAILS
○ BOLTS OR STUDS FOR SOLEPLATE TO FRAME BY
○ PURCHASER ○ SUPPLIER
○ LEVELING PLATES
○ DYNAMIC ANALYSIS REQUIRED (7.7.4.15)
○ WRITTEN REPORT REQUIRED (7.7.4.15)
○ SKID FOR:
○ DIRECT GROUTED ○ SUB SOLEPLATES
○ CEMENTED/MORTAR GROUT (7.7.3.9)
○ EPOXY GROUT; MANUFACTURE
TYPE
○ SUITABLE FOR COLUMN MOUNTING (UNDER SKID AND / OR BASEPLATE) (7.7.4.8)

◯ **BEARING TEMPERATURE DETECTORS**
○ SEE ATTACHED API-670 DATASHEET
○ THERMOCOUPLES TYPE
○ RESISTANCE TEMP DETECTORS
○ RESISTANCE MATERIAL ○ (ohm)
○ LOCATION-JOURNAL BEARING
○ QUANTITY
☐ SCALE RANGE ○ ALARM ☐ SET @
○ SHUTDOWN: ☐ SET @ ○ TIME DELAY (sec)

◯ **PISTON ROD DROP DETECTORS**
○ SEE ATTACHED API-670 DATASHEET
○ TYPE ☐ MODEL
○ MFR ○ NO. REQUIRED
○ SUPPLIED BY:
○ OSCILLATOR-DEMODULATOR SUPPLIED BY:
○ MFR ☐ MODEL
☐ SCALE RANGE ○ ALARM ☐ SET @
○ SHUTDOWN: ☐ SET @ (mil) ○ TIME DELAY (sec)

◯ **BELT DRIVE**

	DRIVEN SHEAVE (Compressor Shaft)	DRIVE SHEAVE (Driver Shaft)
☐ RPM (EXPECTED)		
☐ PITCH DIAMETER (mm)		
☐ POWER TRANSMITTED		
	INCLUDING BELT LOSSES	

◇ CENTER DISTANCE (mm)
◇ QUANTITY OF BELTS
◇ TYPE OF BELTS
◇ CROSSECTION OF BELTS
◇ LENGTH OF BELTS (mm)
◇ BELT SERVICE FACTOR (RELATIVE TO DRIVER NAMEPLATE HP RATING)
○ SHEAVES & BELTS PROVIDED BY:
○ BANDED V-BELTS

◯ **BARRING DEVICE**
○ SUPPLIED BY
○ MANUAL ○ PNEUMATIC ○ ELECTRIC

◯ **CYLINDER LUBRICATION**
○ NON-LUBE STAGE(S)/SERVICE
○ LUBRICATED STAGE(S)/SERVICE
TYPE OF LUBE OIL: ○ SYNTHETIC
○ HYDROCARBON

◯ **CYLINDER AND ROD PACKING LUBRICATOR**
○ SYNTHETIC LUBRICANTS REQUIRED (7.5.3.1.11)
◯ LUBRICATOR DRIVEN BY:
☐ COMPRESSOR CRANKSHAFT, DIRECT
☐ CHAIN, FROM CRANKSHAFT
◯ ELECTRIC MOTOR
◯ OTHER
◇ LUBRICATOR MANUFACTURER
◇ LUBRICATOR MODEL
○ AUTOFILL DEVICE FOR RESERVOIR (7.5.3.1.13)
○ TYPE LUBRICATOR: ○ SINGLE PLUNGER PER POINT
○ DIVIDER BLOCKS
◯ COMPARTMENT, TOTAL QUANTITY
◯ PLUNGERS (PUMPS), TOTAL QUANTITY
◯ SPARE PLUNGERS, QUANTITY
◯ SPARE COMPARTMENT WITHOUT PLUNGERS
○ HEATERS: ○ ELECTRIC ○ STEAM

◯ **DRIVE GUARD(S)**(7.2.2)
○ SUPPLIED BY
○ STANDARD (7.2.2.2)
○ MANUFACTURER'S ○ ISO 14120 ○ ANSI B11.19
○ NON-SPARKING ○ API-671 APPENDIX G
○ MATERIAL
○ OTHER

◯ **FRAME VIBRATION DETECTORS**
○ SEE ATTACHED API-670 DATASHEET
○ TYPE ☐ MODEL
○ MFR ○ NO. REQUIRED
○ SUPPLIED BY:
☐ SCALE RANGE ○ ALARM ☐ SET @
○ SHUTDOWN: ☐ SET @ ○ TIME DELAY (sec)

◯ **CROSSHEAD VIBRATION DETECTORS:**
○ SEE ATTACHED API-670 DATASHEET
○ TYPE ☐ MODEL
○ MFR ○ NO. REQUIRED
○ SUPPLIED BY:
☐ SCALE RANGE ○ ALARM ☐ SET @
○ SHUTDOWN: ☐ SET @ (mil) ○ TIME DELAY (sec)

◯ **PHASE REFERENCE PROBE** ○ SEE ATTACHED API-670 DATASHEET
○ COMPRESSOR ○ GEAR HIGH SPEAD ○ GEAR LOW SPEED
○ DRIVER

◯ **MONITOR** ○ SEE ATTACHED API-670 DATASHEET
○ SUPPLIED BY
○ LOCATION ○ ENCLOSURE
○ MFR. ☐ MODEL

REMARKS / SPECIAL REQUIREMENTS:

DOCUMENT NUMBER: _____
CLIENT DOCUMENT NUMBER: _____

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RECIPROCATING COMPRESSOR DATA SHEET (API 618-6TH) SI UNITS (kPa)

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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ▣ PURCHASER OR MANUFACTURER AS APPLICABLE

PAINTING:
- ○ MANUFACTURER'S STANDARD
- ○ OTHER _____

SHIPMENT:
- ○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQUIRED
- ◉ STANDARD 6 MONTH STORAGE PREPARATION
  - ○ PROVIDED BY: _____
  - ○ PER SPECIFICATION: _____
- ○ OUTDOOR STORAGE MORE THAN 6 MONTHS: _____ MONTHS
  - ○ PROVIDED BY: _____
  - ○ PER SPECIFICATION: _____

TOOLS
- ◉ HYDRAULIC TENSIONING TOOLS
  - ◉ NO ◉ YES

SPARE PARTS
- ○ START-UP
- ○ NORMAL MAINTENANCE

☐ **ESTIMATED WEIGHTS AND NOMINAL DIMENSIONS**

☐ TOTAL COMPRESSOR WEIGHT, LESS DRIVER & GEAR	_____ (kg)
◇ WEIGHT OF COMPLETE UNIT, (LESS CONSOLES)	_____ (kg)
◇ MAXIMUM ERECTION WEIGHT	_____ (kg)
◇ MAXIMUM MAINTENANCE WEIGHT	_____ (kg)
◇ DRIVER WEIGHT	_____ (kg)
◇ GEAR WEIGHT	_____ (kg)
◇ LUBE OIL CONSOLE	_____ (kg)
◇ COOLING H_2O CONSOLE	_____ (kg)
◇ FREE STANDING PANEL	_____ (kg)

SPACE REQUIREMENTS: (m)	LENGTH	WIDTH	HEIGHT
◇ COMPLETE UNIT			
◇ LUBE OIL CONSOLE			
◇ CYLINDER COOLANT CONSOLE			
◇ FREE STANDING PANEL			
◇ PISTON ROD REMOVAL DISTANCE			

OTHER EQUIPMENT SHIPPED LOOSE (DEFINE)

◇ PULSATION SUPPRESSOR, WEIGHT	_____ (kg)
◇ PIPING	_____ (kg)
◇ INTERSTAGE EQUIPMENT	_____ (kg)

○ **INSPECTION AND SHOP TESTS** (8.2)

	REQUIRED	WITNESS	OBSERVE
SHOP INSPECTION	○		
CLEANLINESS OF EQUIPMENT, PIPING, & APPURTENANCES	○	○	○
ACTUAL RUNNING CLEARANCES AND RECORDS	○	○	○
MANUFACTURER STANDARD SHOP TESTS	○	○	○
CYLINDER HYDROSTATIC TEST (8.3.2.1)	○	○	○
CYLINDER PNEUMATIC TEST	○	○	○
CYLINDER HELIUM LEAK TEST (8.3.2.3)	○	○	○
CYLINDER JACKET WATER HYDRO TEST (8.3.2.1)	○	○	○
DISTANCE PIECE HYDRO TEST (8.3.2.2)	○	○	○
MECHANICAL RUN TEST (4 HOUR) (8.3.3.1)	○	○	○
COMPLETE SHOP RUN TEST OF ALL MACHINE MOUNTED EQUIPMENT, PIPING & APPURTENANCES (8.3.3.2)	○	○	○
RECORD VIBRATION DURING RUN TEST (8.3.3.6)	○	○	○
BAR-OVER TO CHECK ROD RUNOUT	○	○	○
LUBE OIL CONSOLE RUN/TEST (4 HOUR)	○	○	○
COOLING H_2O CONSOLE RUN/TEST	○	○	○
PERFORMANCE TEST (8.3.4.4)	○	○	○
RADIOGRAPHY BUTT WELDS	○	○	○
○ GAS ○ OIL ○ FAB CYCLES			
MAG PARTICLE / LIQUID PENETRANT OF WELDS	○	○	○
POSITIVE MATERIAL IDENTIFICATION	○	○	○
HARDNESS OF PARTS, WELDS & HEAT AFFECTED ZONES	○	○	○
NOTIFICATION TO PURCHASER OF ANY REPAIRS TO MAJOR WELDS	○		
SHOP FIT-UP OF EQUIPMENT & ALL ASSOCIATED GAS PIPING (8.3.4.2)	○	○	○
SPECIFY ADDITIONAL REQUIREMENTS			
_____	○	○	○
_____	○	○	○
_____	○	○	○

ANNEX J COMPLIANCE: ○ VENDOR ○ PURCHASER

○ **REPORTS AND SERVICES**
- ○ INITIAL INSTALLATION AND OPERATING TEMPERATURE ALIGNMENT CHECK AT JOBSITE BY VENDOR REPRESENTATIVE (6.1.18)
- ○ COMPRESSOR MANUFACTURER'S USER'S LIST FOR SIMILAR SERVICE
- ○ COMPRESSOR VALVE DYNAMIC RESPONSE REPORT
- ○ PERFORMANCE DATA REQUIRED (E.2.4.1):
  - ○ BHP VS. SUCTION PRESSURE CURVES
  - ○ ROD LOAD/GAS LOAD CHARTS
  - ○ VALVE FAILURE DATA CHARTED
  - ○ SPEED/TORQUE CURVE DATA
  - ○ ACCEPTABLE OPERATING RANGES AND LIMITATIONS GRAPH
- ○ BHP VS. CAPACITY PERFORMANCE CURVES OR TABLES REQUIRED FOR UNLOADING STEPS AND/OR VARIABLE SUCTION/DISCHARGE PRESSURES

REMARKS / SPECIAL REQUIREMENTS: _____

DOCUMENT NUMBER:
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RECIPROCATING COMPRESSOR
DATA SHEET (API 618-6TH)
SI UNITS (kPa)

JOB NO. ITEM NO.
PAGE 8 OF REQUISITION NO.

NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ▣ PURCHASER OR MANUFACTURER AS APPLICABLE

○ **SCOPE OF BASIC SUPPLY**

THE FOLLOWING SHALL BE PROVIDED BY VENDOR. EQUIPMENT SHALL BE PACKAGED TO THE EXTENT SPECIFIED

○ PACKAGED: ○ NO ○ YES **DEFINE BASIC SCOPE OF PACKAGING IN REMARKS SECTION**
○ DRIVER DATA SHEET:
○ GEAR DATA SHEET:
○ COUPLING(S) DATA SHEET:
○ PULSATION SUPPRESSION DEVISES SEE PAGES THROUGH
○ LIQUID KNOCKOUT VESSELS DATA SHEET:
○ SEPARATION AND COLLECTION FACILITIES (7.10.2.1)
○ AUTO DRAIN SYSTEM (7.10.2.8)
○ INTERCOOLER BY SUPPLIER (7.10.1.1) ○ WATER COOLED (7.10.1.3) ○ AIR COOLED (7.10.1.3)
○ OFF MOUNTED ○ MACHINE MOUNTED
○ SHELL AND TUBE ○ TEMA CLASS (7.10.1.5): ○ C ○ R
○ PRESSURE VESSEL CODE : ○ ASME VIII ○ OTHER:
○ PREFABRICATED PIPING 7.10.1.9)
○ DATA SHEET:
○ AFTERCOOLER BY SUPPLIER (7.10.1.2) ○ WATER COOLED (7.10.1.3) ○ AIR COOLED (7.10.1.3)
○ OFF MOUNTED ○ MACHINE MOUNTED
○ SHELL AND TUBE ○ TEMA CLASS (7.10.1.5): ○ C ○ R
○ PRESSURE VESSEL CODE : ○ ASME VIII ○ OTHER:
○ PREFABRICATED PIPING 7.10.1.9)
○ DATA SHEET:
○ STRAINERS
○ INITIAL INLET ○ SPOOL PIECE FOR INLET STRAINERS
○ SIDESTREAM INLET ○ SPOOL PIECE FOR INLET STRAINERS
○ FOR ATMOSPHERIC INLET AIR COMPRESSOR. ONLY: ○ INLET AIR FILTER ○ INLET FILTER -SILENCER
○ PROCESS PIPING
○ PROCESS PIPING SUPPLIED (7.9.6.1):
○ REMOVABLE SPOOL FOR SCREENS (7.9.6.4)
○ FINAL STAGE CHECK VALVE (7.9.6.5)
○ DISTANCE PIECE VENT AND DRAIN PIPE (7.9.7.1)
○ FLANGE FINISH ○ API-618 FLANGE FINISH > 125 < 250 6.8.2.1.16 ○ FLANGE FINISH PER ASME B16.5 ○ SPECIAL FINISH
○ SPECIAL PIPING REQUIREMENTS 7.7.1.13. DEFINE IN REMARKS SECTION
○ AUXILIARY INTERCONNECTING PIPING
○ INTERSTAGE PIPE ○ PARTIAL PRE-FAB, FIELD FIT ○ SHOP FITTED
○ FINAL DISC. PIPE ○ PARTIAL PRE-FAB, FIELD FIT ○ SHOP FITTED
○ MANIFOLD PIPING; ○ DRAINS ○ VENTS ○ RELIEF VALVES ○ AIR/GAS SUPPLY
○ RELIEF VALVES ○ INITIAL INLET ○ INTERSTAGE ○ FINAL DISCHARGE
○ RUPTURE DISCS ○ INITIAL INLET ○ INTERSTAGE ○ FINAL DISCHARGE

REMARKS / SPECIAL REQUIREMENTS:

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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ☒ PURCHASER OR MANUFACTURER AS APPLICABLE

SITE / LOCATION CONDITIONS

ELEVATION _____ (m) BAROMETER _____ (kPaA) AMBIENT TEMPERATURES: MAXIMUM _____ (°C) MINIMUM _____ (°C)
○ MINIMUM DESIGN METAL TEMPERATURE _____ (°C) RELATIVE HUMIDITY: MAXIMUM _____ % MINIMUM _____ %
COMPRESSOR LOCATION: ○ INDOOR ○ OFF-SHORE ○ NO ROOF ○ HEATED ○ AT GRADE LEVEL ○ ELEVATED: _____ (m)
○ OUTDOOR ○ ON-SHORE ○ UNDER ROOF ○ UNHEATED ○ PLATFORM ○ PARTIAL SIDES
○ TROPICALIZATION REQUIRED ○ WEATHER PROTECTION REQUIRED
○ WINTERIZATION REQUIRED
○ PREVISION FOR INSULATION
○ PREVISION FOR HEAT TRACE
○ ELECTRICAL ○ STEAM
UNUSUAL CONDITIONS: ○ CORROSIVES ○ DUST ○ FUMES
○ OTHER _____

ELECTRICAL CLASSIFICATION

MAIN UNIT
○ NON-HAZARDOUS ○ HAZARDOUS
○ CLASS _____ GROUP _____ DIVISION _____
○ ZONE _____ GROUP _____ TEMPERATURE CLASS _____

UTILITY CONDITIONS

ELECTRICAL POWER

	AC VOLTS	/ PHASE	/ HERTZ	/ DC VOLTS
○ MAIN DRIVER		/	/	/
○ AUXILIARY MOTORS		/	/	/
○ HEATERS		/	/	/
○ INSTRUMENT		/	/	/
○ ALARM & SHUTDOWN		/	/	/
○ _____		/	/	/
○ _____		/	/	/
○ _____		/	/	/

AIR / NITROGEN

INSTRUMENT AIR PRESSURE NORMAL _____ (kPaG) MAXIMUM _____ (kPaG) MINIMUM _____ (kPaG)
NITROGEN PRESSURE NORMAL _____ (kPaG) MAXIMUM _____ (kPaG) MINIMUM _____ (kPaG)

STEAM

DRIVERS

INLET: PRESSURE NORMAL _____ (kPaG) MAXIMUM _____ (kPaG) MINIMUM _____ (kPaG)
TEMPERATURE NORMAL _____ (°C) MAXIMUM _____ (°C) MINIMUM _____ (°C)
EXHAUST: PRESSURE NORMAL _____ (kPaG) MAXIMUM _____ (kPaG) MINIMUM _____ (kPaG)
TEMPERATURE NORMAL _____ (°C) MAXIMUM _____ (°C) MINIMUM _____ (°C)

HEATERS

INLET: PRESSURE NORMAL _____ (kPaG) MAXIMUM _____ (kPaG) MINIMUM _____ (kPaG)
TEMPURATURE NORMAL _____ (°C) MAXIMUM _____ (°C) MINIMUM _____ (°C)
EXHAUST: PRESSURE NORMAL _____ (kPaG) MAXIMUM _____ (kPaG) MINIMUM _____ (kPaG)
TEMPURATURE NORMAL _____ (°C) MAXIMUM _____ (°C) MINIMUM _____ (°C)

COOLING FLUIDS

COMPRESSOR CYLINDERS

TYPE OF WATER _____
SUPPLY: PRESSURE NORMAL _____ (kPaG) MAXIMUM _____ (kPaG) MINIMUM _____ (kPaG)
TEMPURATURE NORMAL _____ (°C) MAXIMUM _____ (°C) MINIMUM _____ (°C)
RETURN: PRESSURE NORMAL _____ (kPaG) MAXIMUM _____ (kPaG) MINIMUM _____ (kPaG)
TEMPURATURE NORMAL _____ (°C) MAXIMUM _____ (°C) MINIMUM _____ (°C)

COOLERS

TYPE OF WATER _____
SUPPLY: PRESSURE NORMAL _____ (kPaG) MAXIMUM _____ (kPaG) MINIMUM _____ (kPaG)
TEMPURATURE NORMAL _____ (°C) MAXIMUM _____ (°C) MINIMUM _____ (°C)
RETURN: PRESSURE NORMAL _____ (kPaG) MAXIMUM _____ (kPaG) MINIMUM _____ (kPaG)
TEMPURATURE NORMAL _____ (°C) MAXIMUM _____ (°C) MINIMUM _____ (°C)

ROD PACKING:

TYPE OF FLUID _____
SUPPLY: PRESSURE NORMAL _____ (kPaG) MAXIMUM _____ (kPaG) MINIMUM _____ (kPaG)
TEMPURATURE NORMAL _____ (°C) MAXIMUM _____ (°C) MINIMUM _____ (°C)
RETURN: PRESSURE NORMAL _____ (kPaG) MAXIMUM _____ (kPaG) MINIMUM _____ (kPaG)
TEMPURATURE NORMAL _____ (°C) MAXIMUM _____ (°C) MINIMUM _____ (°C)

REMARKS / SPECIAL REQUIREMENTS: _____

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RECIPROCATING COMPRESSOR
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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ▣ PURCHASER OR MANUFACTURER AS APPLICABLE

☐ **UTILITY CONSUMPTION**

ELECTRIC MOTORS (NOTE 1)

	NAMEPLATE (kW)	LOCKED ROTOR AMPS	FULL LOAD STEADY STATE AMPS
◇ MAIN DRIVER			
◇ MAIN LUBE OIL PUMP			
◇ AUXILIARY LUBE OIL PUMP			
◇ MAIN CYLINDER COOLANT PUMP			
◇ AUXILIARY CYLINDER COOLANT PUMP			
◇ MAIN ROD PACKING COOLANT PUMP			
◇ AUXILIARY ROD PACKING COOLANT PUMP			
◇ CYLINDER LUBRICATOR			
_____			
_____			

MAIN DRIVER NON-STEADY STATE AMPS AT COMPRESSOR RATED HORSEPOWER (INDUCTION ONLY)
_____ AMPS AT COMPRESSOR RATED (kW) OF _____ @ CURRENT PULSATIONS OF _____ %

ELECTRIC HEATERS

	WATTS	VOLTS	HERTZ
◇ FRAME OIL HEATER(S)			
◇ CYLINDER COOLANT HEATER(S)			
◇ CYLINDER LUBRICATOR HEATER(S)			
◇ MAIN DRIVER SPACE HEATER(S)			
_____			
_____			

STEAM

	FLOW		INLET PRESSURE		ILET TEMPERATUR		OUTLET PRESSURE	
◇ MAIN DRIVER	_____	(kg/h) @	_____	(kPaG)	_____	(°C)TT TO	_____	(kPaG)
◇ FRAME OIL HEATER(S)	_____	(kg/h) @	_____	(kPaG)	_____	(°C)TT TO	_____	(kPaG)
◇ CYLINDER LUBE HEATER(S)	_____	(kg/h) @	_____	(kPaG)	_____	(°C)TT TO	_____	(kPaG)
_____	_____	(kg/h) @	_____	(kPaG)	_____	(°C)TT TO	_____	(kPaG)
_____	_____	(kg/h) @	_____	(kPaG)	_____	(°C)TT TO	_____	(kPaG)

COOLING WATER REQUIREMENTS

	FLOW (m^3/h)	INLET TEMPERATURE (°C)	OUTLET TEMPERATURE (°C)	INLET PRESSURE (kPaG)	OUTLET PRESSURE (kPaG)	MAXIMUM PRESSURE (kPaG)
☐ CYLINDER JACKETS						
◇ CYLINDER COOLANT CONSOLE						
◇ FRAME LUBE OIL COOLER						
◇ ROD PRESSURE PACKING (NOTE 2)						
◇ PACKING COOLANT CONSOLE						
◇ INTERCOOLER(S)						
◇ AFTERCOOLER						
_____						
◇ TOTAL FLOW						

REMARKS / SPECIAL REQUIREMENTS: NOTE 1: FOR INDUCTION MOTORS SEE 7.1.2.6 AND MOTOR DATA SHEET
NOTE 2: ROD PACKING COOLANT MAY BE OTHER THAN WATER

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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ◎ PURCHASER OR MANUFACTURER AS APPLICABLE

FRAME LUBE OIL SYSTEM

◎ **BASIC LUBE OIL SYSTEM FOR FRAME:** ◎ SPLASH ◎ PRESSURE (FORCED)
- ○ HEATERS REQUIRED: ○ ELECTRIC ○ STEAM
- ☐ TYPE MAIN BEARINGS: ◎ TAPERED ROLLER ◎ PRECISION SLEEVE

◎ **PRESSURE SYSTEM:** ○ DATA SHEET: _____
- ○ PER SPECIFICATION: ○ API 614 ○ OTHER _____
- ○ MAIN OIL PUMP DRIVEN BY: ○ COMPRESSOR CRANKSHAFT ○ ELECTRIC MOTOR ○ OTHER _____
- ☐ PSV FOR MAIN PUMP EXTERNAL TO CRANKCASE ○ CHECK VALVE ON MAIN PUMP
- ○ AUXILIARY OIL PUMP DRIVEN BY: ○ ELECTRIC MOTOR ○ OTHER _____
- ☐ HAND OPERATED PRE-LUBE PUMP FOR STARTING
- ○ CONTINUOUS OIL FLOW THROUGH SWITCH SENSING LINE
- ○ OPERATIONAL TEST & 4 HOUR MECHANICAL RUN TEST IN SHOP
- ○ **SEPARATE CONSOLE FOR PRESSURE LUBE SYSTEM:**
- ○ ONE CONSOLE FOR EACH COMPRESSOR ○ ONE CONSOLE FOR _____ COMPRESSORS ○ EXTENDED TO MOTOR OUTBOARD BEARING
- ○ CONSOLE TO BE OF DECK PLATE TYPE CONSTRUCTION SUITABLE FOR MULTI-POINT SUPPORT AND GROUTING WITH GROUT & VENT HOLES.
- ☐ MAXIMUM DISTANCE BETWEEN CONSOLE TO FRAME (7.9.2.1) _____ (m)
- ☐ ELEVATION DIFFERENCE FRAME TO CONSOLE 7.9.2.1) _____ (m)
- ○ ELECTRICAL CLASSIFICATION : ○ NON-HAZARDOUS ○ HAZARDOUS
  - ○ CLASS _____ GROUP _____ DIVISION _____
  - ○ ZONE _____ GROUP _____ TEMPERATURE CLASS _____

☐ **BASIC SYSTEM REQUIREMENTS (NORMAL OIL FLOWS & VOLUMES)**

☐ LUBE OIL ○ SHOP RUN	FLOW (m³/h)	PRESSURE (kPaG)	VISCOSITY (SSU)(@ 37.8 °C)	VISCOSITY (SSU)(@ 100 °C)	SUMP VOLUME (l)
☐ COMPRESSOR FRAME					
◇ DRIVER					
◇ GEAR					

- ☐ SYSTEM PRESSURES: ☐ DESIGN _____ (kPaG) ☐ HYDROTEST _____ (kPaG)
- ☐ PRESSURE CONTROL VALVE SETTING _____ (kPaG) ☐ PUMP RELIEF VALVE(S) SETTING _____ (kPaG)

○ **PIPING MATERIALS (7.9.2.2) :**

	CARBON STEEL	STAINLESS STEEL WITH STAINLESS STEEL FLANGES	STAINLESS STEEL WITH CARBON STEEL FLANGES
○ UPSTREAM OF PUMPS & FILTERS	○	●	○
○ DOWNSTREAM OF FILTERS	○	●	○
○ _____	○	○	○
○ _____	○	○	○

☐ **PUMPS** (Gear or Screw Type Only)

	◇ RATED FLOW (m³/h)	◇ PRESSURE (kPaG)	◇ COLD START REQUIRED BHP	◇ DRIVER (kW)	◇ SPEED (rpm)	COUPLING REQUIRED	MECHANICAL SEAL REQUIRED	RELIEF VALVE REQUIRED
☐ MAIN						○	○	○
◎ AUXILIARY						○	○	○

- ☐ PUMP CASING MATERIAL: MAIN PUMP _____ AUXILIARY PUMP _____
- ○ GUARD(S) REQUIRED FOR COUPLING(S): ○ MAIN PUMP ○ AUX PUMP ○ GUARD TYPE OR CODE _____
- ○ AUXILIARY PUMP CONTROL: ○ MANUAL ○ AUTOMATIC
  - ○ ON-OFF-AUTO SELECT SWITCH: ○ BY PURCHASER ○ BY MANUFACTURER
  - ○ WIRING TO TERMINAL BOX: ○ BY PURCHASER ○ BY MANUFACTURER

○ **COOLERS:**
- ☐ DESIGN PRESSURE, _____ (kPaG) @ _____ (°C)
- ◎ MINIMUM DESIGN METAL TEMPERATURE _____ (°C)
- ○ SHELL & TUBE ○ SINGLE ○ DUAL W/TRANSFER VALVE ○ MANUFACTURERS STANDARD ○ TEMA C ○ TEMA R (API-660) (Data Sheets - Attached)
  - ○ REMOVABLE BUNDLE ○ WATER COOLED ○ AIR COOLED W/AUTO TEMP CONTROL (API-661)
  - ○ WITH BYPASS & TEMPERATURE CONTROL VALVE: ○ MANUAL ○ AUTO
  - ○ SEE SEPARATE HEAT EXCHANGER DATA SHEET FOR DETAILS, SPECIFY % GLYCOL ON COOLING WATER SIDE

◎ **FILTER(S)**
- ○ SINGLE ○ DUAL W/TRANSFER VALVE ○ ASME CODE DESIGN ○ ASME CODE STAMPED
- ☐ DESIGN PRESSURE, _____ (kPaG) @ _____ (°C) ☐ ΔP CLEAN _____ (kPa) ☐ ΔP COLLAPSE _____ (kPa)
- ◎ MINIMUM DESIGN METAL TEMPERATURE _____ (°C)
- ☐ MICRON RATING _____
- ☐ BONNET MATERIAL _____ ☐ CASING MATERIAL _____
- ☐ CARTRIDGE MATERIAL _____ ◇ CARTRIDGE PART NUMBER _____
- ○ SPARE CARTRIDGE REQUIRED: QUANTITY TO BE FURNISHED _____

☐ **SYSTEM COMPONENTS**

	MANUFACTURER	MODEL		MANUFACTURER	MODEL
◇ MAIN PUMP			◇ OIL COOLER(S)		
◇ AUXILIARY PUMP			◇ TRANSFER VALVE(S)		
◇ MECHANICAL SEALS			◇ PUMP COUPLING(S)		
◇ ELECTRIC MOTORS			◇ SUCTION STRAINER(S)		
◇ STEAM TURBINES			◇ CHECK VALVE(S)		
◇ OIL FILTER(S)			◇		

REMARKS / SPECIAL REQUIREMENTS: NOTE 1: INSTRUMENTATION TO BE LISTED ON INSTRUMENTATIONSCOPE DATA SHEETS.

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RECIPROCATING COMPRESSOR
DATA SHEET (API 618-6TH)
SI UNITS (kPa)

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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ◈ PURCHASER OR MANUFACTURER AS APPLICABLE

COOLING WATER SYSTEM (NOTE 1)

○ **BASIC COOLING SYSTEM FOR:** ○ COMPRESSOR CYLINDER(S) ○ ROD PACKING(S) ○ PROCESS COOLER(S) ○ OIL COOLER(S)
○ SEPARATE COOLING CONSOLE ○ ONE FOR EACH UNIT ○ ONE COMMON TO ALL UNITS ○ ARRANGED FOR HEATING JACKET WATER AS WELL AS COOLING
○ HEATERS REQUIRED FOR PRE-HEATING: ○ ELECTRIC ○ STEAM
○ ELECTRICAL CLASSIFICATION: ○ NON-HAZARDOUS ○ HAZARDOUS
○ CLASS _____ GROUP _____ DIVISION _____
○ ZONE _____ GROUP _____ TEMPERATURE CLASS _____
○ **SEPARATE COOLING SYSTEM FOR ROD PRESSURE PACKING (6.13.2)**
○ **PRESSURE FORCED CIRCULATING SYSTEM:**
○ OPEN PIPING BY: ○ PURCHASER ○ MANUFACTURER
○ CLOSED PIPING BY MANUFACTURER
MAIN COOLANT PUMP DRIVEN BY: ○ ELECTRIC MOTOR ○ STEAM TURBINE ○ OTHER _____
AUXILIARY COOLANT PUMP DRIVEN BY: ○ ELECTRIC MOTOR ○ STEAM TURBINE ○ OTHER _____
○ **SEPARATE CONSOLE FOR COOLANT SYSTEM.:**
○ ONE CONSOLE FOR EACH COMPRESSOR ○ ONE CONSOLE FOR _____ COMPRESSORS
○ CONSOLE TO BE OF DECK PLATE TYPE CONSTRUCTION SUITABLE FOR MULTI-POINT SUPPORT AND GROUTING WITH GROUT & VENT HOLES.

◈ **BASIC SYSTEM REQUIREMENTS (NORMAL COOLANT FLOW DATA)**
○ COOLANT TO BE _____ % ETHYLENE GLYCOL
○ CYLINDER COOLING FLOW: ○ PARALLEL ○ SERIES

	FORCED COOLING	THERMO SYPHON	STAND PIPE	FLOW (m³/h)	PRESSURE (kPaG)	INLET TEMPERATURE (°C)	OUTLET TEMPERATURE (°C)	SIGHT FLOW INDICATOR
CYLINDER(S), _____ STAGE	○	○	○					○
CYLINDER(S), _____ STAGE	○	○	○					○
CYLINDER(S), _____ STAGE	○	○	○					○
CYLINDER(S), _____ STAGE	○	○	○					○
CYLINDER(S), _____ STAGE	○	○	○					○
CYLINDER(S), _____ STAGE	○	○	○					○
PISTON ROD PACKAGE TOTAL	○							○
INTERCOOLER(S) TOTAL	○							○
AFTERCOOLER	○							○
OIL COOLER(S)	○							○
_____	○							○
TOTAL FLOW								

☐ **SYSTEM PRESSURES:** ☐ DESIGN: _____ (kPaG) ☐ HYDROTEST: _____ (kPaG) ◈ RELIEF VALVE(S), SETTING _____ (kPaG)

○ **PIPING MATERIALS:**
○ CARBON STEEL ○ STAINLESS STEEL WITH STAINLESS STEEL FLANGES ○ STAINLESS STEEL WITH CARBON STEEL FLANGES

◈ **COOLANT RESERVOIR:** ○ HORIZONTAL (7.6.5.6) ○ VERTICAL (7.6.5.7)
◇ SIZE: DIAMETER: _____ (mm X HEIGHT: _____ (mm) ◇ CAPACITY AT NORMAL OPERATING LEVEL: _____ (l)
◇ RESERVOIR MATERIAL _____ ◇ INTERNAL COATING, TYPE _____
○ LEVEL SWITCH ○ DRAIN VALVE
○ RESERVOIR HEATER (7.6.5.10): ○ ELECTRIC ○ HOT WATER ○ STEAM
○ INLINE HEATER REQUIRED (7.6.5.12)

☐ **PUMPS:** (CENTRIFUGAL ONLY)	◇ RATED FLOW (m³/h)	◇ PRESSURE (kPaG)	◇ REQUIRED (BkW)	◇ DRIVER (kW)	◇ SPEED (rpm)	COUPLING REQUIRED	MECHANICAL SEAL REQUIRED
☐ MAIN						○	○
○ AUXILIARY						○	○

☐ PUMP CASING MATERIAL: MAIN PUMP _____ AUXILIARY PUMP _____
○ GUARD(S) REQUIRED FOR COUPLING(S): ○ MAIN PUMP ○ AUX PUMP ○ GUARD TYPE OR CODE _____
○ AUXILIARY PUMP CONTROL: ○ MANUAL ○ AUTOMATIC
○ ON-OFF-AUTO SELECT SWITCH: ○ BY PURCHASER ○ BY MANUFACTURER
○ WIRING TO TERMINAL BOX: ○ BY PURCHASER ○ BY MANUFACTURER

○ **COOLANT HEAT EXCHANGER:**
☐ DESIGN PRESSURE, _____ (kPaG) @ _____ (°C)
◈ MINIMUM DESIGN METAL TEMPERATURE _____ (°C)
○ SHELL & TUBE ○ SINGLE ○ DUAL W/TRANSFER VALVE ○ MANUFACTURERS STANDARD ○ TEMA C ○ TEMA R (API-660) (Data Sheets - Attached)
○ REMOVABLE BUNDLE ○ WATER COOLED ○ AIR COOLED W/AUTO TEMP CONTROL (API-661)
○ WITH BYPASS & TEMPERATURE CONTROL VALVE: ○ MANUAL ○ AUTO ○ LOUVERS FOR AIR HEAT EXCHANGER
○ SEE SEPARATE HEAT EXCHANGER DATA SHEET FOR DETAILS, SPECIFY % GLYCOL ON COOLING WATER SIDE

SYSTEM COMPONENTS

	MANUFACTURER	MODEL		MANUFACTURER	MODEL
◇ MAIN PUMP			◇ TEMP. CONTROL VALVE(S)		
◇ AUXILIARY PUMP			◇ TRANSFER VALVE(S)		
◇ MECHANICAL SEALS			◇ PUMP COUPLING(S)		
◇ ELECTRIC MOTORS			◇		
◇ STEAM TURBINES			◇		
◇ _____			◇		
◇ _____			◇		

REMARKS / SPECIAL REQUIREMENTS: NOTE 1: INSTRUMENTATION TO BE LISTED ON INSTRUMENTATIONSCOPE DATA SHEETS.

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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ▣ PURCHASER OR MANUFACTURER AS APPLICABLE

INSTRUMENTATION

INSTRUMENT & CONTROL PANEL ○ SUPPLIED BY: _____
○ ONE FOR EACH UNIT ○ ONE COMMON TO ALL UNITS
○ MACHINE MOUNTED ○ FREE STANDING (OFF UNIT) ○ LOCAL ○ REMOTE ○ OUTDOORS
○ PNEUMATIC ○ ELECTRONIC ○ HYDRAULIC ○ PROGRAMMABLE CONTROLLER
○ ELECTRICAL CLASSIFICATION : ○ NON-HAZARDOUS
HAZARDOUS ○ CLASS _____ GROUP _____ DIVISION _____
○ ZONE _____ GROUP _____ TEMPERATURE CLASS _____
○ INTRINSICALLY SAFE ○ YES ○ NO
○ INTRINSICALLY SAFE BARRIERS ○ SUPPLIED BY: _____
○ ENCLOSURE TYPE: _____
○ PURGED: ○ YES ○ NO ○ TYPE: _____
○ LOW PURGE PRESSURE ○ ALARM ○ SHUTDOWN
○ VIBRATION ISOLATORS ○ STRIP HEATERS ○ PURGE CONNECTION ○ EXTRA CUTOUTS
○ ANNUNCIATOR W/FIRST-OUT INDICATION LOCATED ON CONTROL PANEL
○ PURCHASER'S CONNECTION BROUGHT OUT TO TERMINAL BOX BY VENDOR

BUFFER GAS CONTROL PANEL ○ SUPPLIED BY: _____
○ ONE FOR EACH UNIT ○ ONE COMMON TO ALL UNITS
○ MACHINE MOUNTED ○ FREE STANDING (OFF UNIT) ○ WITH STAND ○ OUTDOOR
○ ELECTRICAL CLASSIFICATION : ○ NON-HAZARDOUS ○ HAZARDOUS
○ CLASS _____ GROUP _____ DIVISION _____
○ ZONE _____ GROUP _____ TEMPERATURE CLASS _____
○ CONSTANT PRESSURE DISPOSAL SYSTEM ○ VARIABLE PRESSURE DISPOSAL SYSTEM

○ INSTRUMENTATION SUITABLE FOR: ○ INDOORS ○ OUTDOORS ○ OTHER _____

○ PREFERRED INSTRUMENT SUPPLIERS, (TO BE COMPLETED BY PURCHASER), OTHERWISE MANUFACTURER'S STANDARD APPLIES

	MANUFACTURER	SIZE	TYPE	MATERIAL
PRESSURE GAUGES				
TEMPERATURE GAUGES				
LIQUID LEVEL GAUGES				
DIFFERENTIAL PRESSURE GAUGES				
PRESSURE TRANSMITTERS				
LIQUID LEVEL TRANSMITTER				
PRESSURE SWITCHES				
TEMPERATURE SWITCHES				
LIQUID LEVEL SWITCHES				
DIFFERENTIAL PRESSURE SWITCHES				
CONTROL VALVES				
PRESSURE SAFETY VALVES				
SIGHT FLOW INDICATORS				
VIBRATION MONITORS & EQUIPMENT				
THERMOCOUPLES				
RTD'S				
SOLENOID VALVES				
PROGRAMMABLE CONTROLLER				
_____				

	MANUFACTURER	MODEL	QUANTITY OF SPARE POINTS
ANNUNCIATOR			

○ PRESSURE GAUGE REQUIREMENTS ○ LIQUID FILLED PRESSURE GAUGES: ○ YES ○ NO

FUNCTION	LOCALLY MOUNTED	PANEL MOUNTED		LOCALLY MOUNTED	PANEL MOUNTED
LUBE OIL MAIN PUMP DISCHARGE	○	○	SUPPLIED BY:		
LUBE OIL AUXILIARY PUMP DISCHARGE	○	○	SUPPLIED BY:		
LUBE OIL PRESS. AT FRAME HEADER	○	○	SUPPLIED BY:		
LUBE OIL FILTER Δ P	○	○	SUPPLIED BY:		
COOLING H_2O INLET HEADER	○	○	SUPPLIED BY:		
PROCESS GAS:					
INLET PRESSURE	○	○	SUPPLIED BY:		
@ EACH STAGE	○	○	SUPPLIED BY:		
DISCHARGE. PRESSURE	○	○	SUPPLIED BY:		
@ EACH STAGE	○	○	SUPPLIED BY:		
_____	○	○	SUPPLIED BY:		
_____	○	○	SUPPLIED BY:		

REMARKS / SPECIAL REQUIREMENTS: _____

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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ▣ PURCHASER OR MANUFACTURER AS APPLICABLE

PURCHASER TO FILL IN (☐ ○ ▣) AFTER COMMODITY TO INDICATE: ☐ BY COMPRESSOR MANUFACTURER ○ BY PURCHASER ▣ BY OTHERS

INSTRUMENTATION (CONTINUED)

TEMPERATURE MEASUREMENT REQUIREMENTS

FUNCTION	LOCALLY MOUNTED	PANEL MOUNTED	GAUGE WITH CAPILLARY	THERMO-COUPLE SYSTEM	RTD SYSTEM	I/S SYSTEM
LUBE OIL ○ INLET TO ○ OUT OF FRAME	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○
LUBE OIL ○ INLET TO ○ OUT OF COOLER	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○
MAIN JOURNAL BEARINGS (THERMOCOUPLES OR RTD'S ONLY)	(☐ ○ ▣)	(☐ ○ ▣)		○	○	○
MOTOR BEARING(S) (THERMOCOUPLES OR RTD'S ONLY)	(☐ ○ ▣)	(☐ ○ ▣)		○	○	○
COOLING WATER HEADER: ○ INLET ○ OUTLET	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○
CYLINDER COOLING WATER: ○ INLET ○ OUTLET ○ EACH CYLINDER	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○
PROCESS GAS: ○ INLET ○ DISCHARGE ○ EACH CYLINDER	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○
INTERCOOLER(S) ○ INLET ○ GAS ○ COOLANT	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○
○ OUTLET ○ GAS ○ COOLANT	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○
AFTERCOOLER: ○ INLET ○ GAS ○ COOLANT	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○
○ OUTLET ○ GAS ○ COOLANT	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○
PACKING COOLANT ○ INLET ○ OUTLET	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○
PRESSURE PGK CASE, CYL PISTON ROD (THERMO-COUPLE OR RTD'S ONLY)	(☐ ○ ▣)	(☐ ○ ▣)		○	○	○
COMPRESSOR VALVES ○ SUCTION ○ DISCHARGE (TC'S OR RTD'S ONLY)	(☐ ○ ▣)	(☐ ○ ▣)		○	○	○
PACKING CASE VENT TEMPERATURE (6.13.2.9)	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○
_____	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○

ALARM & SHUTDOWN SWITCH REQUIREMENTS (NOTE 1) REF: 7.8.6 TABLE 5 FOR MINIMUM RECOMMENDED PROTECTION REQUIREMENTS

ALARM DEVICES: ○ TRANSMITTER ○ SWITCH
SHUTDOWN DEVICES ○ TRANSMITTER ○ SWITCH
ARRANGEMENT (7.8.2.2) ○ 1 ○ 2 ○ 3 ○ OTHER: _____

FUNCTION	ALARM	SHUT DOWN	ANNUNCIATION POINTS: ALARM IN PANEL BY MFR	ALARM IN CONTROL ROOM PANEL BY OTHERS	SHUTDOWN IN PANEL BY MFR	SHUTDOWN IN CONTROL ROOM PANEL BY OTHERS	TOTAL NUMBER OF POINTS
LOW LUBE OIL PRESSURE AT BEARING HEADER	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
HIGH LUBE OIL ΔP ACROSS FILTER	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
LOW FRAME LUBE OIL LEVEL	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
AUXILIARY LUBE OIL PUMP, FAIL TO START	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
CYLINDER LUBE SYSTEM PROTECTION	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
COMPRESSOR VIBRATION, SHUTDOWN ONLY	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
VIBRATION, WITH CONTINUOUS MONITORING	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
ROD DROP DETECTOR, CONTACT TYPE(1/CYLINDER)	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
ROD DROP PROXIMITY PROBE (1/CYLINDER)	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
OIL TEMPERATURE OUT OF FRAME	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
HIGH GAS DISCHARGE TEMP EACH CYLINDER (6.5.2)	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
HIGH JACKET WATER TEMPERATURE, EACH CYLINDER	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
LOW SUCTION PRESSURE, FIRST STAGE INLET	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
HI DISCHARGE PRESSURE ○ FINAL ○ EACH STAGE	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
HIGH CYLINDER GAS ΔP, EACH STAGE	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
HIGH LIQUID LEVEL, EACH MOISTURE SEPARATOR	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
LOW PURGE GAS PRESSURE DISTANCE PIECE(S)	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
HIGH CROSSHEAD PIN TEMP	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
PRESSURE PACKING CASE (PISTON ROD TEMP)	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
_____	(☐ ○ ▣)	(☐ ○ ▣)	○	○	○	○	
				TOTAL NUMBER OF ANNUNCIATION POINTS			

SWITCH CONTACT OPERATION **(NOTE 2)**

ALARM CONTACTS SHALL:
○ OPEN (DE-ENERGIZED) TO SOUND ALARM & BE ENERGIZED WHEN COMPRESSOR IS IN OPERATION
○ CLOSE (ENERGIZE) TO SOUND ALARM & BE DE-ENERGIZED WHEN COMPRESSOR IS IN OPERATION

SHUTDOWN CONTACTS SHALL:
○ OPEN (DE-ENERGIZED) TO SHUTDOWN & BE ENERGIZED WHEN COMPRESSOR IS IN OPERATION
○ CLOSE (ENERGIZE) TO SHUTDOWN & BE DE-ENERGIZED WHEN COMPRESSOR IS IN OPERATION

REMARKS / SPECIAL REQUIREMENTS: NOTE 1: ALARM & SHUTDOWN DEVICES SHALL BE INDIVIDUALLY SEPARATE

NOTE 2: EACH SWITCH SHALL BE MINIMUM SPDT ARRANGEMENT.

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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ▣ PURCHASER OR MANUFACTURER AS APPLICABLE

INSTRUMENTATION (CONTINUED)

MISCELLANEOUS INSTRUMENTATION

○ SIGHT FLOW INDICATOR (COOLANT ONLY) BY: _____ FOR: ○ INTERCOOLER(S) ○ AFTERCLOOLER ○ OIL COOLER ○ CYLINDER JACKET COOLANT ○ ROD PRESSURE PACKING CASES

○ PNEUMATIC PRESSURE TRANSMITTERS BY: _____ FOR: _____
○ PRESSURE TRANSMITTERS (ELEC. OUTP.) BY: _____ FOR: _____
○ PNEUMATIC LEVEL TRANSMITTERS BY: _____ FOR: _____
○ ALARM HORN & ACKNOWLEDGMENT TEST BUTTON BY: _____ FOR: _____
○ CONDUIT & WIRING W/JUNCTION BOXES (CONSOLES) BY: _____ FOR: _____
○ TEST VALVES BY: _____ FOR: _____
○ DRAIN VALVES BY: _____ FOR: _____
○ GAUGE GLASS(ES) BY: _____ FOR: _____
○ TACHOMETER BY: _____ SPEED RANGE _____ TO _____ (rpm)
○ CRANKSHAFT KEY PHASER AND TRANSDUCER BY: _____ FOR: _____
○ _____ BY: _____ FOR: _____

○ SEPARATE LUBE OIL CONSOLE INSTRUMENTATION: PURCHASER, TO LIST REQUIRMNETS IN ADDITION TO ANY ABOVE REQUIREMENTS
○ _____ BY: _____ FOR: _____
○ _____ BY: _____ FOR: _____
○ _____ BY: _____ FOR: _____
○ _____ BY: _____ FOR: _____
○ _____ BY: _____ FOR: _____
○ _____ BY: _____ FOR: _____

○ SEPARATE COOLING WATER CONSOLE INSTRUMENT: PURCHASER, TO LIST REQUIREMENTS IN ADDITION TO ANY ABOVE REQUIREMENTS
○ _____ BY: _____ FOR: _____
○ _____ BY: _____ FOR: _____
○ _____ BY: _____ FOR: _____
○ _____ BY: _____ FOR: _____
○ _____ BY: _____ FOR: _____
○ _____ BY: _____ FOR: _____

▣ RELIEF VALVES

LOCATION	BY	MANUFACTURER	TYPE	◇ SIZE	◇ SETTING

REMARKS / SPECIAL REQUIREMENTS: SEE MOTOR DATA SHEET FOR ADDITIONAL MOTOR INSTRUMENTATION REQUIREMENTS
FOR TURBINE DRIVERS USE APPLICABLE API DATA SHEETS, FOR GEAR REDUCERS USE APPLICABLE API DATA SHEETS
ELECTRICAL & INSTRUMENTATION CONNECTIONS SHALL BE MADE DIRECTLY BY THE PURCHASER TO INDIVIDUAL INSTRUMENTS ON THE COMPRESSOR

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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ☒ PURCHASER OR MANUFACTURER AS APPLICABLE

PULSATION SUPPRESSION DEVICES FOR RECIPROCATING COMPRESSORS

THESE SHEETS TO BE FILLED OUT FOR EACH SERVICE AND / OR STAGE OF COMPRESSION

GENERAL INFORMATION APPLICABLE TO ALL SUPPRESSORS

○ PULSATION SUPPRESSORS WITH INTERNALS ○ PURCHASER ○ SUPPLIER
○ INITIAL INLET ONLY ○ INITIAL INLET & FINAL DISCHARGE ○ INTERSTAGE ○ ALL INLET SUPPRESSORS
○ SUPPORTS ○ PURCHASER ○ SUPPLIER
○ ACOUSTICAL SIMULATION STUDY ○ SUPPLIER ○ 3RD PARTY
○ STUDY TO CONSIDER: **(NOTE 3)** ○ PARALLEL OPERATION (7.11.3.2)
○ OPERATION WITH EXISTING COMPRESSORS AND ASSOCIATED PIPING (7.11.3.3)
○ DESIGN APPROACH CHECK ONLY ONE (7.11.4 TABLE 6) ○ ACOUSTIC SIMULATION AND PIPING RESTRAINT ANALYSIS
○ ACOUSTIC SIMULATION AND PIPING RESTRAINT ANALYSIS PLUS MECHANICAL ANALYSIS
○ PIPING SYSTEM FLEXIBILITY ANALYSIS (7.11.7.6.2)
○ ANALYSIS OF STRESSES IN SUPPRESSION DEVICE INTERNALS (7.12.1.23)(7.11.6.1.2)
○ PULSATION SUPPRESSION DEVICE LOW CYCLE FATIGUE ANALYSIS (7.12.1.24
○ SUPPRESSOR MANUFACTURER _____
☐ SUPPRESSOR MODEL _____ ☐ SUPPRESSOR TYPE _____
☐ TOTAL NUMBER OF SERVICES _____ ☐ TOTAL NUMBER OF STAGES _____
☐ TOTAL NUMBER OF COMPRESSOR CYLINDERS _____ TOTAL NUMBER OF CRANK THROWS _____ STROKE _____ (mm) RPM _____
○ ASME CODE STAMP ○ NATIONAL BOARD REGISTRATION
○ GOVERNMENTAL CODE REGULATIONS _____
○ OTHER APPLICABLE PRESSURE VESSEL SPECIFICATIONS OR CODE _____
○ LUBE SERVICE ○ NON-LUBE SERVICE ○ NO OIL ALLOWED INTERNALLY DRY TYPE INTERCOOLER CORROSION COATING ○ YES ○ NO
○ RADIOGRAPHY OF WELDS ○ NONE ○ SPOT ○ 100% ○ IMPACT TEST ○ SPECIAL WELDING REQUIREMENTS
○ SHOP INSPECTION
○ HYDROTEST WITNESS
○ OUTDOOR STORAGE MORE THAN 6 MONTHS _____ MONTHS
○ SPECIAL PAINT SPECIFICATION _____

CYLINDER, GAS, OPERATING, AND SUPPRESSOR DESIGN DATA

○ SERVICE: _____ STAGE NUMBER: _____
☐ COMPRESSOR MANUFACTURER'S RATED CAPACITY _____ (kg/h) _____ (m³/h) _____ N(m³/h)/N(m³/h)

		INLET SUPPRESSOR	DISCHARGE SUPPRESSOR
○	SUPPRESSOR TAG NUMBER		
☒	LINE SIDE OPERATING PRESSURE (kPaA)		
☒	OPERATING TEMPERATURE WITHIN SUPPRESSORS (°C)		
○	ALLOWABLE PRESSURE DROP THROUGH SUPPRESSORS	Δ P _____ (kPa / _____ %	Δ P _____ (kPa / _____ %
○	COMBINATION INLET SUPPRESSOR SEPARATOR	○ YES ○ NO	○ YES ○ NO
○	COMBINATION INLET SUPPRESSOR INTERNALS	○ YES ○ NO	○ YES ○ NO
☒	QUANTITY OF SUPPRESSORS PER STAGE		
○	ALLOWABLE PEAK-PEAK PULSE @ LINE SIDE NOZZLE	_____ (kPa / _____ %	_____ (kPa / _____ %
○	ALLOWABLE PEAK-PEAK PULSE @ CYLINDERS FLANGE NOZZLE	_____ (kPa / _____ %	_____ (kPa / _____ %
○	DESIGN FOR FULL VACUUM CAPABILITY	○ YES ○ NO	○ YES ○ NO
○	MINIMUM REQUIRED WORKING PRESSURE & TEMPERATURE **(NOTE 1)**	_____ (kPaG) @ _____ (°C)	_____ (kPaG) @ _____ (°C)
○	INITIAL SIZING VOLUME (This is a Reference)(7.11.1.3) (m³)		
◇	AS BUILT VOLUME (m³)		
○	BASIC MATERIAL REQUIRED: (CS, SS, ETC.)		
◇	ACTUAL SHELL MATERIAL DESIGNATION		
◇	ACTUAL HEAD MATERIAL DESIGNATION		
○	SHELL & HEADS SPECIAL HARDNESS LIMITATIONS, Rc	○ YES ○ NO	○ YES ○ NO
○	WELDS SPECIAL HARDNESS LIMITATIONS, Rc	○ YES ○ NO	○ YES ○ NO
☒	CORROSION ALLOWANCE, ○ REQUIRED (7.12.1.4) (mm		
◇	SHELL WALL THICKNESS (mm		
◇	HEAD WALL THICKNESS (mm		
☐	NOMINAL SHELL DIAMETER X OVERALL LENGTH	_____ (mm) X _____ (m)	_____ (mm) X _____ (m)
☐	PIPE OR ROLLED PLATE CONSTRUCTION	☐ PIPE ☐ ROLLED PLATE	☐ PIPE ☐ ROLLED PLATE
◇	ACTUAL MAXIMUM ALLOWABLE WORKING PRESS. AND TEMPERATURE	_____ (kPaG) @ _____ (°C)	_____ (kPaG) @ _____ (°C)
○	MINIMUM DESIGN METAL TEMPERATURE (6.14.8.1) (°C)		
○	INLET SUPPRESSOR TO BE SAME MAWP AS DISCHARGE SUPPRESSOR	○ YES ○ NO	○ YES ○ NO
◇	MAX EXPECTED PRESSURE DROP (ΔP, PSI / %) LINE PRESSURE	Δ P _____ (kPa / _____ %	Δ P _____ (kPa / _____ %
◇	WEIGHT (EACH) (kg)		
○	INSULATED NUTS & ALLOWANCE FOR INSULATION REQUIRED (X)		
◇	EXPECTED P-P PULSE @ LINE SIDE % LINE PRESS **(NOTE 2)** %		
◇	EXPECTED P-P PULSE @ CYLINDER FLANGE % LINE PRESS (NOTE 2) %		
☒	SUPPORTS, TYPE		
☒	SUPPORTS, QUANTITY		
☒	SUPPORTS FURNISHED BY:		

REMARKS / SPECIAL REQUIREMENTS: NOTE 1: AFTER DESIGN, THE ACTUAL MAWP & TEMPERATURE ARE TO BE DETERMINED BASED ON THE WEAKEST COMPONENT AND STAMPED ON THE VESSEL. THE ACTUAL MAWP IS TO BE SHOWN ON LLINE 57 AND ON THE U1A FORMS.
NOTE 2: BASED ON FINAL SUPPRESSOR DESIGN. NOTE 3: SEE APPENDIX N FOR INFORMATION REQUIRED FOR STUDY

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RECIPROCATING COMPRESSOR
DATA SHEET (API 618-6TH)
SI UNITS (kPa)

JOB NO. _____ ITEM NO. _____
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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ▣ PURCHASER OR MANUFACTURER AS APPLICABLE

PULSATION SUPPRESSION DEVICES FOR RECIPROCATING COMPRESSORS

THESE SHEETS TO BE FILLED OUT FOR EACH SERVICE AND/OR STAGE OF COMPRESSION

○ SERVICE: _____ STAGE NUMBER: _____

CONNECTION REQUIREMENTS & DATA

	INLET SUPPRESSOR	DISCHARGE SUPPRESSOR
○ LINE SIDE FLANGE, SIZE		
○ LINE SIDE FLANGE, RATING		
○ LINE SIDE FLANGE, FACING		
○ LINE SIDE FLANGE, TYPE		
○ COMPRESSOR CYLINDER FLANGE(S), QUANTITY		
○ COMPRESSOR CYLINDER FLANGE(S), SIZE		
○ COMPRESSOR CYLINDER FLANGE(S), RATING		
○ COMPRESSOR CYLINDER FLANGE(S), FACING		
○ COMPRESSOR CYLINDER FLANGE(S), TYPE		
○ FLANGE FINISH, ○ PER ASME B16.5 ○ PER 6.8.2.1.16 >125 <250		
○ SPECIAL (SPECIFY)		
○ INSPECTION OPENINGS REQUIRED (7.12.1.15)	○ YES ○ NO ○ BLINDED	○ YES ○ NO ○ BLINDED
○ SPECIFIED QUANTITY SIZE		
○ SPECIFIED QUANTITY TYPE		
○ SPECIFIED QUANTITY RATING		
◇ AS BUILT QUANTITY		
◇ AS BUILT TYPE		
◇ AS BUILT RATING		
○ VENT CONNECTIONS REQUIRED	○ YES ○ NO	○ YES ○ NO
○ SPECIFIED QUANTITY SIZE		
○ SPECIFIED QUANTITY TYPE		
○ SPECIFIED QUANTITY RATING		
◇ AS BUILT QUANTITY		
◇ AS BUILT TYPE		
◇ AS BUILT RATING		
○ DRAIN CONNECTIONS REQUIRED (7.12.1.11)	○ YES ○ NO	○ YES ○ NO
○ SPECIFIED QUANTITY SIZE		
○ SPECIFIED QUANTITY TYPE		
○ SPECIFIED QUANTITY RATING		
◇ AS BUILT QUANTITY		
◇ AS BUILT TYPE		
◇ AS BUILT RATING		
○ PRESSURE CONNECTIONS REQUIRED (7.12.1.11)	○ YES ○ NO	○ YES ○ NO
○ SPECIFIED QUANTITY SIZE		
○ SPECIFIED QUANTITY TYPE		
○ SPECIFIED QUANTITY RATING		
◇ AS BUILT QUANTITY		
◇ AS BUILT TYPE		
◇ AS BUILT RATING		
○ TEMPERATURE CONNECTIONS REQUIRED (7.12.1.12)	○ YES ○ NO	○ YES ○ NO
○ MAIN BODY	○ YES ○ NO	○ YES ○ NO
○ CYLINDER NOZZLE	○ YES ○ NO	○ YES ○ NO
○ SPECIFIED QUANTITY SIZE		
○ SPECIFIED QUANTITY TYPE		
○ SPECIFIED QUANTITY RATING		
◇ AS BUILT QUANTITY		
◇ AS BUILT TYPE		
◇ AS BUILT RATING		

OUTLINE OR DRAWING NUMBERS

◇ COMPRESSOR MANUFACTURER'S SUPPRESSOR OUTLINE OR DRAWING NUMBER _____
◇ SUPPRESSOR MANUFACTURER'S OUTLINE OR DRAWING NUMBER _____

REMARKS / SPECIAL REQUIREMENTS: _____

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RECIPROCATING COMPRESSOR
DATA SHEET (API 618-6TH)
U.S. CUSTOMARY UNITS

JOB NO. ITEM NO.
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APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ○ AS BUILT
VENDOR DATA, DRAWINGS AND NAMEPLATES, HARDWARE (INCLUDING FASTENERS), AND EQUIPMENT. SHALL BE IN:
LANGUAGE: ● ENGLISH ○ OTHER
UNITS OF MEASURE: ○ U.S. CUSTOMARY ○ SI ○ METRIC ○ OTHER
FOR USER NUMBER REQUIRED
SITE / LOCATION COMPRESSOR MANUFACTURER
SERVICE TYPE MODEL NUMBER/S
UNIT SERIAL NUMBER/S

NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ◯ PURCHASER OR MANUFACTURER AS APPLICABLE

☐ COMPRESSOR THROWS: TOTAL NUMBER NUMBER WITH CYLINDERS
☐ NOMINAL FRAME RATING (BHP) @ RATED RPM OF (rpm)
◯ MAXIMUM ALLOWABLE SPEED (rpm) ☐ MINIMUM ALLOWABLE SPEED (rpm)
☐ DRIVER MANUFACTURER
☐ DRIVER NAMEPLATE POWER: (HP) / OPERATING SPEED: (rpm)
○ DRIVE SYSTEM (7.1.2.2): ○ DIRECT COUPLED ○ GEAR & COUPLED ○ BELT
○ TYPE OF DRIVER (6.1.12): ○ STEAM TURBINE ○ GAS TURBINE ○ ENGINE
○ INDUCTION MOTOR ○ SYNCHRONOUS MOTOR ○ OTHER
○ SINGLE BEARING
○ TEMPORARY SUPPORT (7.1.2.4)
○ CYLINDERS CONSTRUCTION: ○ LUBE ○ NON-LUBE ○ NOT DRILLED OR LUBED (6.8.2.1.19)
○ MAXIMUM ACCEPTABLE AVERAGE PISTON SPEED (ft/min)
○ UNINTERRUPTED CONTINUOUS OPERATION (6.1.1): (hr)
○ STARTING CONDITION (7.1.1.6): ○ UNLOADED ○ LOADED ○ OTHER

OPERATING CONDITIONS

○ SERVICE						
○ STAGE						
○ NORMAL OR ALTERNATE CONDITION (6.1.4						
○ CERTIFIED POINT MARK ONE WITH X						
◯ MOLECULAR WEIGHT						
INLET CONDITIONS: AT INLET TO: ○ PULSE DEVICES ○ COMPRESSOR CYLINDER FLANGES						
○ PRESSURE (psia) @ PULS. SUPPRESSOR INLET						
◯ PRESSURE (psia) @ CYLINDER FLANGE						
○ TEMPERATURE (°F)						
○ REFERENCE SIDE STREAM TEMPERATURES (°F)						
○ DEW POINT (6.1.24) (°F)						
☐ COMPRESSIBILITY (Z_S)						
◯ Cp/Cv (K)(@ 150 °F) OR (°F) (NOTE 2)						

NOTE: ○ SIDE STREAM TO STAGE(S), THESE INLET PRESSURES ARE FIXED

INTERSTAGE:
○ INTERSTAGE ΔP INCLUDES: ○ PULSE DEVICES ○ PIPING ○ COOLERS ○ SEPARATORS ○ OTHER

◯ ΔP BETWEEN STAGES, % / (psi)					

DISCHARGE CONDITIONS: AT OUTLET FROM: ○ PULSE DEVICE ○ COMPRESSOR CYLINDER FLANGES ○ OTHER

○ PRESSURE (psia) @ CYLINDER FLANGE						
○ PRESSURE (psia) @ PULS. SUPPRESSOR OUTLET						
☐ TEMPERATURE, ADIABATIC, (°F)						
☐ TEMPERATURE, PREDICTED,(6.5.1) (°F)						
☐ COMPRESSIBILITY (Z_2) OR (Z_{AVG})						
◯ Cp/Cv (K)(@ 150 °F) OR (°F) (NOTE 2)						
CAPACITY AT INLET TO COMPRESSOR, NO NEGATIVE TOLERANCE (-0%) **NOTE 1**						
○ (lb/hr) CAPACITY SPECIFIED IS ○ WET ○ DRY						
○ MMSCFD/SCFM (14.7 psia & 60°F DRY)						
MANUFACTURER'S RATED CAPACITY(AT INLET TO COMPRESSOR) & (BHP) @ CERTIFIED TOLERANCE OF ±3% FOR CAPACITY & ±3% FOR (BHP) **NOTE 1**						
☐ (lb/hr) CAPACITY SPECIFIED IS ○ WET ○ DRY						
☐ INLET VOLUME FLOW (icfm)						
☐ MMSCFD/SCFM (14.7 psia & 60°F DRY)						
☐ (BHP) /STAGE						
☐ TOTAL (BHP) @ COMPRESSOR SHAFT						
☐ TOTAL (HP) INCLUDING V-BELT & GEAR LOSSES						

REMARKS: **NOTE 1:** CAPACITY FOR NNT: MANUFACTURER'S = REQUIRED ÷ 0.97, THEREFORE REQUIRED = MANUFACTURER'S x 0.97
NOTE 2: IF GAS ANALYSIS IS GIVEN, MANUFACTURER SHALL SUPPLY DATA, OTHERWISE DATA SHALL BE SUPPLIED BY USER

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RECIPROCATING COMPRESSOR
DATA SHEET (API 618-6TH)
U.S. CUSTOMARY UNITS

JOB NO. ITEM NO.
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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ◯ PURCHASER OR MANUFACTURER AS APPLICABLE

GAS ANALYSIS AT OPERATING CONDITIONS
MOLE % (BY VOLUME) ONLY

			(MW)					
○	SERVICE / ITEM NUMBER							
○	STAGE							
○	NORMAL OR ALTERNATE							
	AIR		28.966					
	OXYGEN	O_2	32.000					
	NITROGEN	N_2	28.016					
	WATER VAPOR	H_2O	18.016					
	CARBON MONOXIDE	CO	28.010					
	CARBON DIOXIDE	CO_2	44.010					
	HYDROGEN SULFIDE	H_2S	34.076					
	HYDROGEN	H_2	2.016					
	METHANE	CH_4	16.042					
	ETHYLENE	C_2H_4	28.052					
	ETHANE	C_2H_6	30.068					
	PROPYLENE	C_3H_6	42.078					
	PROPANE	C_3H_8	44.094					
	I-BUTANE	C_4H_{10}	58.120					
	n-BUTANE	C_4H_{10}	58.120					
	I-PENTANE	C_5H_{12}	72.146					
	n-PENTANE	C_5H_{12}	72.146					
	HEXANE PLUS							
	AMMONIA	NH_3	17.031					
	HYDROGEN CHLORIDE	HCl	36.461					
	CHLORINE	Cl_2	70.914					
	CHLORIDES - TRACES							
	CALCULATED MOL WEIGHT							

APPLICABLE SPECIFICATIONS

- ● API-618-RECIPROCATING COMPRESSORS FOR PETROLEUM, CHEMICAL AND GAS INDUSTRY SERVICES
- ○ NACE MR-0103 (6.10.4.3)
- ○ VENDOR HAVING UNIT RESPONSIBILITY:
- ○ GOVERNING SPECIFICATION (IF DIFFERENT):
- ○
- ○
- ○
- ○
- ○
- ○

NOISE SPECIFICATIONS:

- ○ MAXIMUM ALLOWABLE SOUND PRESSURE LEVEL (dBA)
- ○ APPLICABLE TO MACHINE:
  SEE SPECIFICATION
- ○ APPLICABLE TO NEIGHBORHOOD:
  SEE SPECIFICATION

NOTES

IF CORROSIVE AGENTS, REACTIVE AGENTS,
WATER VAPOR AND / OR CHLORIDES ARE PRESENT,
EVEN MINUTE TRACES, IN THE GAS BEING COMPRESSED,
IT MUST BE INCLUDED TO THE LEFT.

REMARKS / SPECIAL REQUIREMENTS:

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RECIPROCATING COMPRESSOR
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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ◯ PURCHASER OR MANUFACTURER AS APPLICABLE

PART LOAD OPERATING CONDITIONS

CAPACITY CONTROL **(NOTE 1, NOTE 2)**

BY: ○ MANUFACTURER'S CAPACITY CONTROL ○ PURCHASERS BY-PASS ○ BOTH
○ OTHER _____

○ SEE DATA SHEET PAGE 2 FOR DETAILS ○ IN INSTRUMENT & CONTROL PANEL ○ SEPARATE MACHINE MOUNTED PANEL
○ SEPARATE FREE STANDING PANEL
○ PNEUMATIC ○ ELECTRIC ○ ELECTRONIC ○ HYDRAULIC
○ PROGRAMMABLE CONTROLLER

○ INSTRUMENT & CONTROL PANEL ○ ONE FOR EACH UNIT ○ ONE COMMON TO ALL UNITS ○ MACHINE MOUNTED ○ FREE STANDING (OFF UNIT)
○ BUFFER GAS CONTROL PANEL ○ ONE FOR EACH UNIT ○ ONE COMMON TO ALL UNITS ○ MACHINE MOUNTED ○ FREE STANDING (OFF UNIT)

FOR: ○ PART LOAD CONDITION ○ START-UP ONLY ○ BOTH
WITH: ○ AUTOMATIC LOADING-DELAY INTERLOCK ○ AUTOMATIC IMMEDIATE UNLOADING (7.8.2.5)
USING: ○ VOLUME POCKET: ○ FIXED ○ VARIABLE
○ SUCTION VALVE UNLOADERS(6.9.2.1): ○ FINGER ○ PLUG ○ OTHER _____
○ ACTION: ○ DIRECT (AIR-TO-UNLOAD) ○ REVERSE (AIR-TO-LOAD/FAIL SAFE)
○ NUMBER OF STEPS: ○ ONE ○ THREE ○ FIVE ○ OTHER _____
○ RAIN COVER REQUIRED OVER UNLOADERS

ALL UNLOADING STEPS BASIS MANUFACTURERS CAPACITY SHOWN ON PAGE 1.

INLET AND DISCHARGE PRESSURE ARE ○ AT CYLINDER FLANGES ○ PULSATION SUPPRESSOR FLANGES

○ SERVICE OR ITEM NUMBER						
◯ STAGE						
◯ NORMAL OR ALTERNATE CONDITION						
○ PERCENT CAPACITY						
○ WEIGHT FLOW, ###						
◯ ###						
☐ POCKETS / VALVES OPERATION *						
☐ POCKET CLEARANCE ADDED %						
☐ TYPE UNLOADERS, PLUG / FINGER						
◯ INLET TEMPERATURE ###						
◯ INLET PRESSURE ###						
◯ DISCHARGE PRESSURE ###						
☐ DISCHARGE TEMPERATURE, ADIABATIC ###						
☐ DISCHARGE TEMPERATURE, PREDICTED ###						
☐ VOLUMETRIC EFFICIENCY, % HE						
☐ VOLUMETRIC EFFICIENCY, % CE						
☐ CALCULATED GAS LOAD ### , C **						
☐ CALCULATED GAS LOAD ### , T **						
◇ CROSSHEAD PIN LOAD ### C (GAS & INERTIA)						
◇ CROSSHEAD PIN LOAD ### T (GAS & INERTIA)						
◇ LOAD REVERSAL, DEGREES MIN @ X-HD PIN ***						
☐ ###						
☐ TOTAL ### @ COMPRESSOR SHAFT						
☐ TOTAL ### INCLUDING V-BELT & GEAR LOSSES						

* SHOW OPERATION WITH THE FOLLOWING SYMBOLS:

HE = HEAD END OR CE = CRANK END } - { S = SUCTION VALVE(S) UNLOADED OR F = FIXED POCKET OPEN
{ OR V = VARIABLE POCKET OPEN

EXAMPLE: HE-F/CE-S = HEAD END FIXED POCKET OPEN / CRANK END SUCTION VALVE(S) UNLOADED.

** C = COMPRESSION
** T = TENSION
*** X-HD = CROSSHEAD

☐ MINIMUM PRESSURE REQUIRED TO OPERATE CYLINDER UNLOADING DEVICES, _____ ###
○ CYLINDER UNLOADING MEDIUM: ○ AIR ○ NITROGEN ○ OTHER _____
○ PRESSURE AVAILABLE FOR CYLINDER UNLOADING DEVICES: MAXIMUM: _____ ### / MINIMUM: _____ ###

REMARKS, SPECIAL REQUIREMENTS, AND / OR SKETCH NOTE 1: SEE INSTRUMENTATIONSCOPE DATA SHEETS FOR DETAILS OF PANEL,
ADDITIONAL REMARKS, AND INSTRUMENTATION DETAILS.
NOTE 2: ALL TUBING, WIRING, & CONNECTIONS BETWEEN OFF-UNIT FREE STANDING PANELS AND COMPRESSOR UNIT BY PURCHASER.

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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ☒ PURCHASER OR MANUFACTURER AS APPLICABLE

☒	**CYLINDER DATA AT FULL LOAD CONDITION**						
	SERVICE/ITEM NUMBER						
	STAGE						
	INLET PRESSURE, AT CYLINDER FLANGES (psia)						
	DISCHARGE PRESSURE, AT CYLINDER FLANGES (psia)						
	CYLINDERS PER STAGE						
	SINGLE OR DOUBLE ACTING (SA OR DA)						
	BORE, (in)						
	STROKE, (in)						
	RATED RPM: (rpm)						
	MAXIMUM ALLOWABLE RPM (rpm)						
	RATED PISTON SPEED: (fps)						
	MAXIMUM ALLOWABLE PISTON SPEED (fps)						
	CYLINDER LINER, YES/NO (6.8.1.5)						
	LINER NOMINAL THICKNESS, (6.8.1.5) (in)						
	PISTON DISPLACEMENT (cfm)						
	CYLINDER DESIGN CLEARANCE, % AVERAGE						
	VOLUMETRIC EFFICIENCY, % AVERAGE						
	QUANTITY OF INLET VALVES PER CYLINDER						
	QUANTITY OF DISCHARGE VALVES PER CYLINDER						
	TYPE OF VALVES						
	VALVE LIFT, INLET (in)						
	VALVE LIFT, DISCHARGE, (in)						
	VALVE VELOCITY, SUCTION VALVE(S) (ft/min)						
	VALVE VELOCITY, DISCHARGE VALVE(S) (ft/min)						
	ROD DIAMETER, (in)						
	MAXIMUM ALLOWABLE CROSSHEAD PIN LOADING,						
	COMPRESSION (lb)						
	TENSION (lb)						
	CALCULATED GAS LOAD,						
	COMPRESSION (lb)						
	TENSION (lb)						
	CROSSHEAD PIN LOAD (GAS + INERTIA),						
	COMPRESSION (lb)						
	TENSION (lb)						
	LOAD REVERSAL, DEGREES MIN. AT CROSSHEAD						
	RECIP WT. (PISTON, ROD, CROSSHEAD & NUTS), (lb)						
	MAXIMUM ALLOWABLE WORKING PRESSURE,(6.8.1.1) (psig)						
	MAXIMUM ALLOWABLE WORKING TEMPERATURE (°F)						
	MINIMUM DESIGN METAL TEMPERATURE (°F)						
	HYDROSTATIC TEST PRESSURE, (psig)						
	GAS LEAKAGE TEST PRESSURE, (psig)						
	INLET FLANGE SIZE						
	INLET FLANGE RATING						
	INLET FLANGE FACING						
	DISCHARGE FLANGE SIZE						
	DISCHARGE FLANGE RATING						
	DISCHARGE FLANGE FACING						
	DISCHARGE RELIEF VALVE SETTING DATA AT INLET PRESSURES GIVEN ABOVE:						
	RECOMMENDED SETTING, (psig)						
	GAS LOAD,						
	COMPRESSION (lb)						
	TENSION (lb)						
	CROSSHEAD PIN LOAD,						
	COMPRESSION (lb)						
	TENSION (lb)						
	LOAD REVERSAL, DEGREES MIN. AT CROSSHEAD						
	NOTE 1						
○	SETTLE-OUT GAS PRESSURE						
	(DATA REQUIRED FOR STARTING)						

REMARKS / SPECIAL REQUIREMENTS: **NOTE 1:** CALCULATED AT INLET PRESSURES GIVEN ABOVE & RECOMMENDED SETTING.

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RECIPROCATING COMPRESSOR
DATA SHEET (API 618-6TH)
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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ◯ PURCHASER OR MANUFACTURER AS APPLICABLE

○ FABRICATED CYLINDER, HEADS, & CONNECTION SKETCHES FOR DESIGN REVIEW BY PURCHASER

◯ CONSTRUCTION FEATURES

SERVICE ITEM NUMBER						
STAGE						
CYLINDER SIZE (BORE DIAMETER) (in)						
ROD RUN-OUT: NORMAL COLD VERTICAL (PER APPENDIX)						
DN 12 INDICATOR TAP AT EACH END OF CYLINDER	○	○	○	○	○	○
CYLINDER INDICATOR VALVES REQUIRED	○	○	○	○	○	○
INDICATOR CONNECTIONS ABOVE 5000 psi	○	○	○	○	○	○
RUNNING BORE SHALL BE HONED (6.8.1.7)	○	○	○	○	○	○
FLUOROCARBON SPRAYED CYLINDER	○	○	○	○	○	○
NON COOLED OR AIR COOLED CYLINDER	○	○	○	○	○	○

○ PREFERRED TYPE OF CYLINDER COOLING **(NOTE 1)**

○ FORCED _____ STAGE / CYLINDERS
○ THERMOSYPHON _____ STAGE /CYLINDERS
○ STATIC STAND-PIPE _____ STAGE / CYLINDERS
○ CYLINDER COOLANT PIPING BY ○ PURCHASER ○ SUPPLIER
○ MATCH MARKED
○ SINGLE INLET/OUTLET MANIFOLD & VALVES ○ SIGHT GLASSES
○ INDIVIDUAL INLET/ OUTLET PER CYLINDER ○ VALVES
○ CLOSED SYSTEM WITH PUMP, COOLER, SURGE TANK, & PIPING

◯ MATERIALS OF CONSTRUCTION

CYLINDER(S)						
CYLINDER LINER(S)						
PISTON(S)						
PISTON RINGS						
WEAR BANDS ○ REQUIRED						
PISTON ROD(S): MATERIAL (6.10.4.1)						
PISTON ROD(S): YIELD (psi)						
THREAD ROOT STRESS @						
MAX ALLOWABLE CROSSHEAD PIN LOAD						
PISTON ROD HARDNESS, BASE MATERIAL, Rc						
PISTON ROD COATING ○ REQUIRED						
COATING HARDNESS, Rc						
VALVE SEATS						
SEAT PLATE						
VALVE SEAT MIN HARDNESS, Rc						
VALVE GUARDS (STOPS)						
VALVE DISCS						
VALVE SPRINGS						
ROD PRESSURE PACKING RINGS						
ROD PRESSURE PACKING CASE						
ROD PRESSURE PACKING SPRINGS						
SEAL / BUFFER PACKING, DISTANCE PIECE						
SEAL / BUFFER PACKING, INTERMEDIATE						
WIPER PACKING RINGS						
MAIN JOURNAL BEARINGS, CRANKSHAFT						
CONNECTING ROD BEARING, CRANKPIN						
CONNECTING ROD BUSHING, CROSSHEAD END						
CROSSHEAD PIN BUSHING						
CROSSHEAD PIN						
CROSSHEAD						
CROSSHEAD SHOES						
INSTRUMENTATION IN CONTACT WITH PROCESS GAS						
COLD SIDE						
HOT SIDE						

◯ COUPLING(S)

○ LOW-SPEED ○ HI-SPEED

	Between Compressor & Driver or Gear	Between Driver & Gear
◇ MANUFACTURER		
◇ MODEL		
◇ TYPE		

○ KEY-LESS DRIVE ○ QUILL SHAFT
○ KEYED DRIVE ○ OTHER
API-671 APPLIES ○ YES ○ NO

◯ FLYWHEEL LOCKING DEVICE (7.14.5)
○ PROVIDED BY:

◯ REDUCTION GEARS (7.3)
○ PROVIDED BY:
○ STANDARD (7.3.1)
○ API 613 ○ API 677 ○ OTHER:
○ SEE DATA SHEET:

◯ CRANKCASE RAPID PRESSURE RELIEF DEVICE(S)(6.11.5)
○ PROVIDED BY:

○ **SPECIAL CORROSION PROTECTION:** ○ NO ○ YES
○ MFR'S STANDARD ○ OTHER

REMARKS / SPECIAL REQUIREMENTS: NOTE 1: MANUFACTURER SHALL RECOMMEND TYPE OF COOLING AFTER FINAL ENGINEERING REVIEW OF ALL OPERATING CONDITIONS

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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ◯ PURCHASER OR MANUFACTURER AS APPLICABLE

CONSTRUCTION FEATURES (CONTINUED)

◯ **DISTANCE PIECE(S):(REFERENCE FIGURE F-3)**(6.12.1.1)
○ TYPE: ○ A ○ B ○ C ○ D
○ COVERS (6.12.2.1): ○ SOLID METAL ○ SCREEN ○ LOUVERED
○ HIGHER PARTITION DIFFERENTIAL PRESSURE ○ YES ○ NO
PRESSURE: _____ (psig)
○ CYLINDER COMPARTMENT: ○ VENTED TO _____ (psig)
(Outboard Distance Piece) ○ PURGED AT _____ (psig)
○ PRESSURIZED TO _____ (psig)
○ WITH RELIEF VALVE
○ FRAME COMPARTMENT: ○ VENTED TO _____ (psig)
(Inboard Distance Piece) ○ PURGED AT _____ (psig)
○ PRESSURIZED TO _____ (psig)
○ WITH RELIEF VALVE
○ VENT SYSTEM MAX PRESSURE (6.12.2.4): _____ (psig)
☐ DISTANCE PIECE MAWP _____ (psig)

◯ **COMPRESSOR CYLINDER ROD PACKING**
○ FULL FLOATING PACKING
○ VENTED TO: ○ FLARE @ _____ (psig) ○ ATMOSPHERE
○ SUCTION PRESSURE @ _____ (psig)
○ FORCED LUBRICATED ○ NON-LUBE
◯ WATER COOLED, _____ STAGE(S), _____ (gpm) REQUIRED
◯ OIL COOLED, _____ STAGE(S), _____ (gpm) REQUIRED
○ WATER FILTER ○ PROVISION FOR FUTURE WATER/OIL COOLING
○ VENT / BUFFER GAS SEAL PACKING ARRANGEMENT
REF: ANNEX H, FIGURES H-1, H-2, H-3, H-4
○ OIL WIPER PACKING PURGE
○ INTERMEDIATE PARTITION PURGE (6.12.1.4, 6.12.1.5)
○ INERT BUFFER PURGE GAS: ○ N_2 ○ OTHER
○ VENT, DRAIN, PURGE PIPING BY MANUFACTURER ○ NO ○ YES
○ DISPOSAL SYSTEM ○ CONSTANT ○ VARIABLE
○ BUFFER GAS PRESSURE, _____ (psig)
○ SPLASH GUARDS FOR WIPER PACKING (6.13.1.1)

○ **BASEPLATE (7.7.4)**
○ BASEPLATE FOR: _____
○ ANCHOR BOLTS BY (7.7.3.6) ○ PURCHASER ○ SUPPLIER
○ SOLEPLATE ○ RAILS
○ BOLTS OR STUDS FOR SOLEPLATE TO FRAME BY
○ PURCHASER ○ SUPPLIER
○ LEVELING PLATES
○ DYNAMIC ANALYSIS REQUIRED (7.7.4.15)
○ WRITTEN REPORT REQUIRED (7.7.4.15)
○ SKID FOR: _____
○ DIRECT GROUTED ○ SUB SOLEPLATES
○ CEMENTED/MORTAR GROUT (7.7.3.9)
○ EPOXY GROUT; MANUFACTURE _____
TYPE _____
○ SUITABLE FOR COLUMN MOUNTING (UNDER SKID AND / OR BASEPLATE) (7.7.4.8)

◯ **BEARING TEMPERATURE DETECTORS**
○ SEE ATTACHED API-670 DATASHEET
○ THERMOCOUPLES TYPE _____
○ RESISTANCE TEMP DETECTORS
○ RESISTANCE MATERIAL _____ ○ _____ (ohm)
○ LOCATION-JOURNAL BEARING
○ QUANTITY _____
☐ SCALE RANGE _____ ○ ALARM ☐ SET @ _____
○ SHUTDOWN: ☐ SET @ _____ ○ TIME DELAY _____ (sec)

◯ **PISTON ROD DROP DETECTORS**
○ SEE ATTACHED API-670 DATASHEET
○ TYPE _____ ☐ MODEL _____
○ MFR _____ ○ NO. REQUIRED _____
○ SUPPLIED BY: _____
○ OSCILLATOR-DEMODULATOR SUPPLIED BY: _____
○ MFR _____ ☐ MODEL _____
☐ SCALE RANGE _____ ○ ALARM ☐ SET @ _____
○ SHUTDOWN: ☐ SET @ _____ ○ TIME DELAY _____ (sec)

◯ **BELT DRIVE** DRIVEN SHEAVE (Compressor Shaft) DRIVE SHEAVE (Driver Shaft)
☐ RPM (EXPECTED) _____ _____
☐ PITCH DIAMETER (in) _____ _____
☐ POWER TRANSMITTED _____ _____
INCLUDING BELT LOSSES
◇ CENTER DISTANCE _____ (in)
◇ QUANTITY OF BELTS _____
◇ TYPE OF BELTS _____
◇ CROSSECTION OF BELTS _____
◇ LENGTH OF BELTS _____ (in)
◇ BELT SERVICE FACTOR (RELATIVE TO DRIVER NAMEPLATE HP RATING) _____
○ SHEAVES & BELTS PROVIDED BY: _____
○ BANDED V-BELTS

◯ **BARRING DEVICE**
○ SUPPLIED BY _____
○ MANUAL ○ PNEUMATIC ○ ELECTRIC

◯ **CYLINDER LUBRICATION**
○ NON-LUBE _____ STAGE(S)/SERVICE
○ LUBRICATED _____ STAGE(S)/SERVICE
TYPE OF LUBE OIL: ○ SYNTHETIC _____
○ HYDROCARBON

◯ **CYLINDER AND ROD PACKING LUBRICATOR**
○ SYNTHETIC LUBRICANTS REQUIRED (7.5.3.1.11)
◯ LUBRICATOR DRIVEN BY:
☐ COMPRESSOR CRANKSHAFT, DIRECT
☐ CHAIN, FROM CRANKSHAFT
◯ ELECTRIC MOTOR
◯ OTHER _____
◇ LUBRICATOR MANUFACTURER _____
◇ LUBRICATOR MODEL _____
○ AUTOFILL DEVICE FOR RESERVOIR (7.5.3.1.13)
○ TYPE LUBRICATOR: ○ SINGLE PLUNGER PER POINT
○ DIVIDER BLOCKS _____
◯ COMPARTMENT, TOTAL QUANTITY _____
◯ PLUNGERS (PUMPS), TOTAL QUANTITY _____
◯ SPARE PLUNGERS, QUANTITY _____
◯ SPARE COMPARTMENT WITHOUT PLUNGERS _____
○ HEATERS: ○ ELECTRIC ○ STEAM

◯ **DRIVE GUARD(S)**(7.2.2)
○ SUPPLIED BY _____
○ STANDARD (7.2.2.2)
○ MANUFACTURER'S ○ ISO 14120 ○ ANSI B11.19
○ NON-SPARKING ○ API-671 APPENDIX G
○ MATERIAL _____
○ OTHER _____

◯ **FRAME VIBRATION DETECTORS**
○ SEE ATTACHED API-670 DATASHEET
○ TYPE _____ ☐ MODEL _____
○ MFR _____ ○ NO. REQUIRED _____
○ SUPPLIED BY: _____
☐ SCALE RANGE _____ ○ ALARM ☐ SET @ _____
○ SHUTDOWN: ☐ SET @ _____ ○ TIME DELAY _____ (sec)

◯ **CROSSHEAD VIBRATION DETECTORS:**
○ SEE ATTACHED API-670 DATASHEET
○ TYPE _____ ☐ MODEL _____
○ MFR _____ ○ NO. REQUIRED _____
○ SUPPLIED BY: _____
☐ SCALE RANGE _____ ○ ALARM ☐ SET @ _____
○ SHUTDOWN: ☐ SET @ _____ ○ TIME DELAY _____ (sec)

◯ **PHASE REFERENCE PROBE** ○ SEE ATTACHED API-670 DATASHEET
○ COMPRESSOR ○ GEAR HIGH SPEAD ○ GEAR LOW SPEED
○ DRIVER

◯ **MONITOR** ○ SEE ATTACHED API-670 DATASHEET
○ SUPPLIED BY _____
○ LOCATION _____ ○ ENCLOSURE _____
○ MFR. _____ ☐ MODEL _____

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PAINTING:
- ○ MANUFACTURER'S STANDARD
- ○ OTHER _____

SHIPMENT:
- ○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQUIRED
- ○ STANDARD 6 MONTH STORAGE PREPARATION
  - ○ PROVIDED BY: _____
  - ○ PER SPECIFICATION: _____
- ○ OUTDOOR STORAGE MORE THAN 6 MONTHS: _____ MONTHS
  - ○ PROVIDED BY: _____
  - ○ PER SPECIFICATION: _____

TOOLS
- ○ HYDRAULIC TENSIONING TOOLS
  - ○ NO ○ YES

SPARE PARTS
- ○ START-UP
- ○ NORMAL MAINTENANCE

☐ **ESTIMATED WEIGHTS AND NOMINAL DIMENSIONS**

☐ TOTAL COMPRESSOR WEIGHT, LESS DRIVER & GEAR	_____ (lb)
◇ WEIGHT OF COMPLETE UNIT, (LESS CONSOLES)	_____ (lb)
◇ MAXIMUM ERECTION WEIGHT	_____ (lb)
◇ MAXIMUM MAINTENANCE WEIGHT	_____ (lb)
◇ DRIVER WEIGHT	_____ (lb)
◇ GEAR WEIGHT	_____ (lb)
◇ LUBE OIL CONSOLE	_____ (lb)
◇ COOLING H_2O CONSOLE	_____ (lb)
◇ FREE STANDING PANEL	_____ (lb)

SPACE REQUIREMENTS: (ft)	LENGTH	WIDTH	HEIGHT
◇ COMPLETE UNIT			
◇ LUBE OIL CONSOLE			
◇ CYLINDER COOLANT CONSOLE			
◇ FREE STANDING PANEL			
◇ PISTON ROD REMOVAL DISTANCE			

OTHER EQUIPMENT SHIPPED LOOSE (DEFINE)
- ◇ PULSATION SUPPRESSOR, WEIGHT _____ (lb)
- ◇ PIPING _____ (lb)
- ◇ INTERSTAGE EQUIPMENT _____ (lb)

○ **INSPECTION AND SHOP TESTS** (8.2)

	REQUIRED	WITNESS	OBSERVE
SHOP INSPECTION	○		
CLEANLINESS OF EQUIPMENT, PIPING, & APPURTENANCES	○	○	○
ACTUAL RUNNING CLEARANCES AND RECORDS	○	○	○
MANUFACTURER STANDARD SHOP TESTS	○	○	○
CYLINDER HYDROSTATIC TEST (8.3.2.1)	○	○	○
CYLINDER PNEUMATIC TEST	○	○	○
CYLINDER HELIUM LEAK TEST (8.3.2.3)	○	○	○
CYLINDER JACKET WATER HYDRO TEST (8.3.2.1)	○	○	○
DISTANCE PIECE HYDRO TEST (8.3.2.2)	○	○	○
MECHANICAL RUN TEST (4 HOUR) (8.3.3.1)	○	○	○
COMPLETE SHOP RUN TEST OF ALL MACHINE MOUNTED EQUIPMENT, PIPING & APPURTENANCES (8.3.3.2)	○	○	○
RECORD VIBRATION DURING RUN TEST (8.3.3.6)	○	○	○
BAR-OVER TO CHECK ROD RUNOUT	○	○	○
LUBE OIL CONSOLE RUN/TEST (4 HOUR)	○	○	○
COOLING H_2O CONSOLE RUN/TEST	○	○	○
PERFORMANCE TEST (8.3.4.4)	○	○	○
RADIOGRAPHY BUTT WELDS	○	○	○
○ GAS ○ OIL ○ FAB CYCLES			
MAG PARTICLE / LIQUID PENETRANT OF WELDS	○	○	○
POSITIVE MATERIAL IDENTIFICATION	○	○	○
HARDNESS OF PARTS, WELDS & HEAT AFFECTED ZONES	○	○	○
NOTIFICATION TO PURCHASER OF ANY REPAIRS TO MAJOR WELDS	○		
SHOP FIT-UP OF EQUIPMENT & ALL ASSOCIATED GAS PIPING (8.3.4.2)	○	○	○
SPECIFY ADDITIONAL REQUIREMENTS			
_____	○	○	○
_____	○	○	○
_____	○	○	○

ANNEX J COMPLIANCE: ○ VENDOR ○ PURCHASER

○ **REPORTS AND SERVICES**
- ○ INITIAL INSTALLATION AND OPERATING TEMPERATURE ALIGNMENT CHECK AT JOBSITE BY VENDOR REPRESENTATIVE (6.1.18)
- ○ COMPRESSOR MANUFACTURER'S USER'S LIST FOR SIMILAR SERVICE
- ○ COMPRESSOR VALVE DYNAMIC RESPONSE REPORT
- ○ PERFORMANCE DATA REQUIRED (E.2.4.1):
  - ○ BHP VS. SUCTION PRESSURE CURVES
  - ○ ROD LOAD/GAS LOAD CHARTS
  - ○ VALVE FAILURE DATA CHARTED
  - ○ SPEED/TORQUE CURVE DATA
  - ○ ACCEPTABLE OPERATING RANGES AND LIMITATIONS GRAPH
- ○ BHP VS. CAPACITY PERFORMANCE CURVES OR TABLES REQUIRED FOR UNLOADING STEPS AND/OR VARIABLE SUCTION/DISCHARGE PRESSURES

REMARKS / SPECIAL REQUIREMENTS: _____

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○ **SCOPE OF BASIC SUPPLY**

THE FOLLOWING SHALL BE PROVIDED BY VENDOR. EQUIPMENT SHALL BE PACKAGED TO THE EXTENT SPECIFIED

○ PACKAGED: ○ NO ○ YES **DEFINE BASIC SCOPE OF PACKAGING IN REMARKS SECTION**
○ DRIVER DATA SHEET:
○ GEAR DATA SHEET:
○ COUPLING(S) DATA SHEET:
○ PULSATION SUPPRESSION DEVISES SEE PAGES THROUGH
○ LIQUID KNOCKOUT VESSELS DATA SHEET:
○ SEPARATION AND COLLECTION FACILITIES (7.10.2.1)
○ AUTO DRAIN SYSTEM (7.10.2.8)
○ INTERCOOLER BY SUPPLIER (7.10.1.1) ○ WATER COOLED (7.10.1.3) ○ AIR COOLED (7.10.1.3)
○ OFF MOUNTED ○ MACHINE MOUNTED
○ SHELL AND TUBE ○ TEMA CLASS (7.10.1.5): ○ C ○ R
○ PRESSURE VESSEL CODE : ○ ASME VIII ○ OTHER:
○ PREFABRICATED PIPING 7.10.1.9)
○ DATA SHEET:
○ AFTERCOOLER BY SUPPLIER (7.10.1.2) ○ WATER COOLED (7.10.1.3) ○ AIR COOLED (7.10.1.3)
○ OFF MOUNTED ○ MACHINE MOUNTED
○ SHELL AND TUBE ○ TEMA CLASS (7.10.1.5): ○ C ○ R
○ PRESSURE VESSEL CODE : ○ ASME VIII ○ OTHER:
○ PREFABRICATED PIPING 7.10.1.9)
○ DATA SHEET:
○ STRAINERS
○ INITIAL INLET ○ SPOOL PIECE FOR INLET STRAINERS
○ SIDESTREAM INLET ○ SPOOL PIECE FOR INLET STRAINERS
○ FOR ATMOSPHERIC INLET AIR COMPRESSOR. ONLY: ○ INLET AIR FILTER ○ INLET FILTER -SILENCER
○ PROCESS PIPING
○ PROCESS PIPING SUPPLIED (7.9.6.1):
○ REMOVABLE SPOOL FOR SCREENS (7.9.6.4)
○ FINAL STAGE CHECK VALVE (7.9.6.5)
○ DISTANCE PIECE VENT AND DRAIN PIPE (7.9.7.1)
○ FLANGE FINISH ○ API-618 FLANGE FINISH > 125 < 250 6.8.2.1.16 ○ FLANGE FINISH PER ASME B16.5 ○ SPECIAL FINISH
○ SPECIAL PIPING REQUIREMENTS 7.7.1.13. DEFINE IN REMARKS SECTION
○ AUXILIARY INTERCONNECTING PIPING
○ INTERSTAGE PIPE ○ PARTIAL PRE-FAB, FIELD FIT ○ SHOP FITTED
○ FINAL DISC. PIPE ○ PARTIAL PRE-FAB, FIELD FIT ○ SHOP FITTED
○ MANIFOLD PIPING; ○ DRAINS ○ VENTS ○ RELIEF VALVES ○ AIR/GAS SUPPLY
○ RELIEF VALVES ○ INITIAL INLET ○ INTERSTAGE ○ FINAL DISCHARGE
○ RUPTURE DISCS ○ INITIAL INLET ○ INTERSTAGE ○ FINAL DISCHARGE

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○ SITE / LOCATION CONDITIONS

ELEVATION _____ (ft) BAROMETER _____ (psia) AMBIENT TEMPERATURES: MAXIMUM _____ (°F) MINIMUM _____ (°F)
○ MINIMUM DESIGN METAL TEMPERATURE _____ (°F) RELATIVE HUMIDITY: MAXIMUM _____ % MINIMUM _____ %
COMPRESSOR LOCATION: ○ INDOOR ○ OFF-SHORE ○ NO ROOF ○ HEATED ○ AT GRADE LEVEL ○ ELEVATED: _____ (ft)
○ OUTDOOR ○ ON-SHORE ○ UNDER ROOF ○ UNHEATED ○ PLATFORM ○ PARTIAL SIDES
○ TROPICALIZATION REQUIRED ○ WEATHER PROTECTION REQUIRED
○ WINTERIZATION REQUIRED
○ PREVISION FOR INSULATION
○ PREVISION FOR HEAT TRACE
○ ELECTRICAL ○ STEAM
UNUSUAL CONDITIONS: ○ CORROSIVES ○ DUST ○ FUMES
○ OTHER _____

ELECTRICAL CLASSIFICATION

MAIN UNIT
○ NON-HAZARDOUS ○ HAZARDOUS
○ CLASS _____ GROUP _____ DIVISION _____
○ ZONE _____ GROUP _____ TEMPERATURE CLASS _____

○ UTILITY CONDITIONS

ELECTRICAL POWER

	AC VOLTS	/ PHASE	/ HERTZ	/ DC VOLTS
○ MAIN DRIVER		/	/	/
○ AUXILIARY MOTORS		/	/	/
○ HEATERS		/	/	/
○ INSTRUMENT		/	/	/
○ ALARM & SHUTDOWN		/	/	/
○ _____		/	/	/
○ _____		/	/	/
○ _____		/	/	/

AIR / NITROGEN

INSTRUMENT AIR PRESSURE NORMAL _____ (psig) MAXIMUM _____ (psig) MINIMUM _____ (psig)
NITROGEN PRESSURE NORMAL _____ (psig) MAXIMUM _____ (psig) MINIMUM _____ (psig)

STEAM

DRIVERS

		NORMAL	MAXIMUM	MINIMUM
INLET:	PRESSURE	_____ (psig)	_____ (psig)	_____ (psig)
	TEMPERATURE	_____ (°F)	_____ (°F)	_____ (°F)
EXHAUST:	PRESSURE	_____ (psig)	_____ (psig)	_____ (psig)
	TEMPERATURE	_____ (°F)	_____ (°F)	_____ (°F)

HEATERS

		NORMAL	MAXIMUM	MINIMUM
INLET:	PRESSURE	_____ (psig)	_____ (psig)	_____ (psig)
	TEMPURATURE	_____ (°F)	_____ (°F)	_____ (°F)
EXHAUST:	PRESSURE	_____ (psig)	_____ (psig)	_____ (psig)
	TEMPURATURE	_____ (°F)	_____ (°F)	_____ (°F)

COOLING FLUIDS

COMPRESSOR CYLINDERS

TYPE OF WATER _____

		NORMAL	MAXIMUM	MINIMUM
SUPPLY:	PRESSURE	_____ (psig)	_____ (psig)	_____ (psig)
	TEMPURATURE	_____ (°F)	_____ (°F)	_____ (°F)
RETURN:	PRESSURE	_____ (psig)	_____ (psig)	_____ (psig)
	TEMPURATURE	_____ (°F)	_____ (°F)	_____ (°F)

COOLERS

TYPE OF WATER _____

		NORMAL	MAXIMUM	MINIMUM
SUPPLY:	PRESSURE	_____ (psig)	_____ (psig)	_____ (psig)
	TEMPURATURE	_____ (°F)	_____ (°F)	_____ (°F)
RETURN:	PRESSURE	_____ (psig)	_____ (psig)	_____ (psig)
	TEMPURATURE	_____ (°F)	_____ (°F)	_____ (°F)

ROD PACKING:

TYPE OF FLUID _____

		NORMAL	MAXIMUM	MINIMUM
SUPPLY:	PRESSURE	_____ (psig)	_____ (psig)	_____ (psig)
	TEMPURATURE	_____ (°F)	_____ (°F)	_____ (°F)
RETURN:	PRESSURE	_____ (psig)	_____ (psig)	_____ (psig)
	TEMPURATURE	_____ (°F)	_____ (°F)	_____ (°F)

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☐ **UTILITY CONSUMPTION**

ELECTRIC MOTORS (NOTE 1)

	NAMEPLATE (HP)	LOCKED ROTOR AMPS	FULL LOAD STEADY STATE AMPS
◇ MAIN DRIVER			
◇ MAIN LUBE OIL PUMP			
◇ AUXILIARY LUBE OIL PUMP			
◇ MAIN CYLINDER COOLANT PUMP			
◇ AUXILIARY CYLINDER COOLANT PUMP			
◇ MAIN ROD PACKING COOLANT PUMP			
◇ AUXILIARY ROD PACKING COOLANT PUMP			
◇ CYLINDER LUBRICATOR			

MAIN DRIVER NON-STEADY STATE AMPS AT COMPRESSOR RATED HORSEPOWER (INDUCTION ONLY)
AMPS AT COMPRESSOR RATED (HP) OF @ CURRENT PULSATIONS OF %

ELECTRIC HEATERS

	WATTS	VOLTS	HERTZ
◇ FRAME OIL HEATER(S)			
◇ CYLINDER COOLANT HEATER(S)			
◇ CYLINDER LUBRICATOR HEATER(S)			
◇ MAIN DRIVER SPACE HEATER(S)			

STEAM

	FLOW		INLET PRESSURE		INLET TEMPERATUR		OUTLET PRESSURE	
◇ MAIN DRIVER		(lb/hr) @		(psig)		(°F)TT TO		(psig)
◇ FRAME OIL HEATER(S)		(lb/hr) @		(psig)		(°F)TT TO		(psig)
◇ CYLINDER LUBE HEATER(S)		(lb/hr) @		(psig)		(°F)TT TO		(psig)
		(lb/hr) @		(psig)		(°F)TT TO		(psig)
		(lb/hr) @		(psig)		(°F)TT TO		(psig)

COOLING WATER REQUIREMENTS

	FLOW (gpm)	INLET TEMPERATURE (°F)	OUTLET TEMPERATURE (°F)	INLET PRESSURE (psig)	OUTLET PRESSURE (psig)	MAXIMUM PRESSURE (psig)
☐ CYLINDER JACKETS						
◇ CYLINDER COOLANT CONSOLE						
◇ FRAME LUBE OIL COOLER						
◇ ROD PRESSURE PACKING (NOTE 2)						
◇ PACKING COOLANT CONSOLE						
◇ INTERCOOLER(S)						
◇ AFTERCOOLER						
◇ TOTAL FLOW						

REMARKS / SPECIAL REQUIREMENTS: NOTE 1: FOR INDUCTION MOTORS SEE 7.1.2.6 AND MOTOR DATA SHEET
NOTE 2: ROD PACKING COOLANT MAY BE OTHER THAN WATER

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FRAME LUBE OIL SYSTEM

◎ **BASIC LUBE OIL SYSTEM FOR FRAME:** ◎ SPLASH ◎ PRESSURE (FORCED)
○ HEATERS REQUIRED: ○ ELECTRIC ○ STEAM
☐ TYPE MAIN BEARINGS: ◎ TAPERED ROLLER ◎ PRECISION SLEEVE
◎ **PRESSURE SYSTEM:** ○ DATA SHEET: _____
○ PER SPECIFICATION: ○ API 614 ○ OTHER _____
○ MAIN OIL PUMP DRIVEN BY: ○ COMPRESSOR CRANKSHAFT ○ ELECTRIC MOTOR ○ OTHER _____
☐ PSV FOR MAIN PUMP EXTERNAL TO CRANKCASE ○ CHECK VALVE ON MAIN PUMP
○ AUXILIARY OIL PUMP DRIVEN BY: ○ ELECTRIC MOTOR ○ OTHER _____
☐ HAND OPERATED PRE-LUBE PUMP FOR STARTING
○ CONTINUOUS OIL FLOW THROUGH SWITCH SENSING LINE
○ OPERATIONAL TEST & 4 HOUR MECHANICAL RUN TEST IN SHOP
○ **SEPARATE CONSOLE FOR PRESSURE LUBE SYSTEM:**
○ ONE CONSOLE FOR EACH COMPRESSOR ○ ONE CONSOLE FOR _____ COMPRESSORS ○ EXTENDED TO MOTOR OUTBOARD BEARING
○ CONSOLE TO BE OF DECK PLATE TYPE CONSTRUCTION SUITABLE FOR MULTI-POINT SUPPORT AND GROUTING WITH GROUT & VENT HOLES.
☐ MAXIMUM DISTANCE BETWEEN CONSOLE TO FRAME (7.9.2.1) _____ (ft)
☐ ELEVATION DIFFERENCE FRAME TO CONSOLE 7.9.2.1) _____ (ft)
○ ELECTRICAL CLASSIFICATION : ○ NON-HAZARDOUS ○ HAZARDOUS
○ CLASS _____ GROUP _____ DIVISION _____
○ ZONE _____ GROUP _____ TEMPERATURE CLASS _____

☐ **BASIC SYSTEM REQUIREMENTS (NORMAL OIL FLOWS & VOLUMES)**

		FLOW (gpm)	PRESSURE (psig)	VISCOSITY (SSU)(@ 100 °F)	VISCOSITY (SSU)(@ 212 °F)	SUMP VOLUME (gal)
☐ LUBE OIL	○ SHOP RUN					
☐ COMPRESSOR FRAME						
◇ DRIVER						
◇ GEAR						

☐ SYSTEM PRESSURES: ☐ DESIGN _____ (psig) ☐ HYDROTEST _____ (psig)
☐ PRESSURE CONTROL VALVE SETTING _____ (psig) ☐ PUMP RELIEF VALVE(S) SETTING _____ (psig)

○ **PIPING MATERIALS (7.9.2.2) :**

	CARBON STEEL	STAINLESS STEEL WITH STAINLESS STEEL FLANGES	STAINLESS STEEL WITH CARBON STEEL FLANGES
○ UPSTREAM OF PUMPS & FILTERS	○	●	○
○ DOWNSTREAM OF FILTERS	○	●	○
○ _____	○	○	○
○ _____	○	○	○

☐ **PUMPS** (Gear or Screw Type Only)

	◇ RATED FLOW (gpm)	◇ PRESSURE (psig)	◇ COLD START REQUIRED BHP	◇ DRIVER (HP)	◇ SPEED (rpm)	COUPLING REQUIRED	MECHANICAL SEAL REQUIRED	RELIEF VALVE REQUIRED
☐ MAIN						○	○	○
◎ AUXILIARY						○	○	○

☐ PUMP CASING MATERIAL: MAIN PUMP _____ AUXILIARY PUMP _____
○ GUARD(S) REQUIRED FOR COUPLING(S): ○ MAIN PUMP ○ AUX PUMP ○ GUARD TYPE OR CODE _____
○ AUXILIARY PUMP CONTROL: ○ MANUAL ○ AUTOMATIC
○ ON-OFF-AUTO SELECT SWITCH: ○ BY PURCHASER ○ BY MANUFACTURER
○ WIRING TO TERMINAL BOX: ○ BY PURCHASER ○ BY MANUFACTURER

○ **COOLERS:**
☐ DESIGN PRESSURE, _____ (psig) @ _____ (°F)
◎ MINIMUM DESIGN METAL TEMPERATURE _____ (°F)
○ SHELL & TUBE ○ SINGLE ○ DUAL W/TRANSFER VALVE ○ MANUFACTURERS STANDARD ○ TEMA C ○ TEMA R (API-660) (Data Sheets - Attached)
○ REMOVABLE BUNDLE ○ WATER COOLED ○ AIR COOLED W/AUTO TEMP CONTROL (API-661)
○ WITH BYPASS & TEMPERATURE CONTROL VALVE: ○ MANUAL ○ AUTO
○ SEE SEPARATE HEAT EXCHANGER DATA SHEET FOR DETAILS, SPECIFY % GLYCOL ON COOLING WATER SIDE

◎ **FILTER(S)**
○ SINGLE ○ DUAL W/TRANSFER VALVE ○ ASME CODE DESIGN ○ ASME CODE STAMPED
☐ DESIGN PRESSURE, _____ (psig) @ _____ (°F) ☐ ΔP CLEAN _____ (psi) ☐ ΔP COLLAPSE _____ (psi)
◎ MINIMUM DESIGN METAL TEMPERATURE _____ (°F)
☐ MICRON RATING _____
☐ BONNET MATERIAL _____ ☐ CASING MATERIAL _____
☐ CARTRIDGE MATERIAL _____ ◇ CARTRIDGE PART NUMBER _____
○ SPARE CARTRIDGE REQUIRED: QUANTITY TO BE FURNISHED _____

☐ **SYSTEM COMPONENTS**

	MANUFACTURER	MODEL		MANUFACTURER	MODEL
◇ MAIN PUMP			◇ OIL COOLER(S)		
◇ AUXILIARY PUMP			◇ TRANSFER VALVE(S)		
◇ MECHANICAL SEALS			◇ PUMP COUPLING(S)		
◇ ELECTRIC MOTORS			◇ SUCTION STRAINER(S)		
◇ STEAM TURBINES			◇ CHECK VALVE(S)		
◇ OIL FILTER(S)			◇		

REMARKS / SPECIAL REQUIREMENTS: NOTE 1: INSTRUMENTATION TO BE LISTED ON INSTRUMENTATIONSCOPE DATA SHEETS.

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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ▣ PURCHASER OR MANUFACTURER AS APPLICABLE

COOLING WATER SYSTEM (NOTE 1)

○ **BASIC COOLING SYSTEM FOR:** ○ COMPRESSOR CYLINDER(S) ○ ROD PACKING(S) ○ PROCESS COOLER(S) ○ OIL COOLER(S)
○ SEPARATE COOLING CONSOLE ○ ONE FOR EACH UNIT ○ ONE COMMON TO ALL UNITS ○ ARRANGED FOR HEATING JACKET WATER AS WELL AS COOLING
○ HEATERS REQUIRED FOR PRE-HEATING: ○ ELECTRIC ○ STEAM
○ ELECTRICAL CLASSIFICATION: ○ NON-HAZARDOUS ○ HAZARDOUS
○ CLASS _____ GROUP _____ DIVISION _____
○ ZONE _____ GROUP _____ TEMPERATURE CLASS _____
○ **SEPARATE COOLING SYSTEM FOR ROD PRESSURE PACKING (6.13.2)**
○ **PRESSURE FORCED CIRCULATING SYSTEM:**
○ OPEN PIPING BY: ○ PURCHASER ○ MANUFACTURER
○ CLOSED PIPING BY MANUFACTURER
MAIN COOLANT PUMP DRIVEN BY: ○ ELECTRIC MOTOR ○ STEAM TURBINE ○ OTHER _____
AUXILIARY COOLANT PUMP DRIVEN BY: ○ ELECTRIC MOTOR ○ STEAM TURBINE ○ OTHER _____
○ **SEPARATE CONSOLE FOR COOLANT SYSTEM.:**
○ ONE CONSOLE FOR EACH COMPRESSOR ○ ONE CONSOLE FOR _____ COMPRESSORS
○ CONSOLE TO BE OF DECK PLATE TYPE CONSTRUCTION SUITABLE FOR MULTI-POINT SUPPORT AND GROUTING WITH GROUT & VENT HOLES.

▣ **BASIC SYSTEM REQUIREMENTS (NORMAL COOLANT FLOW DATA)**
○ COOLANT TO BE _____ % ETHYLENE GLYCOL
○ CYLINDER COOLING FLOW: ○ PARALLEL ○ SERIES

	FORCED COOLING	THERMO SYPHON	STAND PIPE	FLOW (gpm)	PRESSURE (psig)	INLET TEMPERATURE (°F)	OUTLET TEMPERATURE (°F)	SIGHT FLOW INDICATOR
CYLINDER(S), _____ STAGE	○	○	○					○
CYLINDER(S), _____ STAGE	○	○	○					○
CYLINDER(S), _____ STAGE	○	○	○					○
CYLINDER(S), _____ STAGE	○	○	○					○
CYLINDER(S), _____ STAGE	○	○	○					○
CYLINDER(S), _____ STAGE	○	○	○					○
PISTON ROD PACKAGE TOTAL	○							○
INTERCOOLER(S) TOTAL	○							○
AFTERCOOLER	○							○
OIL COOLER(S)	○							○
_____	○							○
TOTAL FLOW								

☐ **SYSTEM PRESSURES:** ☐ DESIGN: _____ (psig) ☐ HYDROTEST: _____ (psig) ▣ RELIEF VALVE(S), SETTING _____ (psig)

○ **PIPING MATERIALS:**
○ CARBON STEEL ○ STAINLESS STEEL WITH STAINLESS STEEL FLANGES ○ STAINLESS STEEL WITH CARBON STEEL FLANGES

▣ **COOLANT RESERVOIR:** ○ HORIZONTAL (7.6.5.6) ○ VERTICAL (7.6.5.7)
◇ SIZE: DIAMETER: _____ (in) X HEIGHT: _____ (in) ◇ CAPACITY AT NORMAL OPERATING LEVEL: _____ (gal)
◇ RESERVOIR MATERIAL _____ ◇ INTERNAL COATING, TYPE _____
○ LEVEL SWITCH ○ DRAIN VALVE
○ RESERVOIR HEATER (7.6.5.10): ○ ELECTRIC ○ HOT WATER ○ STEAM
○ INLINE HEATER REQUIRED (7.6.5.12)

☐ **PUMPS:** (CENTRIFUGAL ONLY)

	◇ RATED FLOW (gpm)	◇ PRESSURE (psig)	◇ REQUIRED (BHP)	◇ DRIVER (HP)	◇ SPEED (rpm)	COUPLING REQUIRED	MECHANICAL SEAL REQUIRED
☐ MAIN						○	○
○ AUXILIARY						○	○

☐ PUMP CASING MATERIAL: MAIN PUMP _____ AUXILIARY PUMP _____
○ GUARD(S) REQUIRED FOR COUPLING(S): ○ MAIN PUMP ○ AUX PUMP ○ GUARD TYPE OR CODE _____
○ AUXILIARY PUMP CONTROL: ○ MANUAL ○ AUTOMATIC
○ ON-OFF-AUTO SELECT SWITCH: ○ BY PURCHASER ○ BY MANUFACTURER
○ WIRING TO TERMINAL BOX: ○ BY PURCHASER ○ BY MANUFACTURER

○ **COOLANT HEAT EXCHANGER:**
☐ DESIGN PRESSURE, _____ (psig) @ _____ (°F)
▣ MINIMUM DESIGN METAL TEMPERATURE _____ (°F)
○ SHELL & TUBE ○ SINGLE ○ DUAL W/TRANSFER VALVE ○ MANUFACTURERS STANDARD ○ TEMA C ○ TEMA R (API-660) (Data Sheets - Attached)
○ REMOVABLE BUNDLE ○ WATER COOLED ○ AIR COOLED W/AUTO TEMP CONTROL (API-661)
○ WITH BYPASS & TEMPERATURE CONTROL VALVE: ○ MANUAL ○ AUTO ○ LOUVERS FOR AIR HEAT EXCHANGER
○ SEE SEPARATE HEAT EXCHANGER DATA SHEET FOR DETAILS, SPECIFY % GLYCOL ON COOLING WATER SIDE

SYSTEM COMPONENTS

	MANUFACTURER	MODEL		MANUFACTURER	MODEL
◇ MAIN PUMP			◇ TEMP. CONTROL VALVE(S)		
◇ AUXILIARY PUMP			◇ TRANSFER VALVE(S)		
◇ MECHANICAL SEALS			◇ PUMP COUPLING(S)		
◇ ELECTRIC MOTORS			◇		
◇ STEAM TURBINES			◇		
◇ _____			◇		
◇			◇		

REMARKS / SPECIAL REQUIREMENTS: NOTE 1: INSTRUMENTATION TO BE LISTED ON INSTRUMENTATIONSCOPE DATA SHEETS.

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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ◯ PURCHASER OR MANUFACTURER AS APPLICABLE

INSTRUMENTATION

INSTRUMENT & CONTROL PANEL ○ SUPPLIED BY: _____
○ ONE FOR EACH UNIT ○ ONE COMMON TO ALL UNITS
○ MACHINE MOUNTED ○ FREE STANDING (OFF UNIT) ○ LOCAL ○ REMOTE ○ OUTDOORS
○ PNEUMATIC ○ ELECTRONIC ○ HYDRAULIC ○ PROGRAMMABLE CONTROLLER
○ ELECTRICAL CLASSIFICATION : ○ NON-HAZARDOUS
HAZARDOUS ○ CLASS _____ GROUP _____ DIVISION _____
○ ZONE _____ GROUP _____ TEMPERATURE CLASS _____
○ INTRINSICALLY SAFE ○ YES ○ NO
○ INTRINSICALLY SAFE BARRIERS ○ SUPPLIED BY: _____
○ ENCLOSURE TYPE: _____
○ PURGED: ○ YES ○ NO ○ TYPE: _____
○ LOW PURGE PRESSURE ○ ALARM ○ SHUTDOWN
○ VIBRATION ISOLATORS ○ STRIP HEATERS ○ PURGE CONNECTION ○ EXTRA CUTOUTS
○ ANNUNCIATOR W/FIRST-OUT INDICATION LOCATED ON CONTROL PANEL
○ PURCHASER'S CONNECTION BROUGHT OUT TO TERMINAL BOX BY VENDOR
BUFFER GAS CONTROL PANEL ○ SUPPLIED BY: _____
○ ONE FOR EACH UNIT ○ ONE COMMON TO ALL UNITS
○ MACHINE MOUNTED ○ FREE STANDING (OFF UNIT) ○ WITH STAND ○ OUTDOOR
○ ELECTRICAL CLASSIFICATION : ○ NON-HAZARDOUS ○ HAZARDOUS
○ CLASS _____ GROUP _____ DIVISION _____
○ ZONE _____ GROUP _____ TEMPERATURE CLASS _____
○ CONSTANT PRESSURE DISPOSAL SYSTEM ○ VARIABLE PRESSURE DISPOSAL SYSTEM

○ INSTRUMENTATION SUITABLE FOR: ○ INDOORS ○ OUTDOORS ○ OTHER _____

○ PREFERRED INSTRUMENT SUPPLIERS, (TO BE COMPLETED BY PURCHASER), OTHERWISE MANUFACTURER'S STANDARD APPLIES

	MANUFACTURER	SIZE	TYPE	MATERIAL
PRESSURE GAUGES				
TEMPERATURE GAUGES				
LIQUID LEVEL GAUGES				
DIFFERENTIAL PRESSURE GAUGES				
PRESSURE TRANSMITTERS				
LIQUID LEVEL TRANSMITTER				
PRESSURE SWITCHES				
TEMPERATURE SWITCHES				
LIQUID LEVEL SWITCHES				
DIFFERENTIAL PRESSURE SWITCHES				
CONTROL VALVES				
PRESSURE SAFETY VALVES				
SIGHT FLOW INDICATORS				
VIBRATION MONITORS & EQUIPMENT				
THERMOCOUPLES				
RTD'S				
SOLENOID VALVES				
PROGRAMMABLE CONTROLLER				
_____				

	MANUFACTURER	MODEL	QUANTITY OF SPARE POINTS
ANNUNCIATOR			

○ PRESSURE GAUGE REQUIREMENTS ○ LIQUID FILLED PRESSURE GAUGES: ○ YES ○ NO

FUNCTION	LOCALLY MOUNTED	PANEL MOUNTED	LOCALLY MOUNTED	PANEL MOUNTED
LUBE OIL MAIN PUMP DISCHARGE	○	○	SUPPLIED BY:	
LUBE OIL AUXILIARY PUMP DISCHARGE	○	○	SUPPLIED BY:	
LUBE OIL PRESS. AT FRAME HEADER	○	○	SUPPLIED BY:	
LUBE OIL FILTER Δ P	○	○	SUPPLIED BY:	
COOLING H_2O INLET HEADER	○	○	SUPPLIED BY:	
PROCESS GAS:				
INLET PRESSURE	○	○	SUPPLIED BY:	
@ EACH STAGE	○	○	SUPPLIED BY:	
DISCHARGE. PRESSURE	○	○	SUPPLIED BY:	
@ EACH STAGE	○	○	SUPPLIED BY:	
_____	○	○	SUPPLIED BY:	
_____	○	○	SUPPLIED BY:	

REMARKS / SPECIAL REQUIREMENTS: _____

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PURCHASER TO FILL IN (☐ ○ ◉) AFTER COMMODITY TO INDICATE: ☐ BY COMPRESSOR MANUFACTURER ○ BY PURCHASER ◉ BY OTHERS

INSTRUMENTATION (CONTINUED)

TEMPERATURE MEASUREMENT REQUIREMENTS

FUNCTION	LOCALLY MOUNTED	PANEL MOUNTED	GAUGE WITH CAPILLARY	THERMO-COUPLE SYSTEM	RTD SYSTEM	I/S SYSTEM
LUBE OIL ○ INLET TO ○ OUT OF FRAME	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○
LUBE OIL ○ INLET TO ○ OUT OF COOLER	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○
MAIN JOURNAL BEARINGS (THERMOCOUPLES OR RTD'S ONLY)	(☐ ○ ◉)	(☐ ○ ◉)		○	○	○
MOTOR BEARING(S) (THERMOCOUPLES OR RTD'S ONLY)	(☐ ○ ◉)	(☐ ○ ◉)		○	○	○
COOLING WATER HEADER: ○ INLET ○ OUTLET	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○
CYLINDER COOLING WATER: ○ INLET ○ OUTLET ○ EACH CYLINDER	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○
PROCESS GAS: ○ INLET ○ DISCHARGE ○ EACH CYLINDER	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○
INTERCOOLER(S) ○ INLET ○ GAS ○ COOLANT	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○
○ OUTLET ○ GAS ○ COOLANT	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○
AFTERCOOLER: ○ INLET ○ GAS ○ COOLANT	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○
○ OUTLET ○ GAS ○ COOLANT	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○
PACKING COOLANT ○ INLET ○ OUTLET	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○
PRESSURE PGK CASE, CYL PISTON ROD (THERMO-COUPLE OR RTD'S ONLY)	(☐ ○ ◉)	(☐ ○ ◉)		○	○	○
COMPRESSOR VALVES ○ SUCTION ○ DISCHARGE (TC'S OR RTD'S ONLY)	(☐ ○ ◉)	(☐ ○ ◉)		○	○	○
PACKING CASE VENT TEMPERATURE (6.13.2.9)	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○
_____	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○

ALARM & SHUTDOWN SWITCH REQUIREMENTS (NOTE 1) REF: 7.8.6 TABLE 5 FOR MINIMUM RECOMMENDED PROTECTION REQUIREMENTS

ALARM DEVICES: ○ TRANSMITTER ○ SWITCH
SHUTDOWN DEVICES ○ TRANSMITTER ○ SWITCH
ARRANGEMENT (7.8.2.2): ○ 1 ○ 2 ○ 3 ○ OTHER: _____

FUNCTION	ALARM	SHUT DOWN	ANNUNCIATION POINTS: ALARM IN PANEL BY MFR	ALARM IN CONTROL ROOM PANEL BY OTHERS	SHUTDOWN IN PANEL BY MFR	SHUTDOWN IN CONTROL ROOM PANEL BY OTHERS	TOTAL NUMBER OF POINTS
LOW LUBE OIL PRESSURE AT BEARING HEADER	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
HIGH LUBE OIL ΔP ACROSS FILTER	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
LOW FRAME LUBE OIL LEVEL	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
AUXILIARY LUBE OIL PUMP, FAIL TO START	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
CYLINDER LUBE SYSTEM PROTECTION	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
COMPRESSOR VIBRATION, SHUTDOWN ONLY	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
VIBRATION, WITH CONTINUOUS MONITORING	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
ROD DROP DETECTOR, CONTACT TYPE(1/CYLINDER)	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
ROD DROP PROXIMITY PROBE (1/CYLINDER)	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
OIL TEMPERATURE OUT OF FRAME	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
HIGH GAS DISCHARGE TEMP EACH CYLINDER (6.5.2)	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
HIGH JACKET WATER TEMPERATURE, EACH CYLINDER	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
LOW SUCTION PRESSURE, FIRST STAGE INLET	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
HI DISCHARGE PRESSURE ○ FINAL ○ EACH STAGE	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
HIGH CYLINDER GAS Δ P, EACH STAGE	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
HIGH LIQUID LEVEL, EACH MOISTURE SEPARATOR	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
LOW PURGE GAS PRESSURE DISTANCE PIECE(S)	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
HIGH CROSSHEAD PIN TEMP	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
PRESSURE PACKING CASE (PISTON ROD TEMP)	(☐ ○ ◉)	(☐ ○ ◉)	○	○	○	○	
_____	(○ ○ ◉)	(☐ ○ ◉)	○	○	○	○	

TOTAL NUMBER OF ANNUNCIATION POINTS

SWITCH CONTACT OPERATION **(NOTE 2)**

ALARM CONTACTS SHALL: ○ OPEN (DE-ENERGIZED) TO SOUND ALARM & BE ENERGIZED WHEN COMPRESSOR IS IN OPERATION
○ CLOSE (ENERGIZE) TO SOUND ALARM & BE DE-ENERGIZED WHEN COMPRESSOR IS IN OPERATION

SHUTDOWN CONTACTS SHALL: ○ OPEN (DE-ENERGIZED) TO SHUTDOWN & BE ENERGIZED WHEN COMPRESSOR IS IN OPERATION
○ CLOSE (ENERGIZE) TO SHUTDOWN & BE DE-ENERGIZED WHEN COMPRESSOR IS IN OPERATION

REMARKS / SPECIAL REQUIREMENTS:

NOTE 1: ALARM & SHUTDOWN DEVICES SHALL BE INDIVIDUALLY SEPARATE

NOTE 2: EACH SWITCH SHALL BE MINIMUM SPDT ARRANGEMENT.

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NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ☒ PURCHASER OR MANUFACTURER AS APPLICABLE

INSTRUMENTATION (CONTINUED)

MISCELLANEOUS INSTRUMENTATION

- ○ SIGHT FLOW INDICATOR (COOLANT ONLY) BY: FOR: ○ INTERCOOLER(S) ○ AFTERCLOOLER ○ OIL COOLER ○ CYLINDER JACKET COOLANT ○ ROD PRESSURE PACKING CASES
- ○ PNEUMATIC PRESSURE TRANSMITTERS BY: FOR:
- ○ PRESSURE TRANSMITTERS (ELEC. OUTP.) BY: FOR:
- ○ PNEUMATIC LEVEL TRANSMITTERS BY: FOR:
- ○ ALARM HORN & ACKNOWLEDGMENT TEST BUTTON BY: FOR:
- ○ CONDUIT & WIRING W/JUNCTION BOXES (CONSOLES) BY: FOR:
- ○ TEST VALVES BY: FOR:
- ○ DRAIN VALVES BY: FOR:
- ○ GAUGE GLASS(ES) BY: FOR:
- ○ TACHOMETER BY: SPEED RANGE ____ TO ____ (rpm)
- ○ CRANKSHAFT KEY PHASER AND TRANSDUCER BY: FOR:
- ○ _____ BY: FOR:

○ SEPARATE LUBE OIL CONSOLE INSTRUMENTATION: PURCHASER, TO LIST REQUIRMNETS IN ADDITION TO ANY ABOVE REQUIREMENTS

- ○ _____ BY: FOR:
- ○ _____ BY: FOR:
- ○ _____ BY: FOR:
- ○ _____ BY: FOR:
- ○ _____ BY: FOR:
- ○ _____ BY: FOR:

○ SEPARATE COOLING WATER CONSOLE INSTRUMENT: PURCHASER, TO LIST REQUIREMENTS IN ADDITION TO ANY ABOVE REQUIREMENTS

- ○ _____ BY: FOR:
- ○ _____ BY: FOR:
- ○ _____ BY: FOR:
- ○ _____ BY: FOR:
- ○ _____ BY: FOR:
- ○ _____ BY: FOR:

☒ RELIEF VALVES

LOCATION	BY	MANUFACTURER	TYPE	◇ SIZE	◇ SETTING

REMARKS / SPECIAL REQUIREMENTS: SEE MOTOR DATA SHEET FOR ADDITIONAL MOTOR INSTRUMENTATION REQUIREMENTS
FOR TURBINE DRIVERS USE APPLICABLE API DATA SHEETS, FOR GEAR REDUCERS USE APPLICABLE API DATA SHEETS
ELECTRICAL & INSTRUMENTATION CONNECTIONS SHALL BE MADE DIRECTLY BY THE PURCHASER TO INDIVIDUAL INSTRUMENTS ON
THE COMPRESSOR

DOCUMENT NUMBER:
CLIENT DOCUMENT NUMBER:

REVISION	0	1	2	3	4
DATE					

RECIPROCATING COMPRESSOR
DATA SHEET (API 618-6TH)
U.S. CUSTOMARY UNITS

JOB NO. _____ ITEM NO. _____
PAGE 16 OF _____ REQUISITION NO. _____

NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ▣ PURCHASER OR MANUFACTURER AS APPLICABLE

PULSATION SUPPRESSION DEVICES FOR RECIPROCATING COMPRESSORS

THESE SHEETS TO BE FILLED OUT FOR EACH SERVICE AND / OR STAGE OF COMPRESSION

GENERAL INFORMATION APPLICABLE TO ALL SUPPRESSORS

○ PULSATION SUPPRESSORS WITH INTERNALS ○ PURCHASER ○ SUPPLIER
○ INITIAL INLET ONLY ○ INITIAL INLET & FINAL DISCHARGE ○ INTERSTAGE ○ ALL INLET SUPPRESSORS
○ SUPPORTS ○ PURCHASER ○ SUPPLIER
○ ACOUSTICAL SIMULATION STUDY ○ SUPPLIER ○ 3RD PARTY
○ STUDY TO CONSIDER: **(NOTE 3)** ○ PARALLEL OPERATION (7.11.3.2)
○ OPERATION WITH EXISTING COMPRESSORS AND ASSOCIATED PIPING (7.11.3.3)
○ DESIGN APPROACH CHECK ONLY ONE (7.11.4 TABLE 6) ○ ACOUSTIC SIMULATION AND PIPING RESTRAINT ANALYSIS
○ ACOUSTIC SIMULATION AND PIPING RESTRAINT ANALYSIS PLUS MECHANICAL ANALYSIS
○ PIPING SYSTEM FLEXIBILITY ANALYSIS (7.11.7.6.2)
○ ANALYSIS OF STRESSES IN SUPPRESSION DEVICE INTERNALS (7.12.1.23)(7.11.6.1.2)
○ PULSATION SUPPRESSION DEVICE LOW CYCLE FATIGUE ANALYSIS (7.12.1.24
○ SUPPRESSOR MANUFACTURER _____
☐ SUPPRESSOR MODEL _____ ☐ SUPPRESSOR TYPE _____
☐ TOTAL NUMBER OF SERVICES _____ ☐ TOTAL NUMBER OF STAGES _____
☐ TOTAL NUMBER OF COMPRESSOR CYLINDERS _____ TOTAL NUMBER OF CRANK THROWS _____ STROKE _____ (in) RPM _____
○ ASME CODE STAMP ○ NATIONAL BOARD REGISTRATION
○ GOVERNMENTAL CODE REGULATIONS _____
○ OTHER APPLICABLE PRESSURE VESSEL SPECIFICATIONS OR CODE _____
○ LUBE SERVICE ○ NON-LUBE SERVICE ○ NO OIL ALLOWED INTERNALLY DRY TYPE INTERCOOLER CORROSION COATING ○ YES ○ NO
○ RADIOGRAPHY OF WELDS ○ NONE ○ SPOT ○ 100% ○ IMPACT TEST ○ SPECIAL WELDING REQUIREMENTS
○ SHOP INSPECTION
○ HYDROTEST WITNESS
○ OUTDOOR STORAGE MORE THAN 6 MONTHS _____ MONTHS
○ SPECIAL PAINT SPECIFICATION _____

CYLINDER, GAS, OPERATING, AND SUPPRESSOR DESIGN DATA

○ SERVICE: _____ STAGE NUMBER: _____
☐ COMPRESSOR MANUFACTURER'S RATED CAPACITY _____ (lb/hr) _____ (scfm) _____ MMSCFD/SCFM

		INLET SUPPRESSOR	DISCHARGE SUPPRESSOR
○	SUPPRESSOR TAG NUMBER		
▣	LINE SIDE OPERATING PRESSURE (psia)		
▣	OPERATING TEMPERATURE WITHIN SUPPRESSORS (°F)		
○	ALLOWABLE PRESSURE DROP THROUGH SUPPRESSORS	Δ P _____ (psi) / _____ %	Δ P _____ (psi) / _____ %
○	COMBINATION INLET SUPPRESSOR SEPARATOR	○ YES ○ NO	○ YES ○ NO
○	COMBINATION INLET SUPPRESSOR INTERNALS	○ YES ○ NO	○ YES ○ NO
▣	QUANTITY OF SUPPRESSORS PER STAGE		
○	ALLOWABLE PEAK-PEAK PULSE @ LINE SIDE NOZZLE	_____ (psi) / _____ %	_____ (psi) / _____ %
○	ALLOWABLE PEAK-PEAK PULSE @ CYLINDERS FLANGE NOZZLE	_____ (psi) / _____ %	_____ (psi) / _____ %
○	DESIGN FOR FULL VACUUM CAPABILITY	○ YES ○ NO	○ YES ○ NO
○	MINIMUM REQUIRED WORKING PRESSURE & TEMPERATURE **(NOTE 1)**	_____ (psig) @ _____ (°F)	_____ (psig) @ _____ (°F)
○	INITIAL SIZING VOLUME (This is a Reference)(7.11.1.3) (ft^3)		
◇	AS BUILT VOLUME (ft^3)		
○	BASIC MATERIAL REQUIRED: (CS, SS, ETC.)		
◇	ACTUAL SHELL MATERIAL DESIGNATION		
◇	ACTUAL HEAD MATERIAL DESIGNATION		
○	SHELL & HEADS SPECIAL HARDNESS LIMITATIONS, Rc	○ YES ○ NO	○ YES ○ NO
○	WELDS SPECIAL HARDNESS LIMITATIONS, Rc	○ YES ○ NO	○ YES ○ NO
▣	CORROSION ALLOWANCE, ○ REQUIRED (7.12.1.4) (in)		
◇	SHELL WALL THICKNESS (in)		
◇	HEAD WALL THICKNESS (in)		
☐	NOMINAL SHELL DIAMETER X OVERALL LENGTH	_____ (in) X _____ (ft)	_____ (in) X _____ (ft)
☐	PIPE OR ROLLED PLATE CONSTRUCTION	☐ PIPE ☐ ROLLED PLATE	☐ PIPE ☐ ROLLED PLATE
◇	ACTUAL MAXIMUM ALLOWABLE WORKING PRESS. AND TEMPERATURE	_____ (psig) @ _____ (°F)	_____ (psig) @ _____ (°F)
○	MINIMUM DESIGN METAL TEMPERATURE (6.14.8.1) (°F)		
○	INLET SUPPRESSOR TO BE SAME MAWP AS DISCHARGE SUPPRESSOR	○ YES ○ NO	○ YES ○ NO
◇	MAX EXPECTED PRESSURE DROP (ΔP, PSI / %) LINE PRESSURE	Δ P _____ (psi) / _____ %	Δ P _____ (psi) / _____ %
◇	WEIGHT (EACH) (lb)		
○	INSULATED NUTS & ALLOWANCE FOR INSULATION REQUIRED (X)		
◇	EXPECTED P-P PULSE @ LINE SIDE % LINE PRESS **(NOTE 2)** %		
◇	EXPECTED P-P PULSE @ CYLINDER FLANGE % LINE PRESS (NOTE 2) %		
▣	SUPPORTS, TYPE		
▣	SUPPORTS, QUANTITY		
▣	SUPPORTS FURNISHED BY:		

REMARKS / SPECIAL REQUIREMENTS: **NOTE 1:** AFTER DESIGN, THE ACTUAL MAWP & TEMPERATURE ARE TO BE DETERMINED BASED ON THE WEAKEST COMPONENT AND STAMPED ON THE VESSEL. THE ACTUAL MAWP IS TO BE SHOWN ON LLINE 57 AND ON THE U1A FORMS.
NOTE 2: BASED ON FINAL SUPPRESSOR DESIGN. **NOTE 3:** SEE APPENDIX N FOR INFORMATION REQUIRED FOR STUDY

DOCUMENT NUMBER:
CLIENT DOCUMENT NUMBER:

REVISION	0	1	2	3	4
DATE					

RECIPROCATING COMPRESSOR
DATA SHEET (API 618-6TH)
U.S. CUSTOMARY UNITS

JOB NO. ITEM NO.
PAGE 17 OF REQUISITION NO.

NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ◌ PURCHASER OR MANUFACTURER AS APPLICABLE

PULSATION SUPPRESSION DEVICES FOR RECIPROCATING COMPRESSORS

THESE SHEETS TO BE FILLED OUT FOR EACH SERVICE AND/OR STAGE OF COMPRESSION

○ SERVICE: STAGE NUMBER:

CONNECTION REQUIREMENTS & DATA

	INLET SUPPRESSOR	DISCHARGE SUPPRESSOR
○ LINE SIDE FLANGE, SIZE		
○ LINE SIDE FLANGE, RATING		
○ LINE SIDE FLANGE, FACING		
○ LINE SIDE FLANGE, TYPE		
○ COMPRESSOR CYLINDER FLANGE(S), QUANTITY		
○ COMPRESSOR CYLINDER FLANGE(S), SIZE		
○ COMPRESSOR CYLINDER FLANGE(S), RATING		
○ COMPRESSOR CYLINDER FLANGE(S), FACING		
○ COMPRESSOR CYLINDER FLANGE(S), TYPE		
○ FLANGE FINISH, ○ PER ASME B16.5 ○ PER 6.8.2.1.16 >125 <250 ○ SPECIAL (SPECIFY)		
○ INSPECTION OPENINGS REQUIRED (7.12.1.15)	○ YES ○ NO ○ BLINDED	○ YES ○ NO ○ BLINDED
○ SPECIFIED QUANTITY SIZE		
○ SPECIFIED QUANTITY TYPE		
○ SPECIFIED QUANTITY RATING		
◇ AS BUILT QUANTITY		
◇ AS BUILT TYPE		
◇ AS BUILT RATING		
○ VENT CONNECTIONS REQUIRED	○ YES ○ NO	○ YES ○ NO
○ SPECIFIED QUANTITY SIZE		
○ SPECIFIED QUANTITY TYPE		
○ SPECIFIED QUANTITY RATING		
◇ AS BUILT QUANTITY		
◇ AS BUILT TYPE		
◇ AS BUILT RATING		
○ DRAIN CONNECTIONS REQUIRED (7.12.1.11)	○ YES ○ NO	○ YES ○ NO
○ SPECIFIED QUANTITY SIZE		
○ SPECIFIED QUANTITY TYPE		
○ SPECIFIED QUANTITY RATING		
◇ AS BUILT QUANTITY		
◇ AS BUILT TYPE		
◇ AS BUILT RATING		
○ PRESSURE CONNECTIONS REQUIRED (7.12.1.11)	○ YES ○ NO	○ YES ○ NO
○ SPECIFIED QUANTITY SIZE		
○ SPECIFIED QUANTITY TYPE		
○ SPECIFIED QUANTITY RATING		
◇ AS BUILT QUANTITY		
◇ AS BUILT TYPE		
◇ AS BUILT RATING		
○ TEMPERATURE CONNECTIONS REQUIRED (7.12.1.12)	○ YES ○ NO	○ YES ○ NO
○ MAIN BODY	○ YES ○ NO	○ YES ○ NO
○ CYLINDER NOZZLE	○ YES ○ NO	○ YES ○ NO
○ SPECIFIED QUANTITY SIZE		
○ SPECIFIED QUANTITY TYPE		
○ SPECIFIED QUANTITY RATING		
◇ AS BUILT QUANTITY		
◇ AS BUILT TYPE		
◇ AS BUILT RATING		

OUTLINE OR DRAWING NUMBERS

◇ COMPRESSOR MANUFACTURER'S SUPPRESSOR OUTLINE OR DRAWING NUMBER
◇ SUPPRESSOR MANUFACTURER'S OUTLINE OR DRAWING NUMBER

REMARKS / SPECIAL REQUIREMENTS:

Annex B
(informative)

Capacity Rating and Tolerance

The content of this informative annex refers to 6.1.4.

This annex discusses capacity sizing of reciprocating compressors and the intent of the term “no-negative tolerance” (NNT) as used in this standard to apply to the “normal capacity” of reciprocating process compressors.

The “normal operating point” is defined by the purchaser and is normally the minimum capacity at the specified pressures and temperatures required to meet the process conditions with NNT permitted (this is typically the process flow sheet material balance capacity). The purchaser completes the data sheets with a capacity, and identifies the operating conditions as “normal” or “alternate.” The purchaser also provides information on the data sheets about any proposed alternate operating conditions. The sizing of the compressor takes into account all specified operating conditions, and the manufacturer’s standard tolerances so that the resulting full-load capacity will never be less than the capacity at the certified operating point.

The compressor “manufacturer’s rated capacity” is that capacity to which the compressor is sized by the manufacturer. The acceptable standard reciprocating compressor industry tolerance of ±3 % is applicable to both the capacity and power at the compressor shaft. Because of this tolerance on capacity, the manufacturer typically will increase the normal capacity by 3 % prior to sizing the compressor. Frequently, the normal capacity divided by 0.97 equals the manufacturer’s rated capacity. However, due to the alternate operating conditions, in some cases the manufacturer’s rated capacity may be higher. Since this standard establishes tolerances on normal capacity, and not the manufacturer’s rated capacity, the purchaser and the manufacturer should ensure that they have a mutually understood tolerance on the manufacturer’s rated capacity.

“Total power at the compressor shaft,” as used in the data sheets under the manufacturer’s rated capacity, is intended to mean the power required at the compressor input shaft.

“Total power including power transmission losses” is the total power at the compressor shaft plus all losses in the drive system and is used for selecting the driver.

The tolerance on the manufacturer’s certified shaft power is ±3 % and is calculated on the basis of manufacturer’s rated capacity. Using the manufacturer’s rated capacity and corresponding power, the proper relationship of power to unit capacity exists and will agree with calculations. (For example, kilowatts per hundred cubic meters per hour or brake horsepower per hundred cubic feet per minute.)

Annex C
(informative)

Piston Rod Runout

C.1 Scope

This annex describes a procedure that can be used to determine expected piston rod runout in horizontal reciprocating compressors with traditional crosshead/piston rod/piston construction. Piston rod runout, using precision dial indicators, is a measurement criterion used to determine piston rod running alignment variations in both horizontal and vertical positions relative to cylinder and crosshead alignment. Whereas other alignment methods, such as optical, laser, or wire, may be used to determine initial assembly alignment, use of dial indicators on the piston rod verifies alignment by determining the true running variation of the rod as it passes through its stroke. Once factory alignment has been verified by correct rod runout measurement, and so recorded, it is a convenient field method of verifying alignment after installation and routine maintenance.

Manufacturers with other types of compressors, having unique or proprietary construction, may require different methods for calculating expected cold vertical rod runout.

C.2 Definition

Piston rod runout is defined in 3.1.39.

C.3 Maximum Allowable Runout

C.3.1 Acceptable limits of rod runout and shop test requirements and records are discussed in 6.3.

C.3.2 The maximum allowable horizontal runout at any side position of the dial indicators shall be zero, ±0.00015 mm/mm (0.00015 in./in.) of stroke, up to a maximum of 0.064 mm (0.0025 in.).

C.3.3 The maximum allowable vertical runout at any top position of the dial indicators shall be the calculated runout, in millimeters (thousandths of an inch), at that specific dial indicator position based on length of stroke, length of rod, rod sag, and the difference between the crosshead and cylinder running clearances, plus or minus a permissible limit of ±0.015 % of stroke to allow for geometric and fit tolerances of all parts that may contribute to slight parallel offset and angular misalignment.

See remainder of this annex for an example of vertical runout calculations based on a suggested procedure.

C.4 General

C.4.1 Piston rod runout is always an inspection requirement during the shop assembly of a new compressor to verify alignment. It is almost always a purchaser's witness test requirement of alignment to determine that geometric and fit dimensions of all parts are correct, and that these parts have been properly assembled with parallel offset and/or angular misalignment within the established runout limits. In addition, as part of new compressor field installations, rod runout is always checked and verified against shop readings. It is also a requirement of normal compressor maintenance, especially after overhaul and reassembly of the cylinders.

C.4.2 Runout should be checked in both horizontal and vertical directions. It is best to check runout at both the crosshead and at the cylinder to verify that the crosshead and piston are running true in the crosshead guide and cylinder, respectively.

C.4.3 Although rod runout can be used to verify alignment, it should not be used to align compressor cylinders during the original assembly of the machine. If the measured cold runout exceeds the expected value, actual running clearances and the runout calculation should be checked. It is also recommended that all assembled components and fits be checked to confirm that they are within the tolerances required for size, squareness, parallelism, and concentricity.

C.4.4 After assembly and in the field, compressor cylinders, distance pieces, and crosshead guides should never be forced into positions of harmful stresses in an attempt to satisfy rod runout requirements.

C.4.5 Due to the piston rod length, vertical runout includes the effect of rod sag when Types B, C, and D distance pieces are used. In the case of older units, or new units with no distance piece, or with the very short Type A distance piece, rod sag may be so minimal that it can be ignored, and the basics of Figure C.1 and Figure C.2 can be used to compute expected vertical rod runout for perfect alignment.

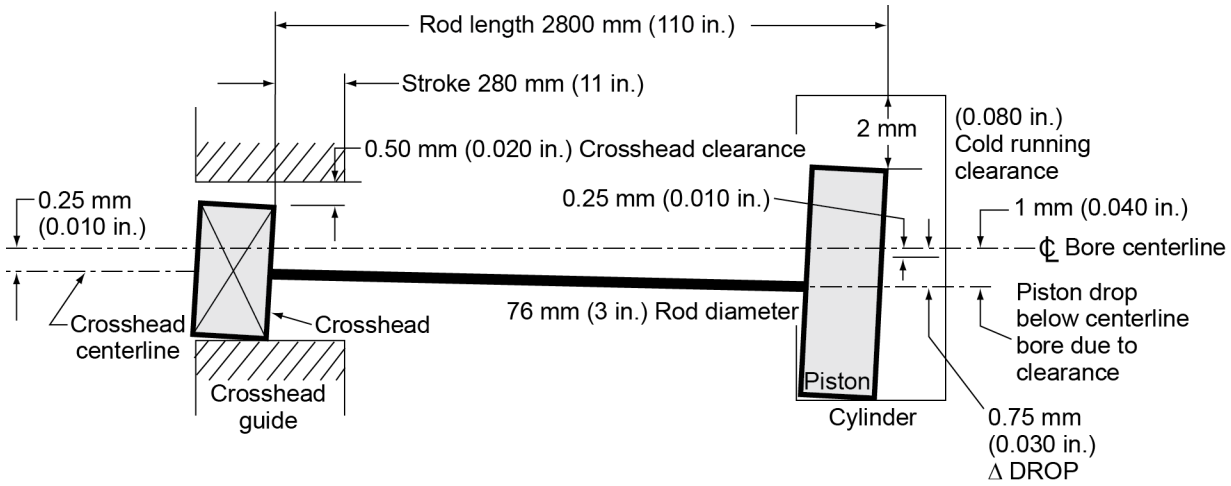


Figure C.1—Basic Geometry with Cold Vertical Runout

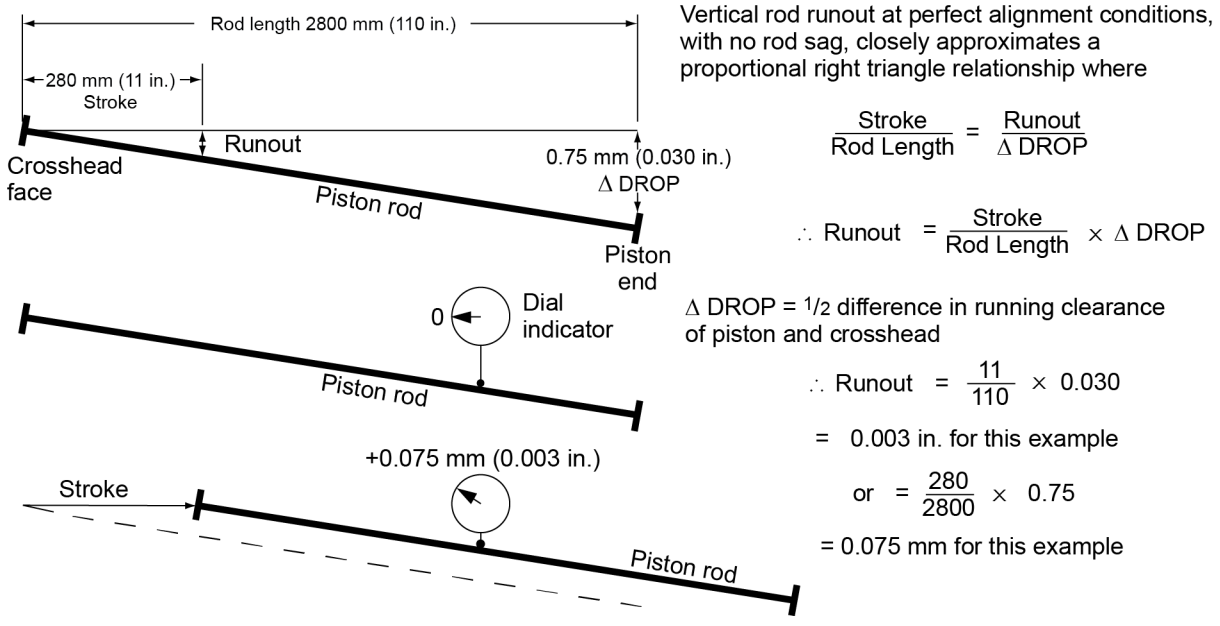


Figure C.2—Vertical Runout Geometric Relationships Based on No Rod Sag

C.5 Procedure

C.5.1 Rod runout should ideally be checked at both the crosshead end and at the piston end of the rod. For this purpose, one dial indicator is placed as close as possible to the crosshead and the other is placed as close as possible to the piston, the latter position being in the distance piece next to the piston rod pressure packing case as shown in Figure C.6. This is about as close to the piston and cylinder as typically attainable. Normally checks are made in the cold condition, that is, when all parts are at ambient temperature.

C.5.2 Factory readings are to be recorded on a "runout table" similar to that illustrated in Figure C.3 and provided as part of the manual for rod runout reference at time of installation.

C.5.3 Dial indicators for vertical runout should be placed on top of the rod at the 12 o'clock position as shown in Figure C.4, Figure C.5, and Figure C.6. For horizontal runout, dial indicators should be placed on the "drive side" (in other words, the side toward the driver) of the rod at the 3 o'clock or 9 o'clock position depending on which throw is being measured. For accurate readings, dial indicators should be perpendicular to the rod at these positions.

C.5.4 For correct vertical rod runout calculations, it is important to use actual measured running clearances for the cylinder and crosshead, as well as the actual measured dimensions of the dial indicator locations along the top of the piston rod. Correct rod lengths as required by Figure C.6 are also important.

C.5.5 Rod runout should always be measured starting with the rod at the extreme end of the stroke, with the piston at the crank end of the cylinder. The dial indicators should be zeroed. Manual bar-over should be such that the connecting rod runs over (i.e. over the top on the outstroke) as the crosshead, piston rod, and piston are stroked slowly outward toward the end of the stroke at the head end of the cylinder. Dial indicator readings are observed during the stroke and recorded at the end of the stroke. If this method and the dial indicator positions noted in C.5.3 are used as the standard measurement procedure, then field runout readings can be properly compared and evaluated with factory runout readings provided in Figure C.3.

C.5.6 The dimensions shown in Figure C.1, Figure C.2, Figure C.5, and used in Figure C.7 for the calculation example, were selected for convenience in illustrating basic runout geometry and principles. Dimensions for actual compressors may vary greatly from the illustration dimensions, while some may be close or identical. Since vertical rod runout will vary according to stroke, rod length, rod sag, and the difference in running clearances between the crosshead and cylinder, different compressors with different cylinder configurations may have significantly different vertical runout readings for conditions of perfect alignment.

C.5.7 Excessive rod runout is corrected by realignment and/or squaring up some or all components involved. These may include cylinders, liners, heads, distance pieces, crossheads and crosshead guides, and rods and pistons. Crosshead threads and face, piston rod nut threads and face, and piston rod threads may have to be checked and corrected for perpendicularity. As a check for squareness at the interface of the crosshead and piston rod, both horizontal and vertical runout should be checked first with the crosshead nut loose and then tight. Certain conditions of excessive rod runout at the packing case can further be evaluated by placing a dial indicator on the rod in the cylinder through a crank end valve port to verify full-length liner concentricity with the cylinder bore and/or cylinder crank end face squareness with the bore. With a dial indicator in the cylinder, full stroke runout cannot be taken since the dial indicator takes up some of the space between the crank-end head and the piston. However, the available stroke is sufficient to get a suitable reading to determine alignment status.

ROD RUNOUT TABLE

Contractor/User _____ Job No. _____ Item No. _____

Purchase Order No. _____ Site/Location _____ Date _____

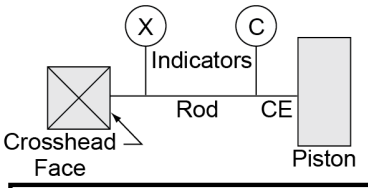
Compressor Mfgr. _____ Type/Model _____ Ser. No. _____

Piston Rod Runout Data: Throw No. _____ Stage _____ Cyl. Bore Dia. _____ Stroke _____

Cylinder Bore Running Clearance _____ Crosshead Running Clearance _____

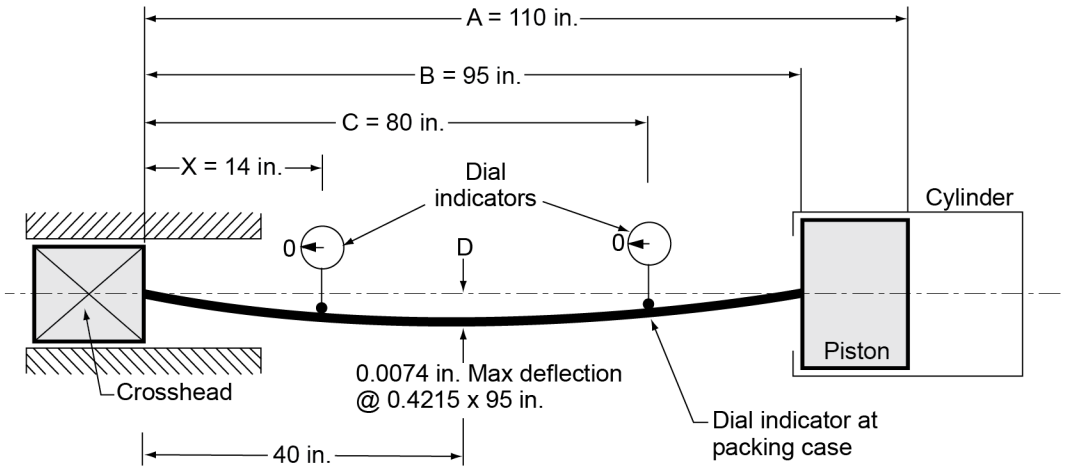
Ref: Rod Dia. _____ Rod Length (Crosshead Face to CE Piston Face) _____ Rod Sag _____

Indicator Positions (Piston at CE) From Crosshead Face To: X _____ C _____

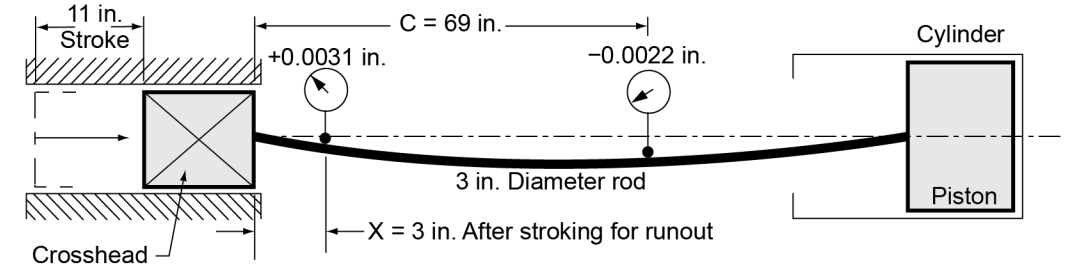


	EXPECTED / ACTUAL ROD RUNOUT				
	Allowable Limits @ X Expected	Measured Values @ X Actual	Allowable Limits @ C Expected	Measured Values @ C Actual	Inspector and Date
Cold (Before Run)					
Vertical (Top, Nut Loose)					
Horizontal (Drive Side, Nut Loose)					
Vertical (Top, Nut Tight)					
Horizontal (Drive Side, Nut Tight)					
Hot (After run) ❑ Unit Not Shop Run					
Vertical (Top)					
Horizontal (Drive Side)					
Cold (Retake) ❑ Required ❑ Not Required					
Vertical (Top)					
Horizontal (Drive Side)					

Figure C.3—Rod Runout Table



Crosshead and cylinder clearances identical, Δ DROP = 0



NOTE This example is based on US customary units.

Initial deflection calculation: Crosshead end supported (free end) - piston end fixed.
Max deflection occurs at 0.4215 × rod length 95 in.

Rod diameter = 3 in.
Density = 0.283 lb/in^3 (steel)
Modulus of elasticity, E = 30 × 10^6 psi
Rod length B = 95 in.

Total weight = 190 lb
Moment of inertia, I = 3.9761 in.^{4}
Rod length C at cylinder indicator position = 80 in.

$$\text{Max D} = \frac{1}{184.65}\left(\frac{WB^3}{EI}\right) = \frac{1}{184.65}\left(\frac{190 \times 95^3}{30 \text{ X } 10^6 \times 3.9761}\right) = 0.0074 \text{ in. at 40.04 in. from free end}$$

Deflection at any point C on the rod $= \frac{1}{48} \times \frac{W}{EIB} (3BC^3 - 2C^4 - B^3C)$

∴ Deflection at indicator location C = 80 in. $= \frac{1}{48} \times \frac{190}{EI \times 95} (3 \times 95 \times 80^3 - 2 \times 80^4 - 95^3 \times 80)$

$= 0.02083 \times 1.6767 \times 10^{-8} (-4{,}590{,}000) = -0.0016$ in.

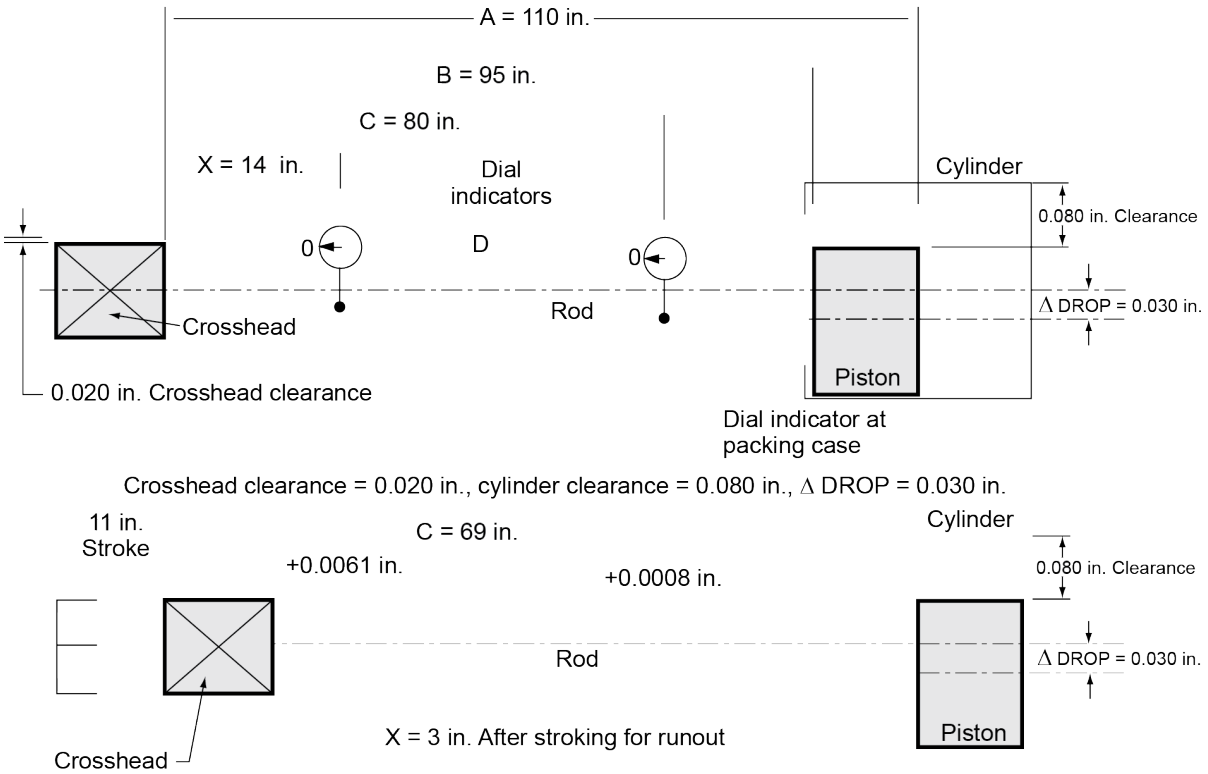
Deflection at C = 69 in. (80 in. minus stroke) $= 0.02083 \times 1.6767 \times 10^{-8} (3 \text{ X } 95 \text{ X } 69^3 - 2 \times 69^4 - 95^3 \times 69)$

$= 0.02083 \times 1.6767 \times 10^{-8} (-10{,}868{,}052) = -0.0038$ in.

∴ Rod runout at packing case = 0.0016 in. − 0.0038 in. = −0.0022 in.

The same calculations for the indicator location of 14 in. from the crosshead and at 3 in. after stroking 11 in. gives a value of +0.0031 for rod runout at the crosshead.

Figure C.4—Rod Runout Attributable to Piston Rod Sag with Δ DROP = 0

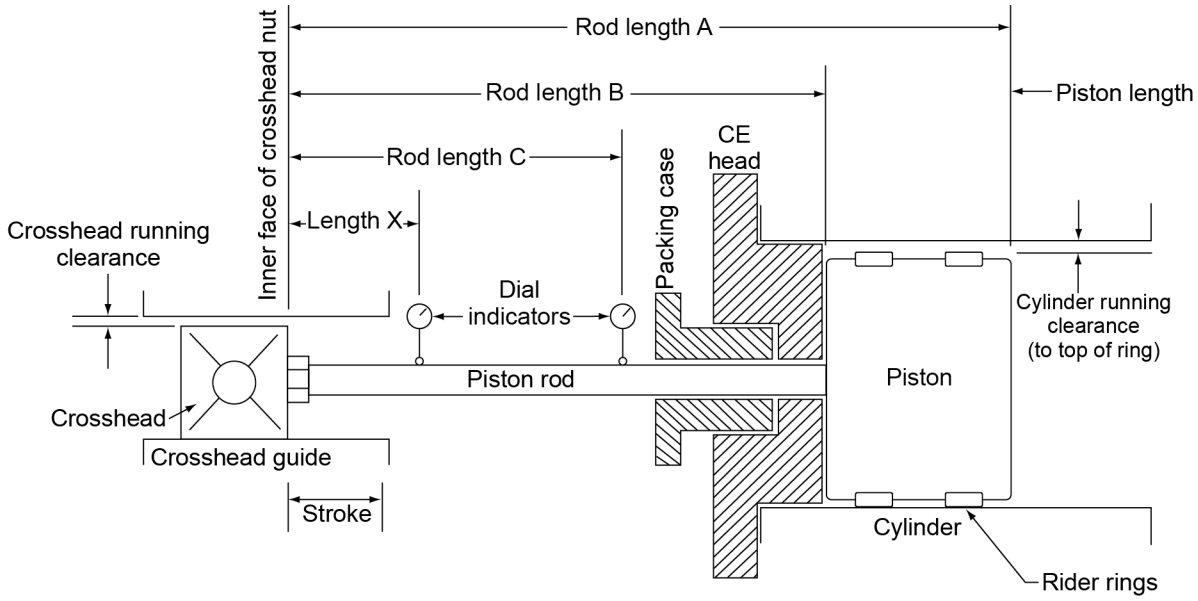


NOTE This example is based on US customary units.
D = Maximum sag

To calculate rod runout at cylinder running clearances that are different than the crosshead running clearance, combine the deflection runout shown for Figure C.4 with incremental Δ DROPS at indicator positions based on Figure C.2. These calculations can be quite extensive and are best done by a suitable computer program. A printout of an example of one such program is illustrated in Figure C.8 using the calculation data shown in Figure C.7. This particular program calculates the runout values at increments of 1 in. rod lengths, combines the values, calculates the expected runout figures at the indicator positions, and plots the curves shown in Figure C.9 through Figure C.13.

As shown on the computer printout sheet Figure C.8 and the curve of Figure C.9, the combined rod runout would be +0.0008 in. at the packing case indicator location, and +0.0061 in. at the crosshead indicator location with a cylinder running clearance of 0.080 in., and a crosshead running clearance of 0.020 in. for a Δ DROP of 0.030 in. The effect of decreasing cylinder running clearance by 0.020 in. increments is also shown in Figure C.9 and the curves of Figure C.10 through Figure C.13. As mentioned in Figure C.10, this is equivalent to removing 0.010 in. of shims from the bottom shoe of the crosshead, changing the Δ DROP by 0.010 in. increments. Note that each 0.010 in. shim removal changes the rod runout by only about 0.001 in. for this example.

Figure C.5—Rod Runout Attributable to Piston Rod Sag with Δ DROP > 0

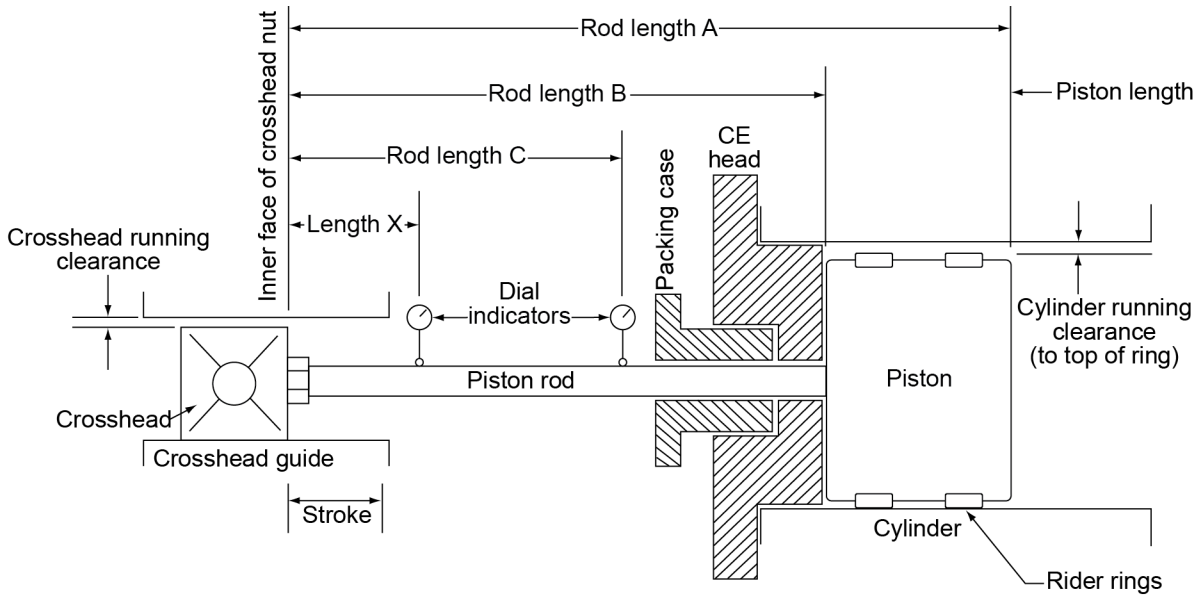


☐ Throw number	
☐ Stage	
☐ Cylinder bore diameter	
● Cylinder running clearance	
● Crosshead running clearance	
● Stroke	
● Rod diameter	
● Rod length A	
● Rod length B	
● Rod length C Indicator Position	
● Rod length X Indicator Position	
☐ Rod material	
● Material density, kg/m^3 (lb/in^3)	
● Modulus of elasticity, MPa (psi)	

☐ Reference data
● Calculation data

NOTE The cylinder running clearance is the bore ID minus the OD across the rider rings. Use actual values for final calculations.

Figure C.6—Data for Rod Runout Calculation



☐	Throw number	1
☐	Stage	1
☐	Cylinder bore diameter	20 in.
●	Cylinder running clearance	0.080 in., 0.060 in., 0.020 in., 0.010 in.
●	Crosshead running clearance	0.020 in.
●	Stroke	11 in.
●	Rod diameter	3 in.
●	Rod length A	110 in.
●	Rod length B	95 in.
●	Rod length C Indicator Position	80 in.
●	Rod length X Indicator Position	14 in.
☐	Rod material	AISI 4140
●	Material density, kg/m^3 (lb/in.^{3})	0.283 lb/in.^{3}
●	Modulus of elasticity, MPa (psi)	30 x 10^6 psi

☐ Reference data
● Calculation data

NOTE The cylinder running clearance is the bore ID minus the OD across the rider rings. Use actual values for final calculations. This example is based on US customary units.

Figure C.7—Rod Runout Calculation Example

C.6 Horizontal Runout

Horizontal runout readings can be used as a direct indication of the horizontal alignment from the crosshead through the distance pieces to the cylinder. No calculations are necessary, as horizontal runout should be within the zero limits regardless of whether the unit is cold or hot, or of the axial location of the dial indicator along the side of the rod. It is measured by placing dial indicators on the side of the rod as close as possible to the crosshead and the piston rod pressure packing case at the locations noted in C.5.1, and shown in Figure C.6. For perfect alignment, the dial indicators should read zero as the rod is moved slowly through the entire length of the stroke during manual bar-over. The best indication of perfect horizontal alignment is when horizontal rod runout measures zero with dial indicators set at both the crosshead end and the piston end of the rod, in other words, as close to the packing case as possible.

C.7 Vertical Runout

C.7.1 Cold Runout

Cold vertical runout readings other than zero are not necessarily an indication of misalignment. When all components are perfectly aligned, the normal cold vertical rod runout is the result of the difference between the cold running clearance of the piston in the bore and that of the crosshead in the crosshead guide, plus the effect of normal rod sag, the length of the stroke, the length of the rod, and the location of the dial indicators along the top of the rod. It is, therefore, important that the actual running clearances for the cylinder and crosshead are used for the calculations, as well as the rod lengths and actual dial indicator locations shown in Figure C.6.

C.7.2 Basic Geometry

The basic geometry is illustrated in Figure C.1 and Figure C.2. Piston and crosshead centerlines lie below the perfect alignment centerline by one-half of the running clearances. In cylinders where the running clearance is greater (or less) than the crosshead running clearance, the piston will lie below (or above) the crosshead centerline by one-half of the difference in the cold running clearances. The result is basic vertical rod runout that is normally something other than zero for perfect alignment. This one-half clearance difference is referred to as the differential drop (Δ DROP). The basic geometry closely approximates a right triangle condition.

Basic ideal vertical runout through the stroke length, as shown in Figure C.2, is determined by the normal running clearances and resulting Δ DROP, the rod length, and the stroke. Assuming an ideal straight-rod situation, in other words, without sag, basic cold vertical runout for perfect alignment can be calculated with sufficient accuracy using proportional right-triangle equations as shown in Figure C.2, when these values are known. The principle can also be used to calculate Δ DROP at any point on the rod, which is necessary to calculate vertical rod runout at specific dial indicator locations when combining Δ DROP with rod sag as shown in Figure C.4 and Figure C.5.

C.7.3 Rod Sag

Since all horizontal rods sag, especially those used in Types B, C, and D distance pieces, it is necessary to incorporate the effects of deflection based on rod length, rod diameter, rod weight, and rod material into the vertical runout calculations. When vertical rod runout readings are taken at several positions along the entire length of the piston rod, the readings will generally indicate that sag for a long rod attached to a crosshead and to a piston, when installed in a compressor assembly with precise geometric parts that have been proven to be perfectly aligned, will exhibit deflection characteristics similar to that for one end supported (at the crosshead) and one end fixed (at the piston). For these reasons, it is necessary to calculate the expected vertical rod runout at the crosshead end and at the piston end of the rod based on Figure C.6. Note that the data include both dial indicator positions along the top of the rod. The combined Δ DROP and deflection should be calculated at these dial indicator positions as shown in Figure C.4 and Figure C.5.

As can be seen from Figure C.4 and Figure C.5, rod sag will cause different vertical runout readings at different dial indicator positions along the top of the rod. For conditions of perfect alignment, at the lowest point of sag, runout readings may be nearly zero depending on cylinder clearance (Δ DROP), while at the crosshead end, readings should always be positive. Next to the cylinder packing case, readings may be positive, or they may be negative, depending on rod length, sag, and cylinder running clearance (Δ DROP). The zero vertical runout position can usually be found by placing the dial indicator along the top of the rod until the lowest point of sag is reached.

When the rod is stroked forward (that is, out toward the head end as noted in C.5.3 and shown in Figure C.4 and Figure C.5), the dial indicator at the crosshead should normally read positive.

C.8 Hot Runout

For large cylinders with aluminum pistons and fluorocarbon rider bands, there can be a significant difference between the cold rod runout and the hot runout. This is because of the high thermal expansion rate of the aluminum piston and the fluorocarbon rider band, which can result in a significant difference in the differential clearance between the piston and the crosshead. On the other hand, there may be operating conditions involving low suction temperatures such that normal operating temperatures may be no greater than the ambient temperature on which the cold vertical runout readings are taken. Expected hot runout can be determined by calculating the expected thermal growth of the cylinders, the pistons, and the rider ring radial thickness. The cylinder running clearance, affecting hot Δ DROP, is then adjusted accordingly in the vertical runout calculations.

Design and construction shall be aimed to achieve zero hot vertical rod runout at the packing case. Due to the effects of rod sag, this may not always be attainable under conditions of perfect alignment, and it is necessary to determine whether the value should be positive or negative. This can be seen from a study of Figure C.8 and the five curves illustrated by Figure C.9 through Figure C.13. Sometimes this requirement can be attained by shim adjustment of the crosshead shoes (see C.9), but a thorough study of cold readings compared to expected results from computer calculations is required to determine what adjustments, if any, are needed, or should be done to obtain the ideal desired vertical runout at operating temperatures. In many cases, where there is considerable sag, it may be better to operate as is than attempt to adjust the vertical runout, particularly if the cylinder and crosshead guide alignments are near perfect.

C.9 Vertical Runout Adjustment

C.9.1 If it is believed that some adjustment is necessary to the vertical runout readings, it should first be ensured that cylinder alignment and cylinder level are properly set so that the components are free of harmful stresses at operating conditions. If crosshead shim adjustment is then considered necessary by interchanging shims under the crosshead shoes, it should be remembered that taking shims from the bottom shoe and placing them under the top shoe drops the crosshead centerline further below the perfect alignment centerline. This decreases the Δ DROP and thus decreases the positive rod runout at the crosshead, but may actually increase negative runout at the packing case due to sag. This is illustrated in Figure C.8 and in the series of five runout curves of Figure C.9 through Figure C.13.

With reference to Figure C.8 and Figure C.11, note that a 0.76 mm (0.030 in.) change of shims, which would put the crosshead and piston on the same centerline such that Δ DROP = 0.00, changes the runout by only 0.076 mm (0.003 in.), that is, the crosshead runout goes to +0.079 mm (+0.0031 in.) from +0.155 mm (+0.0061 in.), and the runout at the packing case goes to –0.056 mm (–0.0022 in.) from +0.020 mm (+0.0008 in.). In other words, for this example, rod runout is changed by only 0.0254 mm (0.001 in.) for each 0.254 mm (0.010 in.) of shims removed from the bottom shoe in an attempt to lower the crosshead closer to the centerline of the cylinder. Because rod length and rod diameter, which affect sag, and cylinder size, which affects running clearance, can significantly affect vertical runout, every compressor cylinder assembly should be fully evaluated for expected vertical runout based on perfect alignment conditions. If crosshead shims are shifted in an attempt to adjust vertical runout, it is important that the crosshead always be installed with the “top” side up following removal for maintenance.

These illustrations also demonstrate the importance of using the actual measured running clearances of the cylinder and crosshead when calculating and evaluating vertical rod runout since a change of cylinder running clearance will affect Δ DROP, which in turn affects vertical runout. For some combinations of cylinder size, rod length, and stroke, the cylinder clearance will have a greater effect on vertical rod runout than other combinations. As illustrated in Figure C.1 and Figure C.2, it can be seen that the longer the stroke, the greater the runout, and the shorter the piston rod, the greater the runout, for the same Δ DROP.

To see the effect of rider ring wear on vertical rod runout, use Figure C.12 as the initial reference and compare it to Figure C.11, which has a Δ DROP of 0.254 mm (0.010 in.). The 0.254 mm (0.010 in.) drop is representative of 0.254 mm (0.010 in.) rider ring wear, which changes the vertical rod runout by 0.0254 mm (0.001 in.) to 0.030 mm (0.0012 in.) from 0.056 mm (0.0022 in.).

Where there is much concern about rod runout, each application needs to be studied carefully to fully understand what the vertical rod runout should be under conditions of perfect alignment in order to make the right decision and proper adjustment.

C.9.2 If crosshead shim adjustment has been considered necessary by interchanging shims under the crosshead shoes, the final arrangement shall be recorded in the as-built data sheet included in the operation and maintenance manual.

ROD RUNOUT

EXAMPLE OF COMPUTERIZED PRINTOUT USING THE CYLINDER DATA OF FIGURE C.7

U.S. Customary Units

Piston rod runout calculation By: Engineering Ref: Runout sample
Customer: Runout
Size unit: 11 in. stroke

Piston rod runout calculation data

☐ Throw number	1	
☐ Stage	1	Ref: rod runout
☐ Cylinder bore diameter	20.00	At crosshead At cylinder
• Cylinder running clearance	0.080	0.0061 0.0008
• Crosshead running clearance	0.020	Ref: piston Δ DROP = 0.030
• Stroke	11	
• Total rod length A	110	Enter rod lengths as integers only

Standard calculated rod runout per Figure C.2		Limits
Vert rod runout - basis no sag	0.0030	0.0047 0.0014
Hor rod runout	0	0.0017 -0.0017

Rod sag calculation data

• rod diameter	3	☐ Rod material AISI 4140
• rod length B	95	
• material density lb/in^3	0.2830	
• modulus of elasticity E	3.00e+07	

Moment of inertia I	3.9761	
Total rod weight	190.0	
Maximum deflection piston end fixed per Figure C.3	0.007398	Max at D = 0.4215 x length = 40.04 in. from free end (crosshead) Ref: nominal runout due to sag = 0.0026

	Calculated Runout	Runout Limits	
Rod runout at cylinder	0.0008	0.0025	-0.0008
Rod runout at crosshead	0.0061	0.0077	0.0044
Horz runout	0	0.0017	-0.0017

ROD RUNOUT AT DIFFERENT CYLINDER CLEARANCES				
Cylinder Running Clearance (in.)	Crosshead Running Clearance (in.)	Δ DROP	Rod Runout (in.)	
			At Crosshead	At Cylinder
0.080	0.020	0.030	0.0061	+0.0008
0.060	0.020	0.020	0.0051	-0.0002
0.040	0.020	0.010	0.0041	-0.0012
0.020	0.020	0.000	0.0031	-0.0022
0.010	0.020	-0.005	0.0026	-0.0027

NOTE See Figure C.9 through Figure C.13.

Figure C.8—Sample Printout for Rod Runout

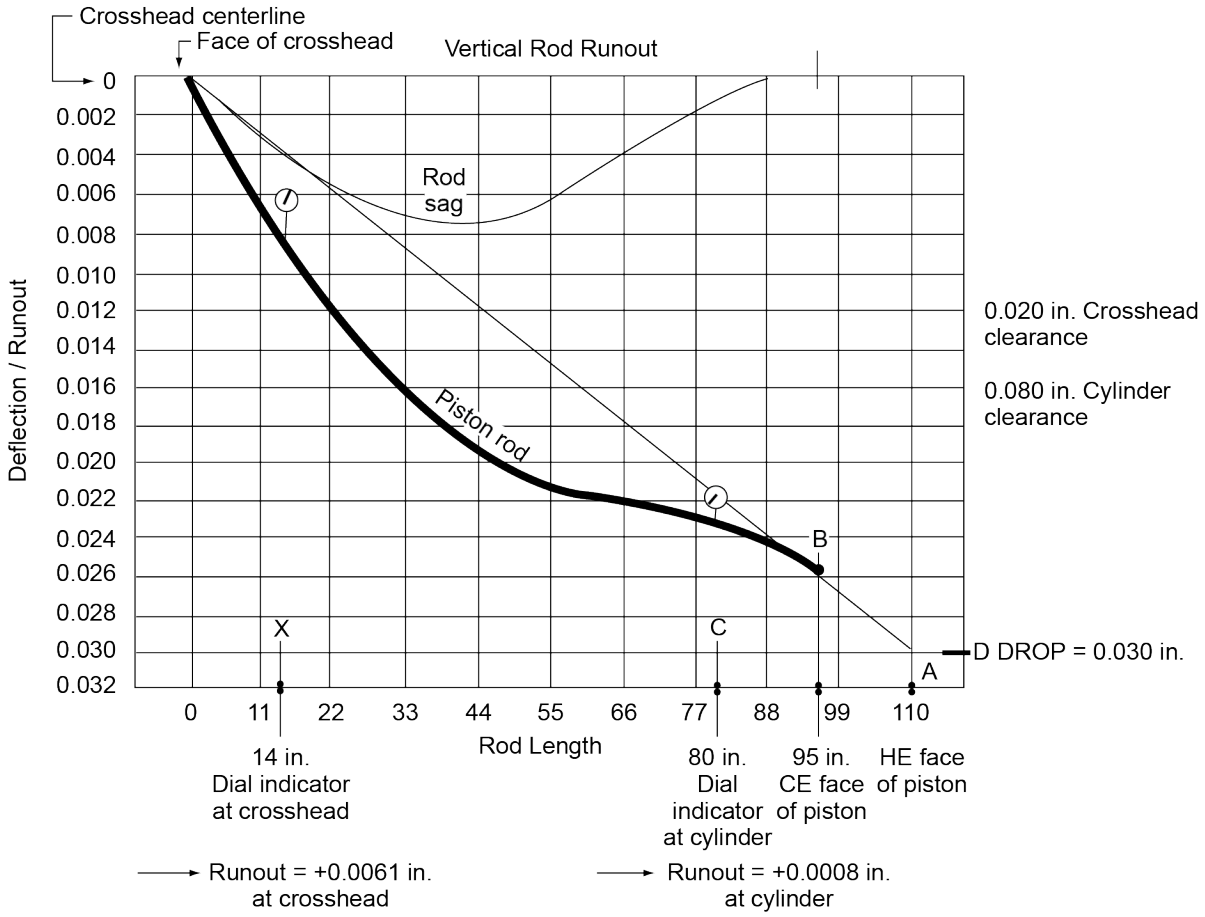


Figure C.9—Graphical Illustration of Rod Runout at 0.080 in. Cylinder Running Clearance

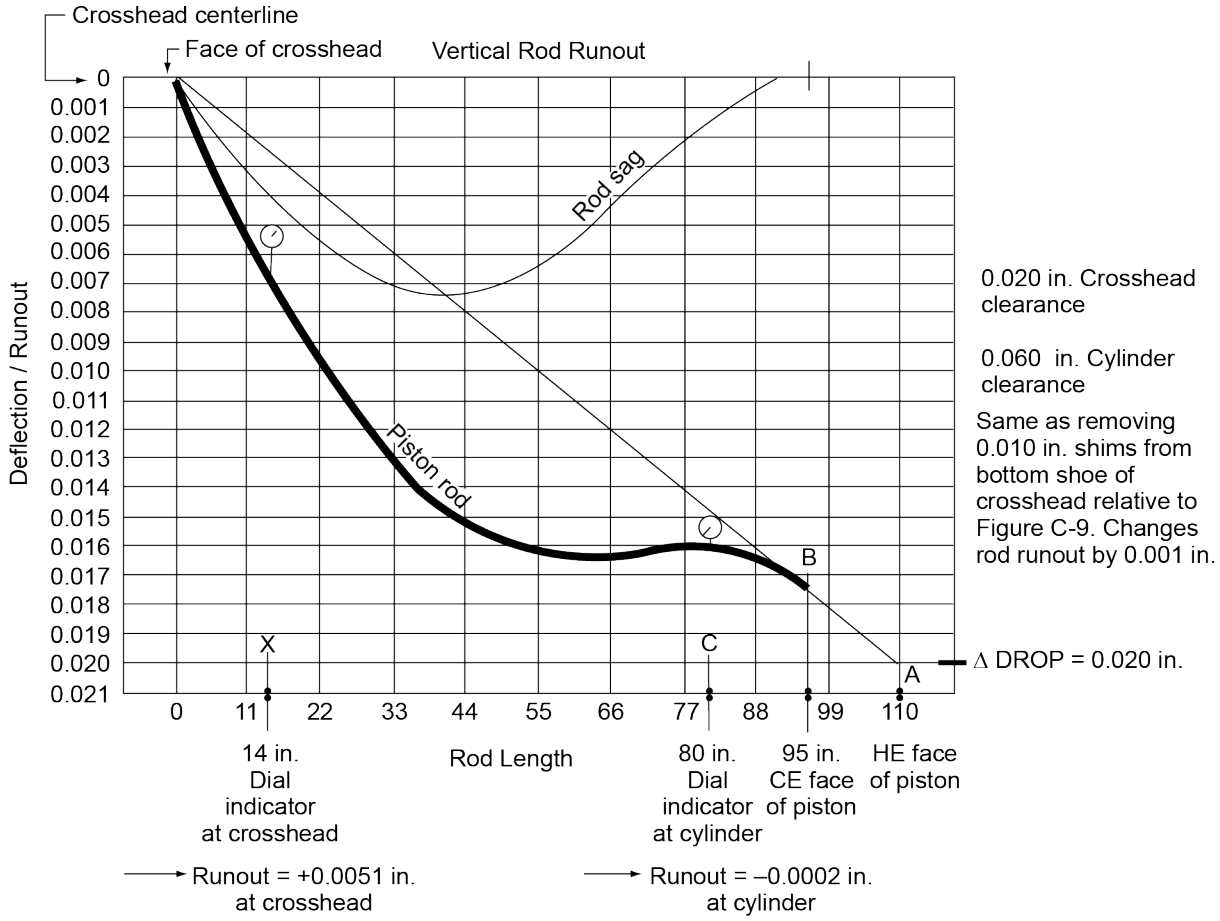


Figure C.10—Graphical Illustration of Rod Runout at 0.060 in. Cylinder Running Clearance

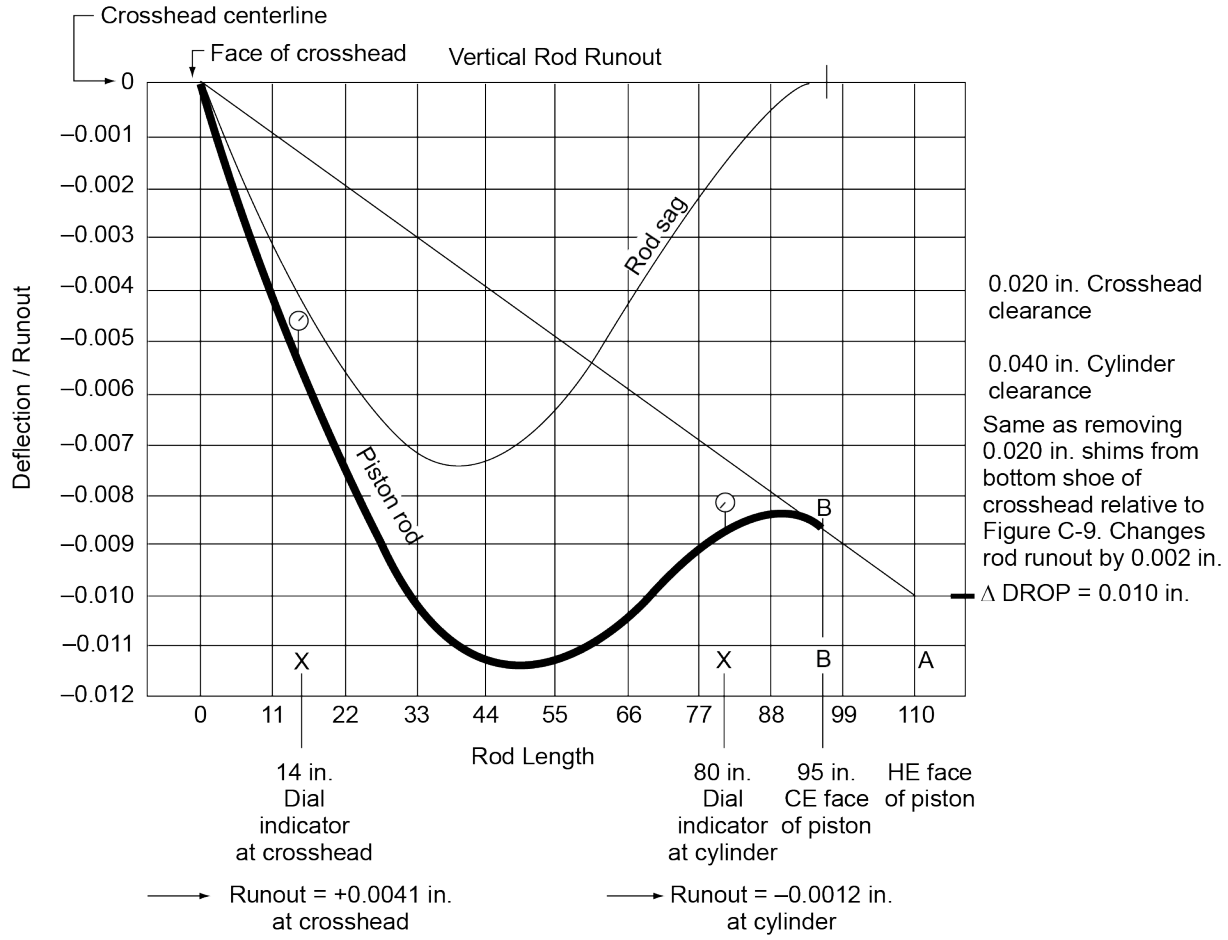


Figure C.11—Graphical Illustration of Rod Runout at 0.040 in. Cylinder Running Clearance

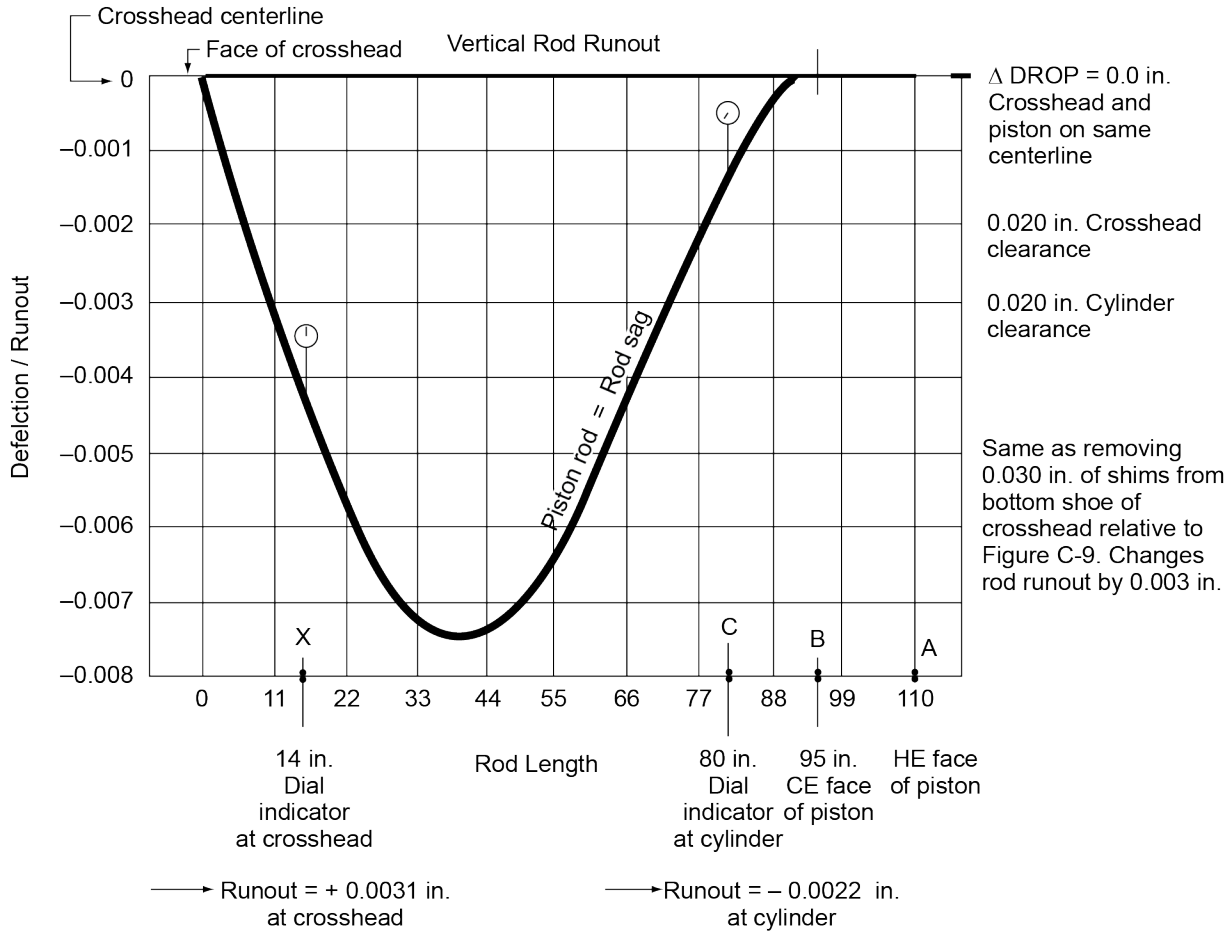


Figure C.12—Graphical Illustration of Rod Runout at 0.020 in. Cylinder Running Clearance

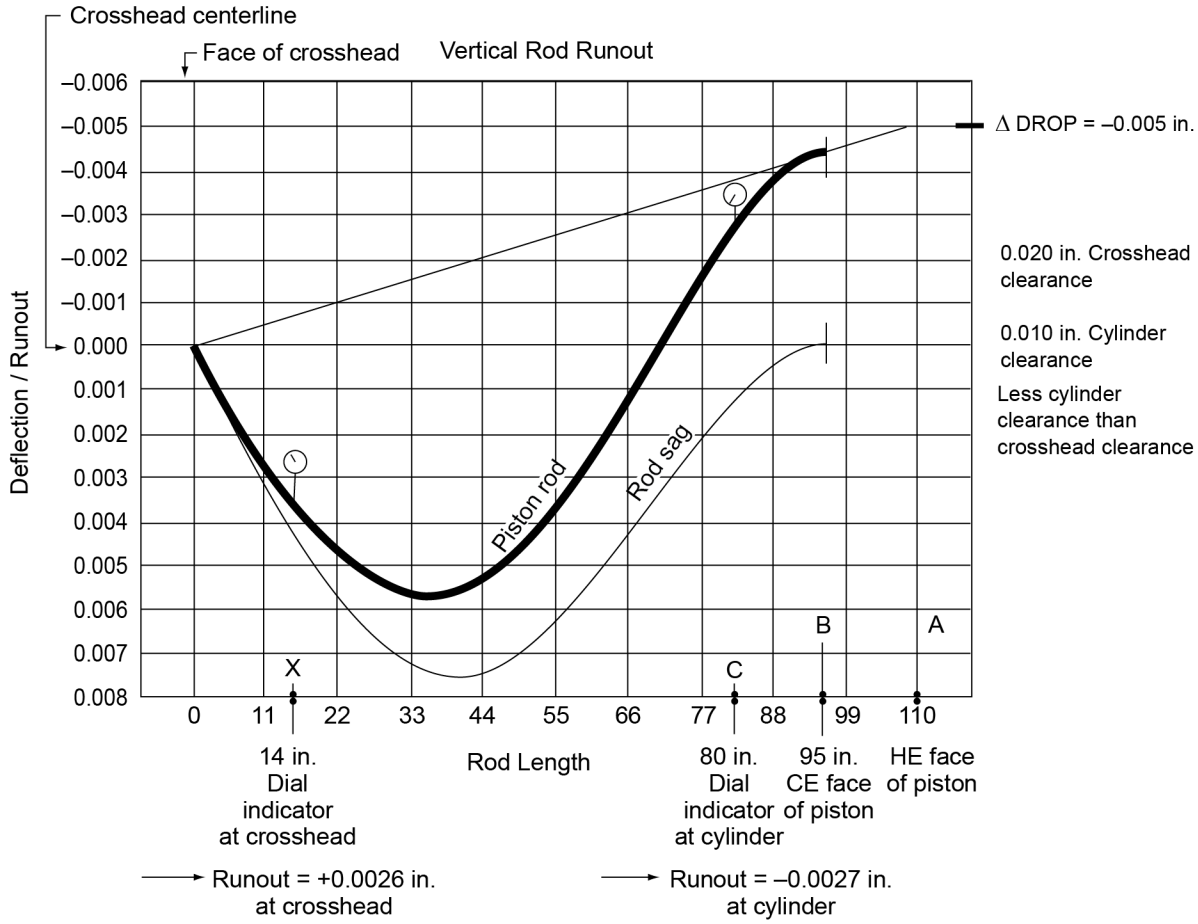


Figure C.13—Graphical Illustration of Rod Runout at 0.010 in. Cylinder Running Clearance

Annex D
(informative)

Purchaser's Checklist

This checklist (Table D.1) may be used to indicate the purchaser's specific requirements when this standard indicates, with a bullet (•), that a decision or information is required from the purchaser.

The checklist should be used in conjunction with the data sheets (Annex A). Below, the purchaser should circle yes or no, or mark the appropriate space with an X, or fill in the requirements.

NOTE The use of this checklist is optional where these items are covered by a narrative specification.

Table D.1—Purchaser's Checklist

Section	Question	Answer
2.3	Applicable standards: _____	
5.1	Have units of measurement been specified?	Yes No
6.1.4	Has equipment's normal operating point been specified?	Yes No
6.1.6	Has the pressure design code been specified?	Yes No
6.1.7	Requirements and maximum allowable sound pressure level? Requirement: _____ Maximum allowable sound pressure level: _____dB (A)	
6.1.14	Area classification for electrical components? Applicable standards: _____ Are local codes and regulations applicable?	 Yes No
6.1.18	Which details of an initial installation check shall be agreed by the vendor and the purchaser? _____ _____ Operating temperature alignment check?	 Yes No
6.1.21	Location and environmental conditions	
6.1.22	Have utility streams been identified?	Yes No
6.1.4	Equipment's normal operating point specified?	Yes No
6.4	Values specified by the purchaser, based on their experience? for: maximum average piston speed: _____ m/s for: maximum speed: _____ rpm	
6.1.26	Is 100 % unloading necessary?	Yes No
6.8.1.6	Is coating of the running bore of the cylinder required?	Yes No
6.13.2.6	Self-contained, forced circulation, closed jacket cooling system to be furnished by the vendor:	Yes No
6.8.2.1.17	Indicator tap at each end of each cylinder?	Yes No
6.8.2.1.18	Have indicator valves been specified?	Yes No
6.9.1.8	Shall the vendor submit a written valve dynamics report?	Yes No

Section	Question	Answer
6.9.2.1	Is unloading to be specified?	Yes No
6.10.3.2	Purchaser requires wear bands	Yes No
6.11.5	Are relief devices for crankcases required?	Yes No
6.12.1.1	Has type of distance piece been specified?	Yes No
6.12.1.4/ 6.12.1.5	Provision for intermediate packing sealing gas required?	Yes No
6.12.2.1	Type of distance piece covers required: Mesh screens/Louvered/Solid metal/Other	
6.12.2.3	Is higher partition differential pressure specified?	Yes No
6.12.2.5	Is distance piece purge or vacuum connection specified?	Yes No
6.13.1.1	Are shields in the crosshead housing over the oil return drains required?	Yes No
6.13.2.6	Closed liquid cooling system for packing to be supplied?	Yes No
6.13.3.2	Venting and buffer gas cups for piston rod pressure packing required?	Yes No
7.5.2.1.3	Is special-purpose oil system specified?	Yes No
7.5.2.2	Has the type of driver for auxiliary lube oil pump been specified?	Yes No
7.5.2.5	Has the heating device for oil reservoir been specified?	Yes No
7.5.2.6	Shall the relief valve for crankcase-driven pump be mounted outside the crankcase?	Yes No
7.5.3.1.1	Has the type of lubricator for compressor cylinders and for the piston rod pressure packing lubrication been specified?	Yes No
7.5.3.1.3	How shall lubricator to be driven? From crankshaft/Independently	
7.5.3.1.5	Is a heating device with thermostatic control for the lubricator reservoir required?	Yes No
7.5.3.1.7	Which alarm functions for cylinder and piston rod pressure packing lubrication are required? for cylinder: _____ for pressure packing: _____	
7.5.3.1.11	Are synthetic lubricants of compressor cylinder lubrication required and specified?	Yes No
7.5.3	Is an agreement for additional or alternative protection device for divider block lubrication required?	Yes No
6.14.1.4	Are additional material tests specified?	Yes No
6.14.1.6	Has the presence and maximum amounts of corrosive, reactive, or hazardous agents or components in the process fluid been specified?	Yes No
6.14.1.9	Has the amount of hydrogen sulfide been specified?	Yes No
6.14.5.12	Is additional inspection required for specific welds?	Yes No
6.14.5.13	Shall the proposed welding designs of fabricated cylinders be available for purchaser's review?	Yes No
6.14.6.5	Shall purchaser be given notice of repairs to major components?	Yes No
6.14.7.5	Is 100 % radiography of butt welds or magnetic particle inspection or liquid inspection of welds required?	Yes No
6.14.7.6	Shall proposed connection sketches be submitted to the purchaser before fabrication?	Yes No
6.14.8.1	Has the minimum design metal temperature related to the expected operating conditions been specified?	Yes No
6.15.4	Shall US customary or SI units be shown on the nameplates? US customary units/SI units	
7.1.1.1	Has the type of driver been specified?	Yes No

Section	Question	Answer
7.1.1.5	Are there process-variation or start-up conditions that affect driver selection?	Yes No
7.1.1.6	Are the driver starting conditions specified?	Yes No
7.1.2.2	Have the type of motor, its characteristics, and accessories been specified?	Yes No
7.1.2.4	Shall single bearing motors be provided with a temporary inboard support device?	Yes No
7.1.2.5	Has the reduced voltage for starting-torque requirements been specified?	Yes No
7.1.2.12	Shall hydrodynamic motor bearings be supplied with oil from compressor frame lubrication system?	Yes No
7.1.3.1	Has the standard for turbine drivers been specified?	Yes No
7.1.3.2	Is a separate lube oil system for turbine drive train in accordance with API 614 required?	Yes No
7.2.1.3	Are couplings required to comply with API 671?	Yes No
7.2.2.1	Has the standard for guards been specified?	Yes No
7.3.1	Has the standard for gear units been specified?	Yes No
7.7.1.1	Has the type of mounting plates been specified?	Yes No
7.7.3.5	Have chock blocks been specified?	Yes No
7.7.3.10	Have leveling plates been specified?	Yes No
7.7.4.1	Has the major equipment mounted on a baseplate been indicated?	Yes No
7.7.4.8	Has a baseplate suitable for column mounting been specified?	Yes No
7.7.4.9	Shall the baseplate be designed to facilitate optical, laser, or other accurate leveling in the field?	Yes No
7.7.4.15	Shall a dynamic response analysis of the skid be performed?	Yes No
7.7.5.1	Shall subsoleplates be provided with the baseplate?	Yes No
7.7.5.1	Have soleplates or rails been specified?	Yes No
7.8.1.3	Are all auxiliary system instrumentation be provided by the vendor specified?	Yes No
7.8.2.1	Which sensing lines handling hazardous fluids require transduced signals?_____ Source of the control signal and its sensitivity and range? _____	
7.8.2.2	Has the configuration of the control system been specified?	Yes No
7.8.2.5	Is an automatic loading-delay interlock required?	Yes No
7.8.4.1	Have instruments for local, gauge board, or instrument panel been specified?	Yes No
7.8.4.2	Has a tachometer to indicate compressor speed been specified?	Yes No
7.8.4.3.2	Have temperature detectors for packing been specified?	Yes No
7.8.4.3.2	Have temperature detectors for main bearings and valves been specified?	Yes No
7.8.6.1	Has the extent of the alarm/shutdown system to be supplied by the vendor been specified?	Yes No
7.8.6.1	Has the design of alarm and shutdown circuits been specified?	Yes No
7.8.6.5	Have high temperature alarms for crosshead pins been specified?	Yes No
7.8.7.1	Shall the vendor furnish and mount vibration detection and transducing devices?	Yes No
7.8.7.2	Shall a noncontacting proximity device to measure vertical movement of each piston rod be installed?	Yes No
7.8.7.3	Shall a one-event-per-revolution mark be provided on the crankshaft?	Yes No
7.8.7.2	Shall the vendor provide piston rod drop detectors?	Yes No

Section	Question	Answer
7.8.8	Shall the vendor supply a temperature monitoring system in accordance with API 670?	Yes No
7.9.1.2	Has the extent of piping system to be supplied by the vendor been specified on data sheet page 4?	Yes No
7.9.1.4	Shall piping, pulsation suppression devices and knockout vessels be arranged for heat tracing and insulation?	Yes No
7.9.1.15	Special requirements for piping, flanges, valves, and other appurtenances for hydrogen, hydrogen sulfide, or toxic services: _____	
7.9.5	Is a continuous through flow for instrument sensing lines to safety switches required?	Yes No
7.9.4.3	Shall coolant piping on the compressor be furnished by the vendor?	Yes No
7.9.6.1	Extent of process piping to be furnished by the vendor? _____	
7.9.6.2	Have design, location, and orientation of start-up screens been agreed?	Yes No
7.9.6.4	Shall a removable spool pieces for start-up screens by supplied?	Yes No
7.10.1.1	Has the type of intercoolers to be furnished by the vendor been specified?	Yes No
7.10.1.2	Has the type of aftercoolers to be furnished by the vendor been specified?	Yes No
7.10.2.1	Shall liquid separation and collection facilities be provided?	Yes No
7.10.2.8	Shall an automatic drainage system be provided?	Yes No
7.10.2.9	Shall level indicator and alarm and shutdown devices be provided? Has piping between compressor stages and the intercoolers and aftercoolers furnished by the vendor been specified?	Yes No Yes No
7.11.2	Have alternate gases, conditions of service or start-up been specified?	Yes No
7.11.3.3	Will compressor be operated in conjunction with other compressor units?	Yes No
7.11.4	Has Design Approach 1 been specified?	Yes No
7.11.1.5	Shall the analysis be performed by the vendor or a third party?	
7.11.1.2	Have criteria for flow pulsations in systems with sensitive elements been agreed?	Yes No
7.11.7.6.2	Shall a piping system flexibility analysis be performed?	Yes No
7.12.1.1	Shall the pulsation suppressors be stamped with the symbol of the specified pressure vessel code?	Yes No
7.12.1.5	Shall butt welds of pulsation suppression devices be 100 % radiographed?	Yes No
7.12.1.8	Shall a final moisture removal section be included in the suction suppression device?	Yes No
7.12.1.11	Has purchaser approved use of circular notched baffles?	Yes No
7.12.1.12	Shall a thermowell connection for the cylinder nozzle of each suction pulsation suppressor be provided?	Yes No
7.12.1.18	Has provision for insulation at pulsation suppression devices been specified?	Yes No
7.12.1.21	Shall internals of carbon steel suppressors be coated with phenolic or vinyl resin?	Yes No
7.12.1.23	Shall dynamic and static stresses from pulsation-induced forces be analyzed?	Yes No
7.12.3	Shall the vendor supply supports for the pulsation suppression devices and for vendor supplied piping?	Yes No
7.13.1	Has purchaser specified special design details for air intake filters?	Yes No
7.14.2	Shall hydraulic tensioning tools be included in special tools?	Yes No
7.14.5	Shall the compressor be fitted with a device to lock the shaft in position during maintenance?	Yes No

Section	Question	Answer
8.1.2	Is purchaser's inspector to submit completed inspection checklist before shipment?	Yes No
8.1.5	Has the extent of purchaser's participation in the inspection and testing and amount of advance notification been specified?	Yes No
8.2.1.1	Shall the vendor keep available for at least 20 years final assembly, maintenance, and running clearances?	Yes No
8.2.1.3 a)	Which parts shall be subjected to surface and subsurface examination?_____ _____ and which type of examination is required? _____ _____	
8.2.2.1.1	Required radiographic, ultrasonic, magnetic particle or liquid penetrant inspection of welds or materials?	
	— radiographic	Yes No
	— ultrasonic	Yes No
	— magnetic particle	Yes No
	— liquid penetrant	Yes No
8.2.3.2	Shall the oil system to be run in the manufacturer's shop?	Yes No
8.2.3.3	Has inspection for cleanliness of the equipment and all piping and appurtenances by the purchaser been specified?	Yes No
8.2.3.4	Shall the hardness of parts, welds, and heat-affected zones be tested?	Yes No
8.3.3.2	Is an operational test and a 4-hour mechanical running test prior to shipment for auxiliary system consoles required?	Yes No
8.3.4.2	Shall all machine-mounted equipment, prefabricated piping and appurtenances furnished by the vendor be fitted and assembled in the vendor's shop?	Yes No
8.3.4.4	Shall the compressor be performance tested in accordance with ISO 1217?	Yes No
8.4.1	Time for storage for a longer period than 6 months? _____	
8.4.14	Shall the equipment be packed for domestic or export shipment? Domestic/Export	
8.4.16	Special requirements for long-term storage of spare parts: _____ _____	
E.2.3.2 l)	Is a list of similar machines installed to be attached to the proposal required?	Yes No
E.3.1.2	Has time allowed for the purchaser to review vendor's data been specified and agreed?	Yes No
E.2.4	Shall the vendor submit performance curves or tables etc.?	Yes No
E.2.4.3	Shall the vendor furnish data required for independent rod load, gas load, and rod load reversal calculations?	Yes No
E.2.4.4	Shall the effect of valve failure on rod loads and reversals be calculated and furnished?	Yes No

Annex E
(informative)

Contract Documents and Engineering Design Data

E.1 General

E.1.1 When specified by the purchaser (see Section 9), the contract documents and engineering design data shall be supplied by the vendor, as listed in this annex.

E.1.2 The following data shall be identified with the following information on transmittal (cover) letters, title pages, and correspondence:

a) purchaser's/owner's corporate name;

b) job/project number;

c) equipment item number and service name;

d) inquiry or purchase order number;

e) any other identification specified in the inquiry or purchase order;

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

E.1.3 Each drawing shall have a title block in the lower right-hand corner with the date of certification, identification data specified in E.1.2, revision number, and date and title. Similar information shall be provided on all other documents including subvendor items.

E.2 Proposals

E.2.1 General

E.2.1.1 The vendor shall forward the original proposal, with the specified number of copies, to the addressee specified in the inquiry documents.

E.2.1.2 The proposal shall include, as a minimum, the data specified in E.2.2 through E.2.5, and a specific statement that the equipment and all its components and auxiliaries are in strict accordance with this standard.

E.2.1.3 If the equipment or any of its components or auxiliaries is not in strict accordance, the vendor shall include a list that details and explains each deviation.

E.2.1.4 The vendor shall provide sufficient detail to enable the purchaser to evaluate any proposed alternative designs.

E.2.1.5 All correspondence shall be clearly identified in accordance with E.1.3.

E.2.2 Drawings

E.2.2.1 The drawings indicated in the "Vendor Drawing and Data Requirements" section in this annex shall be included in the proposal. As a minimum, the following shall be included:

a) a general arrangement or outline drawing for each machine train or skid-mounted package, showing overall dimensions, maintenance clearance dimensions, overall weights, erection weights, and the largest maintenance weight for each item; the direction of rotation and the size and location of major purchaser connections shall also be indicated;

b) cross-sectional drawings showing the details of the proposed equipment;

c) schematics of all auxiliary systems, including fuel, lube oil, control, and electrical systems;

d) bills of material;

e) sketches that show methods of lifting the assembled machine or machines, packages, and major components and auxiliaries. (This information may be included on the drawings specified in item a above.)

E.2.2.2 If "typical" drawings, schematics, and bills of material are used, they shall be marked up to show the weight and dimension data to reflect the actual equipment and scope proposed.

E.2.3 Technical Data for Proposal

E.2.3.1 All technical data shall be given in units of measurement according to the purchase order. If needed, the technical data in alternate units can be included in parentheses.

E.2.3.2 The following data shall be included in the proposal:

a) purchaser's data sheets with complete vendor's information entered thereon and literature to fully describe details of the offering;

b) predicted noise data (see 6.1.7);

c) vendor drawing and data requirements (VDDR) form (or equivalent listing) 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; to include as a minimum three lube oil filter cartridge sets, rings/plates and springs for each valve, one set of packing rings for each rod, one set of rings and rider bands for each piston, plus all O-rings and gaskets necessary for a complete change-out of all packing rings, all piston rings, and all valves;

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 data sheets; 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 8.3.4;

k) description of any special requirements, whether specified in the purchaser's inquiry or as outlined in this document;

l) a 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) a list of any components that can be construed as being of alternative design, hence requiring purchaser's acceptance (see E.2.1.4);

o) component designed for a finite life (see 6.1.2);

p) materials of major components of the compressor (see 6.14.1.1 and 6.14.1.2);

q) preliminary crosshead pin and gas load tabulation in accordance with 6.6.3.

E.2.4 Performance Data

● **E.2.4.1** If specified, the vendor shall submit performance curves or tables of power and capacity versus suction pressure with parameters of discharge pressure, showing the effects of unloading devices and showing any operating limitation and with calculation input and output data identified, all as agreed.

E.2.4.2 Crosshead pin load and gas load charts for each load step, complete in accordance with 6.6, including inertial forces and crosshead pin load reversal magnitude and duration shall be furnished.

● **E.2.4.3** If specified, the vendor shall furnish the data required for independent crosshead pin load, gas load, and reversal calculations.

● **E.2.4.4** If specified, the effect of valve failure on crosshead pin loads and reversal shall be calculated and furnished. The required specifics of this study shall be agreed upon by the purchaser and the vendor.

E.2.4.5 Curves of starting torque versus speed shall be furnished for the compressor, for the motor at the specified voltage reduction. The curve sheet shall also state separately the moment of inertia of the motor alone and the resultant moment of inertia of the driven equipment referred to the motor shaft speed plus the calculated time for acceleration to full speed at the specified voltages (see 7.1.2) and specified operating conditions (see 7.1.1.6 and 7.1.2.1). All curves shall be scaled in finite values. Values expressed in percentage terms alone shall not be provided.

● **E.2.4.6** If specified, the vendor shall submit operating envelope graphs that define the acceptable operating ranges and limitations.

E.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.

E.3 Engineering Design Data

E.3.1 General

E.3.1.1 Engineering data shall be furnished by the vendor in accordance with the agreed VDDR form.

E.3.1.2 The purchaser shall 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 in writing. After the data have been reviewed and accepted, the vendor shall furnish certified copies in the quantities specified.

E.3.1.3 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.

E.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 E.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, and shall satisfy the applicable detailed descriptions in this annex.

E.3.3 Progress Reports

The vendor shall submit progress reports to the purchaser at intervals specified which shall, as a minimum, include the following:

a) overall progress summary;

b) status of engineering;

c) status of document submittals;

d) status of major suborders;

e) updated production schedule;

f) inspection/testing highlights for the month;

g) any pending issues.

E.3.4 Parts Lists and Recommended Spares

E.3.4.1 The vendor shall submit complete parts lists for all equipment and accessories supplied.

E.3.4.2 These lists shall include part names, manufacturers' unique part numbers, and materials of construction (identified by applicable international standards).

E.3.4.3 Each part shall be completely identified and shown on appropriate cross-sectional, assembly-type cutaway, or exploded-view isometric drawings.

E.3.4.4 Interchangeable parts shall be identified as such.

E.3.4.5 Parts that have been modified from standard dimensions or finish to satisfy specific performance requirements shall be uniquely identified by part number.

E.3.4.6 The vendor shall indicate on each of these complete parts lists all those parts that are recommended as start-up or maintenance spares, and the recommended stocking quantities of each. These shall include spare parts recommendations of subvendors that were not available for inclusion in the vendor's original proposal.

E.3.5 Installation, Operation, Maintenance, and Technical Data Manuals

E.3.5.1 General

E.3.5.1.1 The vendor shall provide sufficient written instructions and all necessary drawings to enable the purchaser to install, operate, and maintain all of the equipment covered by the purchase order. This information shall be compiled in a manual or manuals with a cover sheet showing the information listed in E.1.3, an index sheet, and a complete list of the enclosed drawings by title and drawing number. The manual pages and drawings shall be numbered. The manual or manuals shall be prepared specifically for the equipment covered by the purchase order. "Typical" manuals are unacceptable.

E.3.5.1.2 A draft manual(s) shall be issued to purchaser 8 weeks prior to mechanical testing for review and comment.

E.3.5.1.3 Refer to the VDDR form for number of copies. Hard copies as well as electronic copies shall be provided as described on VDDR.

E.3.5.2 Installation Manual

E.3.5.2.1 All information required for the proper installation of the equipment shall be compiled in a manual that shall be issued no later than the time of issue of final certified drawings. For this reason, it may be separate from the operating and maintenance instructions.

E.3.5.2.2 This manual shall contain information on alignment and grouting procedures, normal and maximum utility requirements, centers of mass, rigging provisions and procedures, and all other installation data.

E.3.5.2.3 All drawings and data specified in E.2.2 and E.2.3 that are pertinent to proper installation shall be included as part of this manual.

E.3.5.2.4 One extra manual, over and above the specified quantity, shall be included with the first equipment shipped.

E.3.5.2.5 All recommended receiving and storage procedures shall be included.

NOTE Refer to API 686 for data required for installation.

E.3.5.3 Operating and Maintenance Manual

E.3.5.3.1 A manual containing all required operating and maintenance instructions shall be supplied at shipment. 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.

E.3.5.3.2 Torque values for all studs and bolting shall be included in the manufacturer's instruction manual.

E.3.5.4 Technical Data Manual

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

E.3.6 Vendor Drawing and Data Requirements

E.3.6.1 General

This annex consists of a sample VDDR form (see Figure E.1), followed by a list of possible items that may be included on the form and representative descriptions of those items. Since different manufacturers will use different names for the same drawing, the items in the description column of the VDDR should be modified in the early stages of the order using the drawing names supplied by the manufacturer.

VDDR Form Example

VENDOR DRAWING AND DATA REQUIREMENTS		
	Job No.	Item No.
	Purchase Order No.	Date
	Requisition No.	Date
	Inquiry No.	Date
	Revision by	Manufacturer
	For	Unit
	Site	Service

Proposal [a]—Bidder shall furnish number of paper copies/number of electronic copies of data as indicated
Review—Vendor shall furnish number of paper copies/number of electronic copies of data as indicated
Final—Vendor shall furnish number of paper copies/number of electronic copies of data as indicated

			Description (see text)	**Distribution Record**				
				Review Due from Vendor [b c]	Review Received from Vendor	Review Returned to Vendor	Final Due from Vendor [c]	Final Received from Vendor

[a] Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.
[b] Purchase may indicate in the column the desired time frame for submission of data.
[c] Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

Notes:

1. All drawings and data shall show project, purchase order, and item numbers as well as plant location and unit. One set of the drawings and instructions necessary for field installation, in addition to the copies specified above, shall be forwarded with shipment.

2. See the descriptions of required items that follow.

3. If typical drawings, schematics, and bills of material are used for proposals, they shall be marked-up to show the expected weight and dimensions to reflect the actual equipment and scope proposed.

Nomenclature:

S number of weeks before 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)

Figure E.1—Sample VDDR Form

E.3.6.2 Items for VDDR Form

Items to be entered on the VDDR should be selected from the following list as appropriate. However, this list is not necessarily all-inclusive.

1) Certified dimensional outline drawing (general arrangement) and list of connections.

2) Foundation plan showing anchor bolt locations.

3) Allowable flange loading (either cylinder or pulsation suppression device) and coordinates.

4) Driver outline.

5) Drive arrangement drawing.

6) Dimensional outline for all vendor-supplied major accessory equipment.

7) Performance data.

8) Piston rod pressure packing drawing(s).

9) Gas load, rod load, and crosshead pin load reversal and duration charts.

10) Starting torque versus speed curves (for driver and compressor).

11) Motor driver performance characteristics.

12) Tabulation of utility requirements.

13) List of unsafe or undesirable speeds.

14) Gear data.

15) Other driver data.

16) Shaft coupling assembly drawing and bill of materials.

17) Weld procedures for fabrication and repair, including those for pulsation suppression devices.

18) Intercooler and aftercooler data.

19) Parts list with sectional drawings.

20) “Start-up” spares list.

21) Recommended normal maintenance spare parts.

22) Process schematic.

23) Frame and cylinder lube oil schematics and bills of materials.

24) Lube oil system assembly drawings and list of connections.

25) Lube oil system component drawings and data.

26) Cooling system schematics and bills of materials.

27) Cooling system assembly drawings and list of connections.

28) Cooling system component drawings and data.

29) Distance piece vent, drain and buffer schematics, and list of connections.

30) Capacity control schematics and bill of materials.

31) Instrumentation and electrical schematics and bills of materials.

32) Instrumentation and electrical arrangement drawing and list of connections.

33) Instrumentation and electrical wiring diagrams.

34) Instrumentation set point list.

35) Instrumentation data sheets.

36) Pulsation suppression device detail drawings and final pressure code calculations.

37) Special tools list.

38) Fabrication, testing, and delivery schedule.

39) Drawing list.

40) Weather protection and climatization required.

41) Comments on purchaser’s piping and foundation drawings.

42) Progress reports.

43) Torsional analysis report.

44) Data for an independent torsional analysis.

45) Acoustic and mechanical analysis report.

46) Data required for third-party acoustic and mechanical analysis.

47) Engineering analysis for fabricated cylinders.

48) Balancing data tabulation.

49) Valve dynamics report.

50) Data for an independent valve dynamic analysis.

51) Connection sketches.

52) Shaft alignment diagram.

53) As-built dimensions and data.

54) Hydrostatic and gas test certificates.

55) Certified mechanical run test data (if test ordered).

56) Certified performance test data (if test ordered).

57) Nondestructive test procedures for fabricated cylinders.

58) Procedures for special or optional tests (if tests ordered).

59) Certified data from special or optional tests (if tests ordered).

60) Certified mill test reports.

61) Crankshaft ultrasonic test certificate.

62) Valve leak test certificate.

63) As-built data sheets.

64) Installation manual.

65) Operation and maintenance manual.

66) Technical data manual.

67) Procedures for preservation, packing, and shipping.

68) Shipping list.

69) Material safety data sheets.

70) Quality plan.

71) Control logic diagrams.

E.3.6.3 Description of VDDR Items

The following items describe what is typically included on each item. However, this list is not necessarily all-inclusive.

1) Certified dimensional outline drawings (general arrangement) and tables include, but are not limited to, the following:

   a) size, type, rating, location, and identification of all customer connections, including vents, drains, lubricating oil, conduits, conduit boxes, electrical and pneumatic junction boxes, and instruments; the vendor's plugged connections shall be identified; details of special connections are required;

   b) the mass (weight) of each assembly, of the heaviest piece of equipment to be handled for erection and of significant items to be handled for maintenance;

   c) all principal dimensions, as well as those required for piping design, maintenance clearances, and dismantling clearances, including valve maintenance clearance if pulsation suppression devices are not supplied;

   d) shaft center line height;

   e) shaft end separation;

   f) center of mass (gravity), vertical and plan location;

g) direction of rotation;

h) when applicable, the make, size, and type of couplings and the location of guards and their coverage.

2) Foundation plan, including the following:

a) dimensions of mounting plates for the complete train and auxiliary systems complete with diameter, number and location of both holes, and thickness of metal through which bolts pass;

b) speed, critical speed (if any);

c) location and direction in the x-, y-, z-coordinate system of static and the first and second order dynamic (unbalanced) forces and moments;

d) location of the center of mass;

e) leveling jackscrew location.

3) Allowable flange loading (either cylinder or pulsation suppression device) and coordinates; allowable flange loading(s) for all cylinder (or pulsation bottle) connections, including anticipated thermal movements referenced to a defined point, and x-, y-, z-coordinate system.

4) Driver outline; certified dimensional outline drawing for the driver and all its auxiliary equipment including the following:

a) size, location, orientation, and purpose of all customer connections, including conduit boxes, conduit, instrumentation, and any piping or ducting;

b) type, rating, and facing for any flanged connections;

c) size and location of anchor bolt holes and leveling jackscrews and thickness of sections through which bolts pass;

d) total mass of each item of equipment (driver and auxiliary equipment), plus loading diagrams, heaviest weight, and name of the part;

e) overall dimensions and all horizontal and vertical clearances necessary for dismantling and the approximate location of lifting lugs;

f) shaft center line height;

g) shaft end dimensions, plus tolerances for the coupling;

h) direction of rotation.

5) Drive arrangement drawing, including, but not limited to, the following:

a) flywheel data;

b) driver and mechanical transmission mass;

c) moments of inertia;

d) stator shift;

e) air gap.

6) Dimensional outline for all vendor supplied major accessory equipment.

7) Performance data. See E.2.4.

8) Piston rod pressure packing drawing(s). (One for each packing type.)

9) Gas load, rod load, and crosshead pin load reversal and duration charts. See E.2.4.2.

10) Starting torque versus speed curves. (For driver and compressor—on the same chart.) Acceleration time. See E.2.4.5.

11) Motor driver performance characteristics and performance data, including the following.

a) For induction motors 150 kW (200 hp) and smaller:

i) efficiency and power factors at one-half, three-quarter, and full load;

ii) torque-speed curves.

b) For induction motors larger than 150 kW (200 hp), certified test reports for all tests run and performance curves as follows:

i) time-current heating curve;

ii) torque-speed curves at 70 %, 80 %, 90 %, and 100 % of rated voltage;

iii) efficiency and power factor curves from 0 to rated service factor;

iv) current versus load curves from 0 to rated service factor;

v) current versus speed curves from 0 to 100 % of rated speed;

vi) permissible safe stall time and repeated start capability (hot and cold).

c) For synchronous motors:

i) torque-speed, current-speed, and power factor-speed curves at 70 %, 80 %, 90 %, and 100 % of rated voltage;

ii) pull-in and pull-out torque;

iii) permissible safe stall time and repeated start capability (hot and cold);

iv) efficiency and power factor curves from 0 to rated service factor;

v) current pulsation-speed curve during normal acceleration.

12) Tabulation of utility requirements (may be on data sheets).

13) List of unsafe or undesirable speeds. See 6.1.12.

14) Gear data.

a) Certified dimensional outline drawings and list of connections, including the following:

i) the size, rating, location, and identification of all customer connections including vents, drains, lube oil, conduit boxes, junction boxes, and instruments;

ii) all principal dimensions, including those required for the purchaser's foundation, piping design, maintenance clearances, and dismantling clearances;

iii) overall and handling masses;

iv) shaft center line heights;

v) shaft end dimensions and tolerances for the couplings;

vi) direction of rotation;

vii) location of the center of mass of the gear unit;

viii) the size and location of anchor bolt holes and thickness of sections through which bolts pass;

ix) thermal and mechanical movements of casings and shafts.

b) Cross-sectional drawing and bill of materials, including axial gear and pinion float.

c) As-built data sheets, including the following:

i) data for torsional analysis;

ii) lateral critical speed reports, if specified;

iii) certified mechanical running test data.

d) Certified gear manufacturer's standard test data including gear contact test data.

e) Optional test data and reports agreed upon by the purchaser and the manufacturer.

f) Spare parts recommendations.

15) Other driver data, including the following:

a) cross-sectional drawing and bill of materials, including the axial rotor float;

b) as-built data sheets;

c) certified drawings of driver auxiliary systems including wiring diagrams for each auxiliary system supplied; the drawings shall clearly indicate the extent of the system to be supplied by the manufacturer and the extent to be supplied by others;

d) spare parts recommendations;

e) other driver data per driver VDDR.

16) Shaft coupling assembly drawing and bill of materials, including the following:

a) allowable misalignment;

b) hydraulic mounting procedure;

c) shaft end gap and tolerance;

d) coupling guards.

17) Weld procedures for fabrication and/or repair, including those for pulsation suppression devices. See 6.14.6.3.

18) Intercooler and aftercooler data, including, but not limited to, the following:

a) dimensional outline drawings;

b) data sheets (e.g. TEMA);

c) final calculation in accordance with the specified pressure code.

19) Parts list with sectional drawings; the parts list shall include pattern number, stock or production drawing numbers, and the materials of construction. The list shall completely identify each part so that the purchaser may determine interchangeability of parts with other equipment furnished by the same manufacturer. Standard purchased items shall be identified by the original manufacturer's name and part number. Materials shall be identified as specified in 6.14.1.2.

20) "Start-up" spares list. See E.3.4.

21) Recommended normal maintenance spare parts. See E.3.4.

22) Process schematic: Schematic diagram of the process fluids flowing through the machine, including the following:

a) steady-state and transient gas flow rates, temperatures, and pressures;

b) cooler heat loads;

c) pipe, tubing, and valve sizes of equipment provided by the vendor;

d) instrumentation, safety devices, and control schemes;

e) bill of materials.

23) Frame and cylinder lube oil schematics, including the following:

a) steady-state and transient oil flows and pressures at each point;

b) control, alarm, and trip settings (pressure and recommended temperatures);

c) total heat loads;

d) utility requirements, including electrical, water, and air;

e) pipe, tubing, and valve sizes;

f) instrumentation, safety devices, and control schemes;

g) bills of materials.

24) Lube oil system assembly drawings and list of connections. Lube oil system assembly and arrangement drawing(s), including size, rating, and location of all customer connections.

25) Lube oil system component drawings and data, including the following:

    a) outline and sectional drawings and data sheets for auxiliary pumps and drivers;

    b) outline and sectional drawings and data sheets for coolers, filters, and reservoir;

    c) instrumentation;

    d) spare parts lists and recommendations.

26) Cooling system schematics and bill of materials; cooling (including packing cooling) or heating schematic and bill of materials including cooling or heating fluid, fluid flows, pressure, pipe and valve sizes, instrumentation, and orifice sizes.

27) Cooling system assembly drawings and list of connections; cooling (including packing cooling) or heating system assembly and arrangement drawing(s), including size, rating, and location of all customer connections.

28) Cooling system component drawings and data:

    a) outline and sectional drawings and data sheets for pumps and coolers;

    b) outline and sectional drawings and data sheets for coolers, filters, and reservoir;

    c) instrumentation;

    d) spare parts lists and recommendations.

29) Distance piece vent, drain, and buffer schematics and list of connections. Distance piece vent, drain, and purge schematic and bill of materials including fluid, fluid flows, pressure, pipe, tube and valve sizes, and instrumentation.

30) Capacity control schematics and bill of materials.

31) Instrumentation and electrical schematics and bills of materials for all systems, including pneumatic and hydraulic systems (including bar-over device limit switch).

32) Instrumentation and electrical arrangement drawing and list of connections, including pneumatic and hydraulic systems and including, but not limited to, the following:

    a) control panel general arrangement;

    b) control panel certified outline;

    c) control panel bill of materials.

33) Instrumentation and electrical wiring diagrams for all systems.

34) Instrumentation set point list, including set points for all alarm, shutdown, and control devices, including the following:

    a) vibration alarm and shutdown limits;

b) bearing temperature alarm and shutdown limits;

c) lube oil temperature alarm and shutdown limits;

d) lube oil pressure alarm and shutdown limits;

e) gas discharge temperature alarm and shutdown limits;

f) frame oil level alarm limit;

g) rod packing temperature alarm;

h) oil filter differential pressure alarm;

i) inlet separator level shutdown;

j) cylinder lubrication protection;

k) jacket water protection.

35) Instrumentation data sheets.

36) Pulsation suppression device detail drawings and final pressure code calculations.

37) Special tools list (see 7.14); list of special tools furnished for maintenance.

38) Fabrication, testing, and delivery schedule; milestone fabrication, testing, and delivery schedule, including vendor buyouts.

39) Drawing list including latest revision numbers and dates.

40) Weather protection and climatization required.

41) Comments on purchaser's piping and foundation drawings.

42) Progress reports (see E.3.3), including the following:

a) planned and actual milestone dates;

b) engineering and manufacturing information on all major components;

c) details of causes of delays.

43) Torsional analysis report (see 6.7.1 and 7.1.1.7), including, but not limited to, the following:

a) complete description of method used;

b) graphic display of mass elastic system;

c) tabulation identifying the mass moment and torsional stiffness for each component identified in the mass elastic system;

d) graphic display of exciting forces versus speed and frequency;

e) graphic display of torsional critical speeds and deflections (mode shape diagram);

f) effects of proposed changes on analysis;

g) current pulsation analysis.

44) Data for an independent torsional analysis.

45) Acoustic and mechanical analysis report (see 7.11.6), including, but not limited to, the following:

a) design approach (see 7.11.6.1.1) and method used (complete description), including description of design techniques used;

b) findings and comparison with permitted values;

c) effects of required modifications and marked-up drawings showing changes.

46) Data required for third-party acoustic and mechanical analysis.

NOTE It is the purchaser's responsibility to provide some of the information described.

47) Engineering analysis for fabricated cylinders. See 6.14.5.1.

48) Balancing data tabulation; listing of mass balance data for each throw, including piston, rod, crosshead, nuts, bushings, bearings, and balance masses and including both design target masses and actual assembly masses. The allowable mass tolerance per throw shall be stated.

49) Valve dynamics report. See 6.9.1.8.

50) Data for an independent valve dynamic analysis.

51) Connection sketches. See 6.14.7.6.

52) Coupling-to-shaft alignment diagram; shaft alignment diagrams (vertical and horizontal), including recommended coupling limits during operation. Note all shaft-end position changes and support growths from 15 °C (60 °F) ambient reference temperature or other reference temperature specified by the purchaser. Include the recommended alignment method and cold setting targets.

53) As-built dimensions and data, including the following:

a) fits, clearances, and runouts measured during final assembly;

b) nameplate data for each cylinder;

c) cylinder minimum and design clearances for each end of each cylinder;

d) volume of all clearance pockets, plugs, or bottles installed on each cylinder;

e) crank angle phasing.

54) Hydrostatic and gas test certificates. See 8.3.2.

55) Certified mechanical run test data (if test ordered).

56) Certified performance test data (if test ordered).

57) Nondestructive test procedures for fabricated cylinders.

58) Procedures for any special or optional tests (if tests ordered).

59) Certified data from special or optional tests (if test ordered). See E.2.5.

60) Certified mill test reports of items as agreed in the precommitment or pre-inspection meeting(s). Physical and chemical data.

61) Crankshaft ultrasonic test certificate. See 8.2.2.3.2.

62) Valve leak test certificate.

63) As-built data sheets for compressor, gear, driver, and auxiliary equipment, including gas data.

64) Installation manual (see E.3.5.2) describing the installation requirements for the complete train, including the drawings necessary for assembly of the equipment and location of field connections and including but not limited to the following.

    a) Section 1—Compressor:

        i) items 1), 2), 3), 40), and 52);

        ii) grouting (see 7.7.4.10);

        iii) setting equipment, rigging procedures, component masses, and lifting diagram;

        iv) dismantling clearances;

        v) preservation and storage requirements (see 8.4.1);

        vi) field assembly procedures, including frame and cylinder alignment requirements.

    b) Section 2—Driver:

        i) storage and preservation;

        ii) setting gear, rigging procedures, component masses, and lifting diagram;

        iii) piping recommendations;

        iv) composite outline drawing for driver, including anchor bolt hole locations;

        v) dismantling clearances;

        vi) thermal and mechanical movements of frame and shaft;

        vii) motor air gap data (see 7.1.2.11).

    c) Section 3—Gear:

        i) storage and preservation;

        ii) setting gear, rigging procedures, component masses, and lifting diagram;

        iii) piping recommendations;

        iv) composite outline drawing for gear, including anchor bolt hole locations;

v) dismantling clearances;

vi) thermal and mechanical movements of casing and shaft.

d) Section 4—Auxiliary equipment:

i) storage and preservation;

ii) setting equipment, rigging procedures, component masses, and lifting diagram;

iii) piping recommendation.

65) Operation and maintenance manual (see E.3.5.3) describing the operating and maintenance procedures, requirements, and limitations for the complete train and auxiliary equipment, including but not limited to the following.

a) Section 1—Operation:

i) initial commissioning and start-up, including final tests and checks;

ii) normal start-up;

iii) normal shutdown;

iv) emergency shutdown;

v) operating limits, including item 13) above;

vi) lube oil recommendations, including injection rates and specifications;

vii) routine operational procedures;

viii) items 22), 30), 34), and 71).

b) Section 2—Maintenance, disassembly, repair, and reassembly instructions for the complete train and auxiliary and accessory equipment, including, but not limited to, the following:

i) valve overhaul data;

ii) cylinder overhaul data;

iii) table of bolt torques; the required torque values or elongations for tensioning the valve cover, valve hold-down bolts, connecting rod and main bearing bolts, piston and crosshead nuts, flange bolts, and any other bolts that the vendor feels are critical; data should be included for fasteners in both the lubricated and nonlubricated condition;

iv) fits and clearances for wearing parts, recommended, maximum and minimum;

v) items 4), 8), 19), 21), 37), 48), 52), 53), and 63);

vi) routine maintenance requirements;

vii) maximum allowable crankshaft web deflection.

c) Section 3—Performance data. Items 7), 9), and 10).

d) Section 4—As-built data. Items 53) and 63).

e) Section 5—Drawing and data:

i) drawings in the manual shall be for the specific equipment supplied; typical drawings are unacceptable;

ii) items 1), 5), 6), 8), 11), 15), 16), 19), 23), 24), 25), 26), 27), 28), 29), 30), 31), 32), 33), 36), and 39).

66) Technical data manual (see E.3.5.4); technical and quality control data for technical support personnel for the complete train and auxiliary equipment, including, but not limited to, items 1), 2), 3), 4), 5), 6), 7), 8), 9), 10), 11), 12), 13), 14), 15), 16), 18), 19), 20), 23), 26), 29), 30), 31), 33), 34), 35), 36), 37), 39), 40), 43), 45), 46), 47), 48), 49), 52), 53), 54), 55), 56), 57), 58), 59), 60), 61), 62), and 63).

67) Procedures for preservation, packing, and shipping.

68) Shipping list, including all major components that will ship separately.

69) Material safety data sheets; description of the hazardous and potentially hazardous materials included in the scope of supply.

70) Quality plan; in accordance with ISO 9000 series.

71) Control logic diagram.

Annex F
(normative)

Figures and Schematics

The schematics presented here illustrate the general philosophy and requirements of this standard and are typical of commonly used systems: they are not intended to include all details such as vent and drain details and minor piping connections to permit disassembly. The systems may be modified as necessary with the agreement of the purchaser and the vendor.

Instrument piping and valving details are not shown on typical schematics. Such requirements, including online testing requirements, shall be agreed upon by the purchaser and the vendor.

Requirements for all of the systems illustrated here are covered in the main text, as indicated by the cross-references in the notes accompanying each figure. Further elaboration on the details of pressure packing to minimize process gas emissions is given in Annex H.

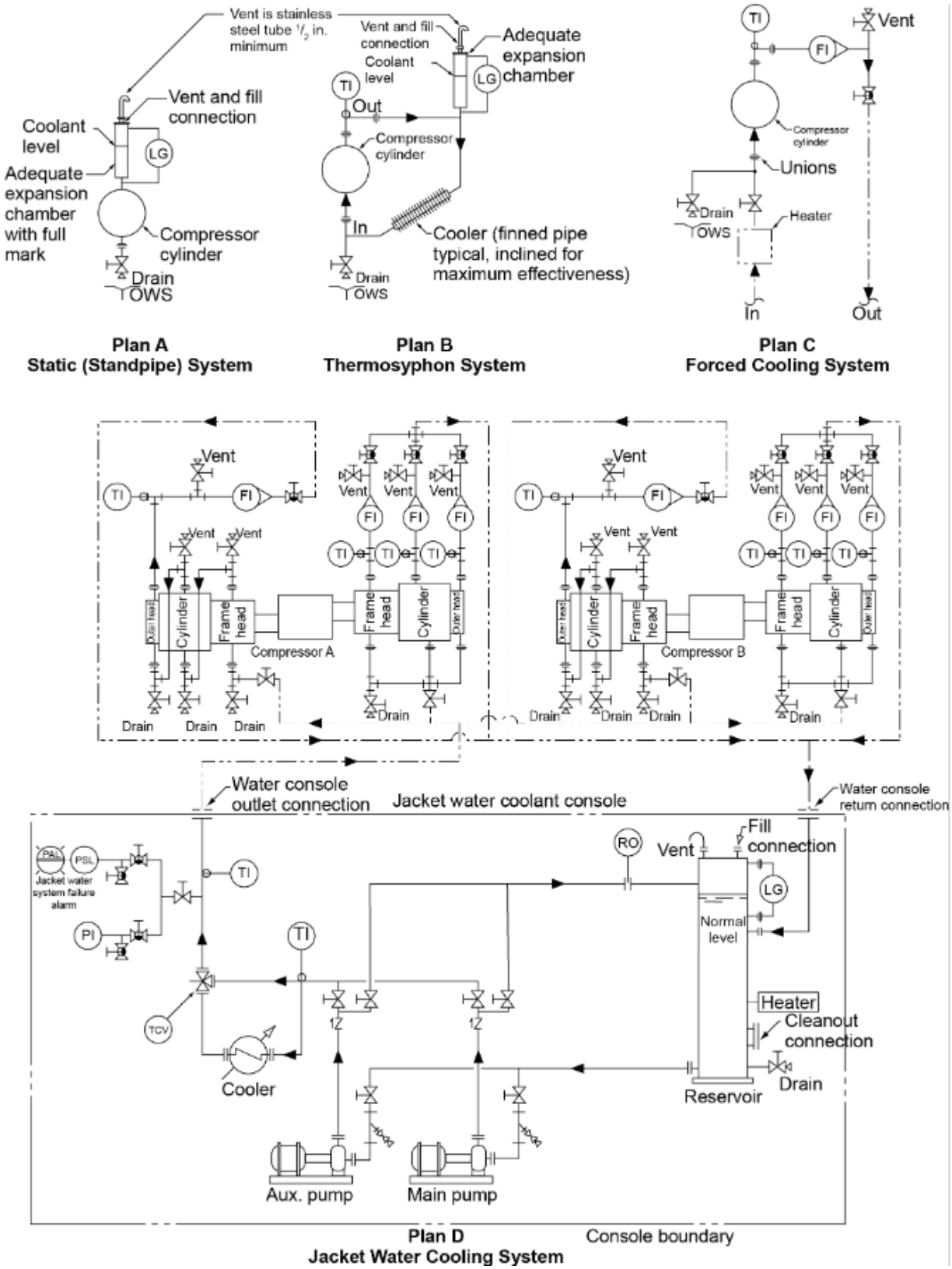
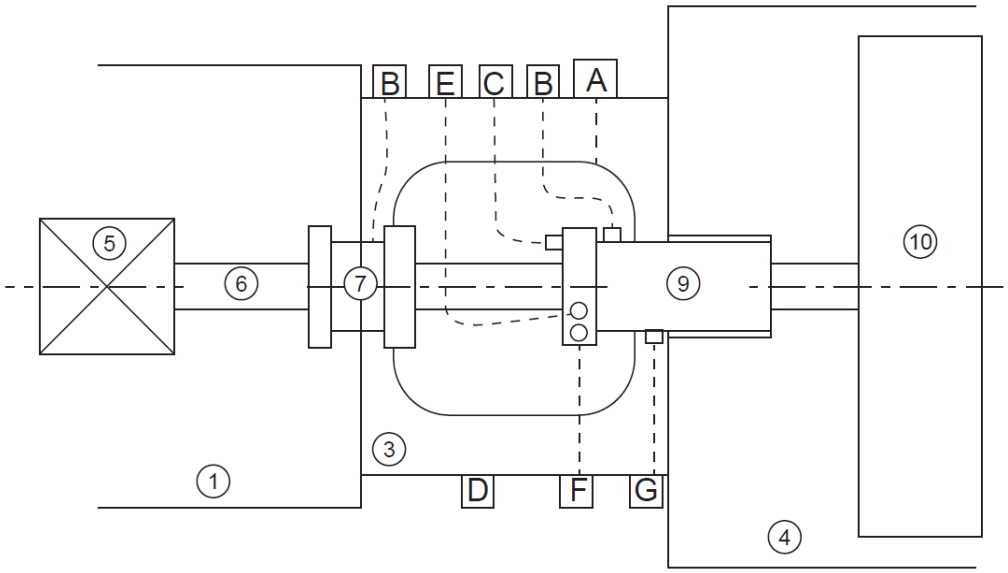
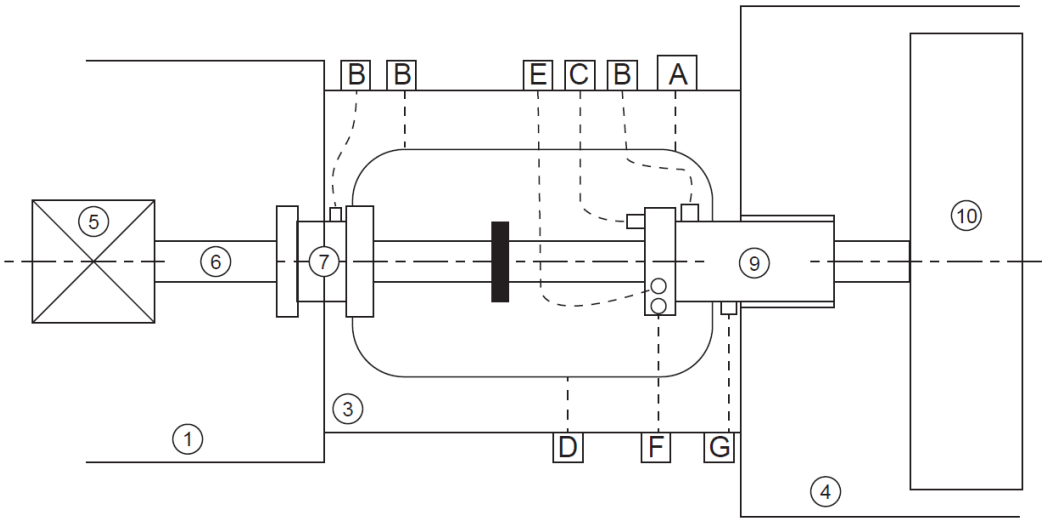


Figure F.1—Cylinder Cooling System

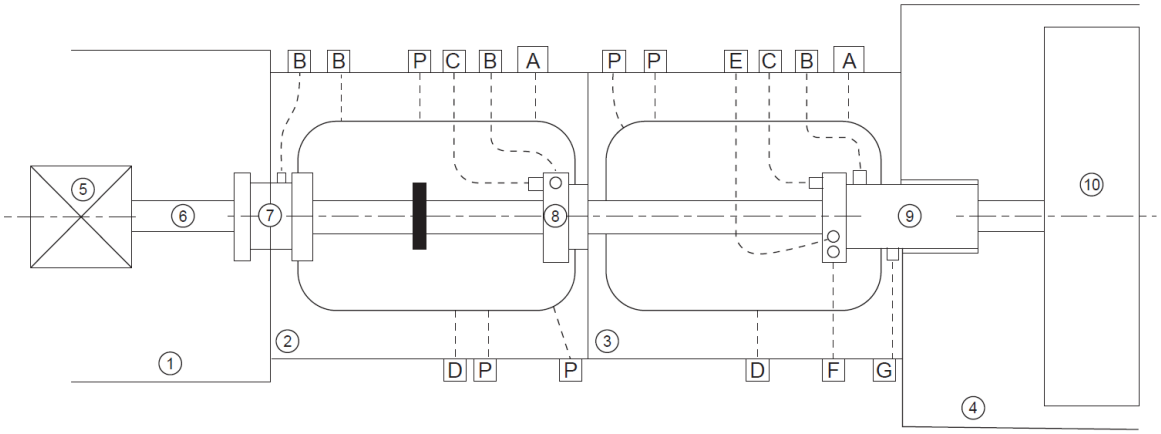


Type A—Short, single-compartment distance piece

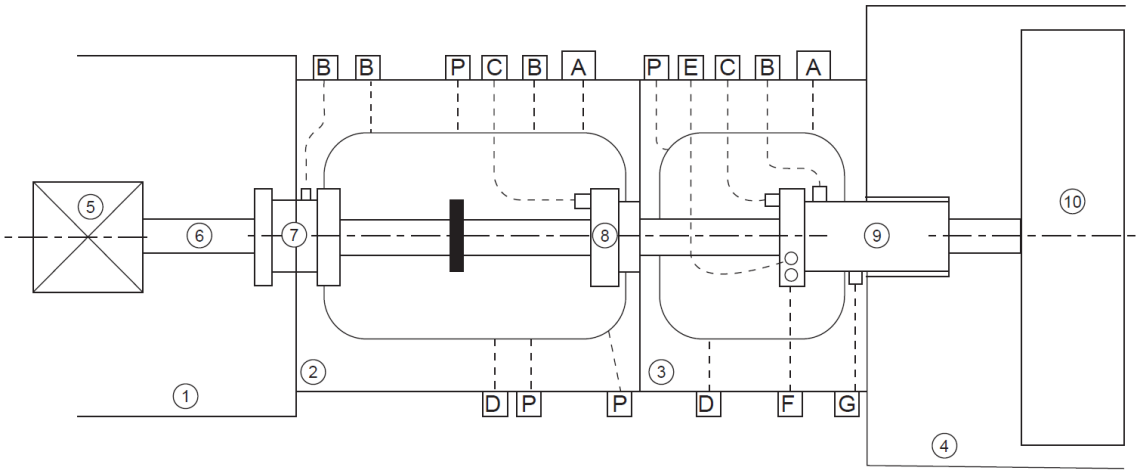


Type B—Long single-compartment distance piece

Figure F.2—Distance Piece and Packing Arrangements



Type C—Long/long two-compartment distance piece



Type D—Long/short two-compartment distance piece

Key

Connections

A	Vent, distance piece
B	Purge, buffer, or pressure, packing or distance piece
C	Lube, pressure packing
D	Drain, distance piece
E	Coolant out, pressure packing
F	Coolant in, pressure packing
G	Common vent and drain, pressure packing
P	Plugged connection

Components

1	Crosshead housing
2	Distance piece; inner or frame side [for Types B and C double designs]
3	Distance piece [for Types A, and B single designs]
4	Cylinder body
5	Crosshead
6	Piston rod
7	Piston rod oil-wiper packing case
8	Intermediate partition packing case
9	Cylinder pressure packing case
10	Piston assembly

Figure F.2—Distance Piece and Packing Arrangements *(continued)*

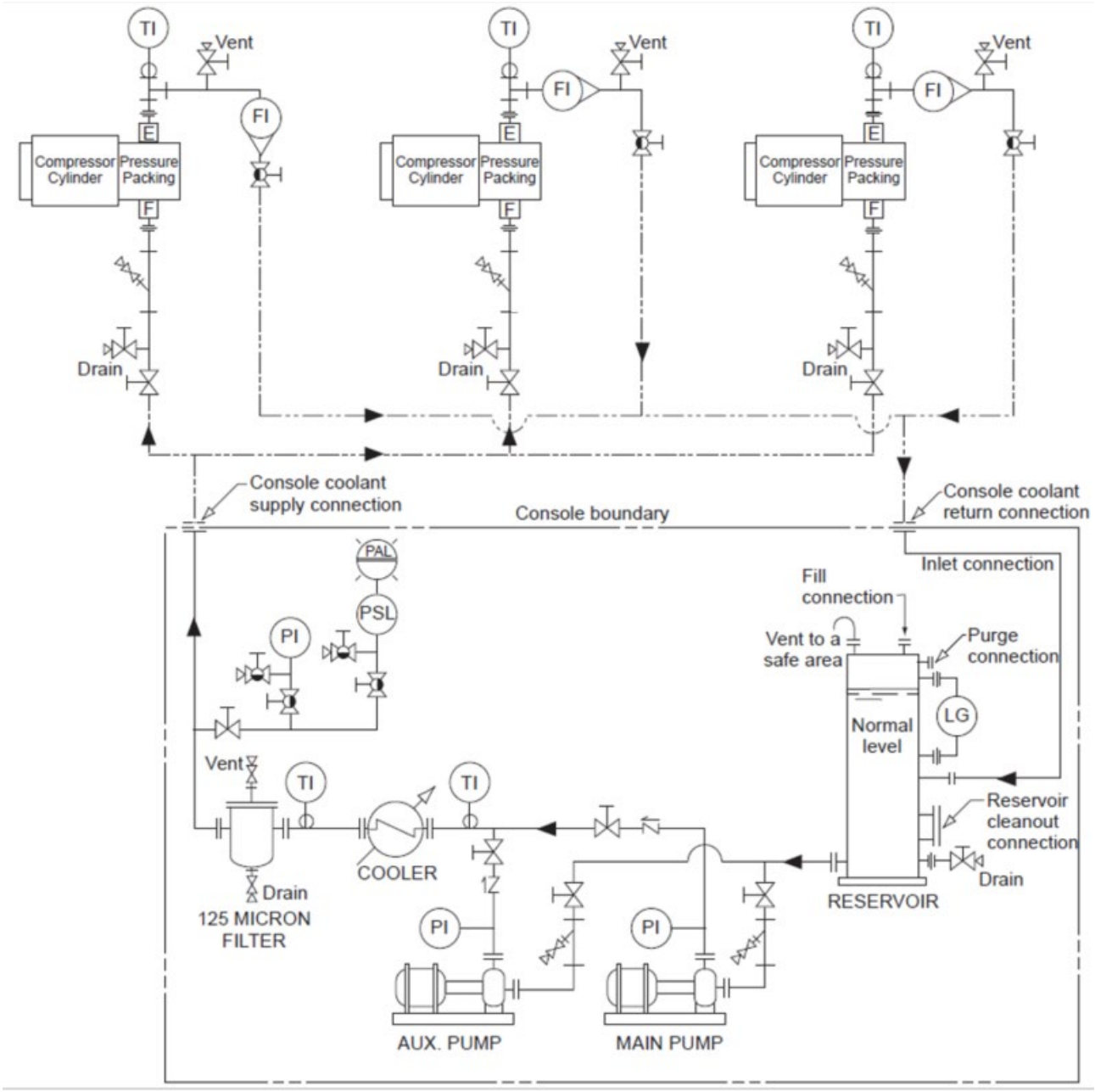


Figure F.3—Typical Self-contained Cooling System for Piston Rod Pressure Packing

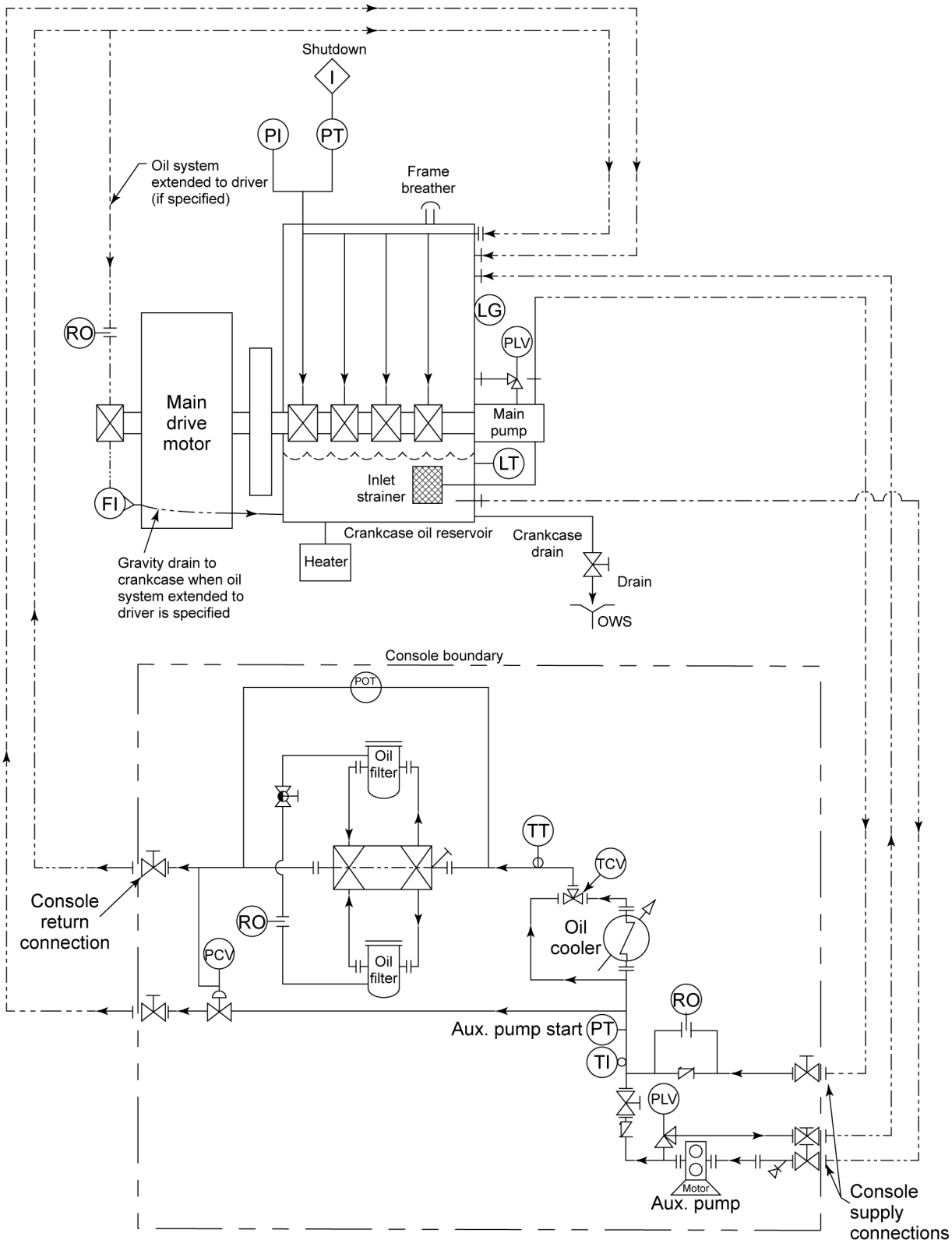


Figure F.4—Typical Pressurized Frame Lube Oil System

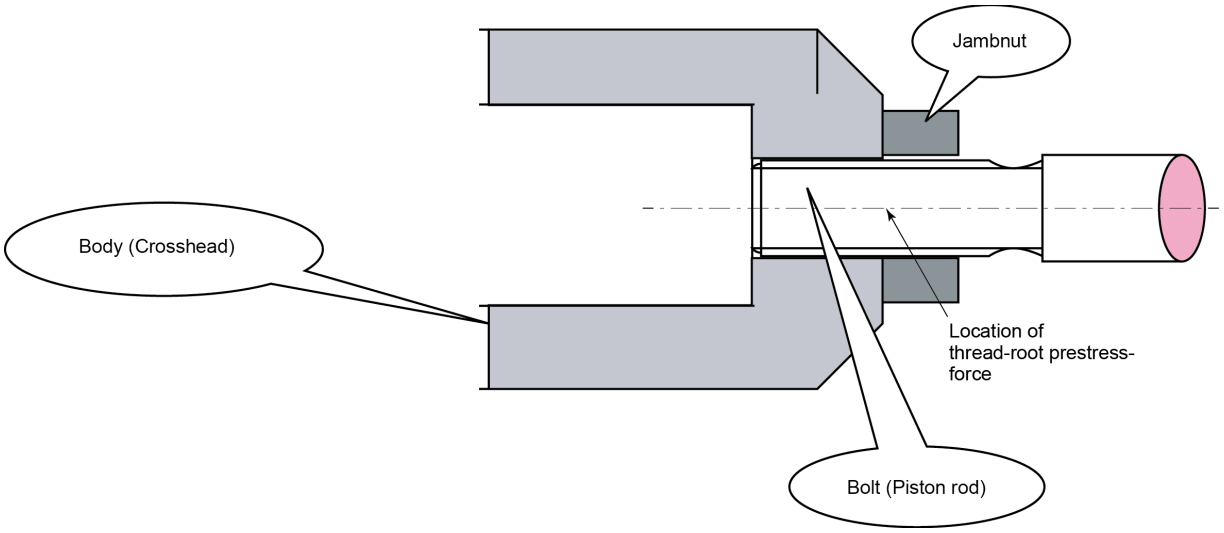


Figure F.5—Conceptual Direct Rod Connection

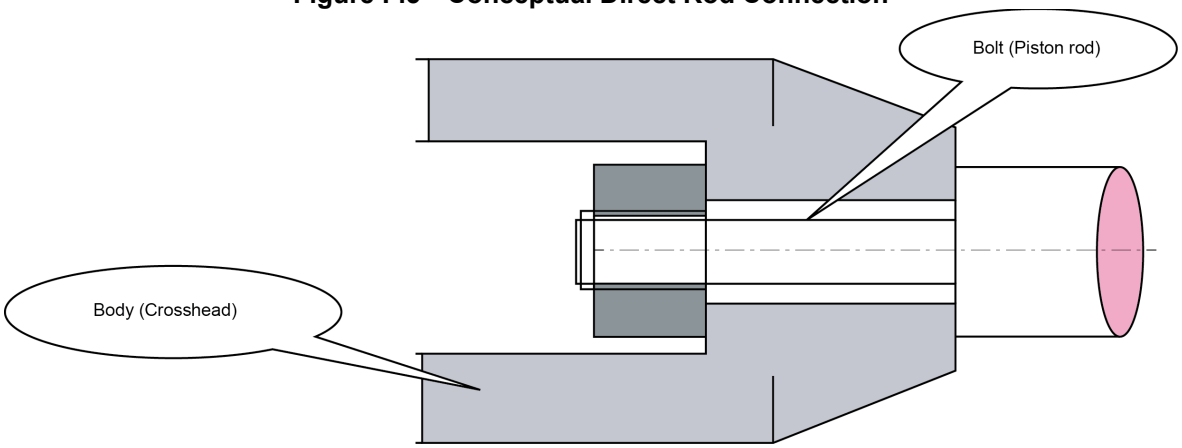


Figure F.6—Conceptual Indirect Rod Connection

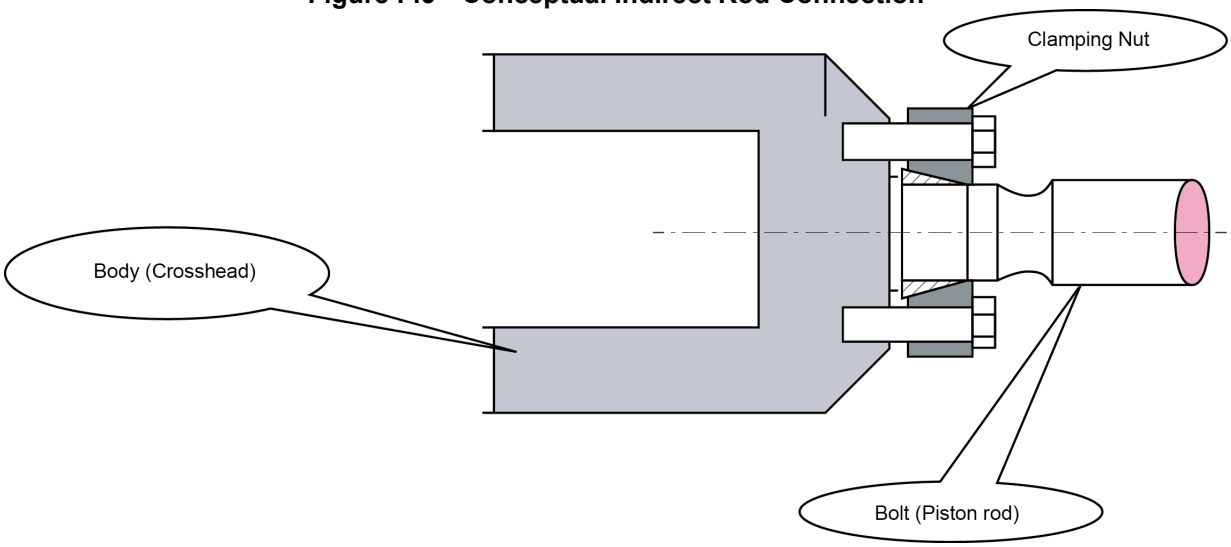


Figure F.7—Conceptual Indirect Clamped Rod Connection

Annex G
(informative)

Typical Materials for Major Component Parts

Table G.1—Typical Material Specifications for Reciprocating Compressor Parts

Part	Material	Form
Frame	Cast iron	Cast
Crankshafts	Steel	Forged
	Ductile iron	Cast
Connecting rods	Steel	Forged
Crossheads	Steel	Bar stock, forged, or cast
	Ductile iron	Cast
Crosshead pins	Steel	Forged or bar stock
Distance pieces	Cast iron	Cast
Cylinders	Steel	Cast, forged, or fabricated
	Stainless steel	Cast or fabricated
	Nodular iron	Cast
	Gray iron	Cast
Cylinder liners	Steel	Tubing
	Stainless steel	Cast
	Ni-resist	Cast
	Nodular iron	Cast
	Gray iron	Cast
Cylinder heads	Steel	Cast, forged, or fabricated
	Stainless steel	Plate
	Nodular iron	Cast
	Gray iron	Cast
Pistons	Steel	Forged, cast, bar stock, or fabricated
	Cast iron	Cast
	Aluminum	Forged or cast
Piston rods and tail rods	Steel	Forged or bar stock
	Stainless steel	Bar stock
Piston rod nuts	Steel	Forged or bar stock
	Stainless steel	Forged or bar stock
Valve seats and guards	Steel	Plate or bar stock
	Stainless steel	Plate, bar stock, or cast
	Nodular iron	Cast or bar stock
	Cast iron	Cast
Valve plates	Stainless steel	Plate
	Nonmetallic	Molded
Valve springs	Steel	Drawn
	Stainless steel	Formed
Packing cases	Steel	Bar stock
	Stainless steel	Bar stock
	Cast iron	Cast
Packing case flange	Steel	Forged, bar stock, or plate
Piston rings, wear bands, and packing rings	Metallic	Cast or bar stock
	Nonmetallic	Molded or sintered

Annex H
(informative)

Distance Piece Vent, Drain, and Buffer Systems to Minimize Process Gas Leakage

H.1 Scope

This annex contains a general philosophy for the design of reciprocating compressor distance piece vent, drain, and gas buffer systems, which are typical of systems commonly used to minimize process gas leakage. This annex is not intended to cover all possible situations; rather, it focuses on providing an approach, which can be used to design successful systems.

NOTE The piping, tubing, and components external to the distance piece may be supplied by either the purchaser or the vendor. It is good practice for the vendor and the purchaser to discuss the vent and drain system and agree on its design.

Instrument piping and valving details are not shown on typical schematics.

H.2 Abbreviation and Symbols

The distance piece and packing arrangements are shown in Figure F.2.

H.3 The Purpose of Distance Piece Vent, Drain, and Buffer Systems

A distance piece vent and drain system working in conjunction with packing, buffer system, and partitions accomplishes several functions, including the following:

a) confining and collecting leakage from piston rod pressure packing and carrying the leakage to a safe location;

b) minimizing process gas, toxic gas, or hazardous gas leakage into the area around the machine;

c) minimizing contamination of the crankcase lube oil;

d) atmospheric fugitive emission control;

e) minimizing the potential for a hazardous atmosphere in the crankcase;

f) minimizing liquid accumulation in the distance piece;

g) avoiding gas leakage to sewer systems;

h) allowing the operator to monitor and determine the condition of piston rod pressure packing.

H.4 Minimizing Process Gas Leakage

Figures H.1 to H.8 illustrate the arrangement of two typical distance piece types that may be used when it is necessary to reduce the leakage of process gas to a minimum. The accompanying packing detail drawing (see Figures H.5 to H.7) shows the arrangement of the packing rings and the direction of flow and typical pressures of the buffer gas.

Side-loaded packing rings provide constant mechanical axial loading toward the sealing face of the cup. This mechanical axial loading, added to a buffer gas pressure at least 1 bar higher than the vent system pressure, holds the rings positively against their sealing faces minimizing buffer gas leakage and, at the same time, ensures that all the process gas that leaks past the piston rod pressure packing cups will be forced into the vent system.

When proper differential buffer gas pressures are maintained, process gas leakage into the distance pieces is minimal; process gas is prevented from entering the compressor frame. To minimize gas emissions, special packing and long-distance pieces should be specified.

H.5 Design Consideration

In addition to meeting the purposes described in H.3, the following factors should be considered when designing a distance piece vent, drain, and buffer system.

a) Small diameter vent and drain piping will tend to foul and corrode over time, inhibiting their function. Consider using large [e.g. DN 50 (NPS 2)] vent and drain headers and corrosion-resistant materials.

b) On two-compartment distance piece systems, external cross-connections between the inner and outer compartment vents and drains should be avoided.

c) On multiple machine systems, it should be possible to isolate each machine for maintenance.

d) Effective control of gas leakage requires the specification of gasketed solid metal covers on distance pieces.

e) Where vents, drains, liquid collection pots, and distance pieces are connected to disposal systems, such as a flare or closed drain system, they should be designed to withstand the maximum disposal system pressure (e.g. flare back pressure under relieving conditions).

   NOTE Distance pieces are typically designed for a maximum gauge pressure of 3 bar (45 psi). Special designs are required for higher pressures.

f) Typically, the common vent and drain from the piston rod pressure packing (connection G in Figures H.1 to H.4) will be carrying a mixture of liquid and gas. The system should be designed to separate these phases to avoid liquid blockage of the vent system.

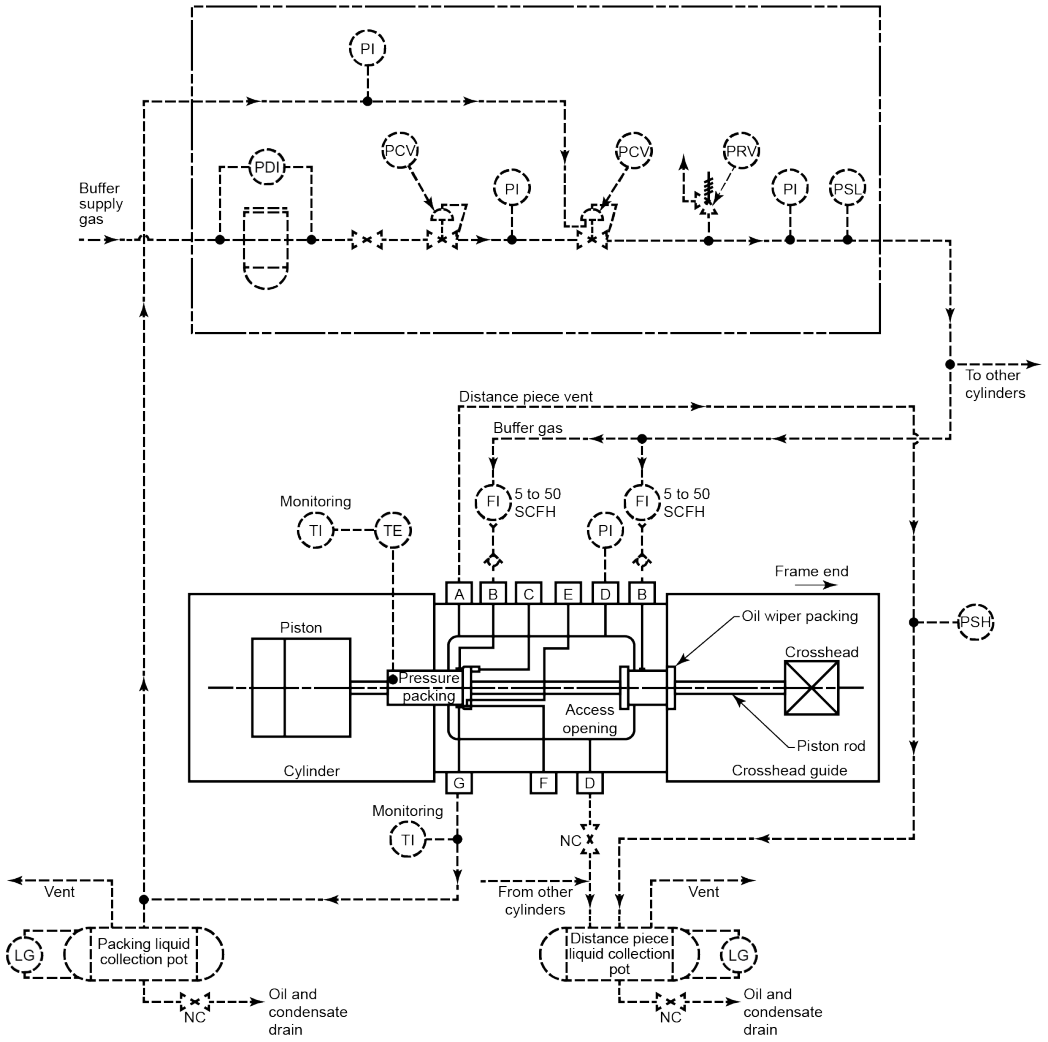
g) Leaks from the stems of valve unloaders and clearance pockets may also need to be collected and controlled. These can be integrated with the distance piece vent and drain system.

h) Except for the piston rod pressure packing combined vent and drain, which is a pressure-driven flow, separate vent and drain lines are necessary between the distance piece and liquid collection pot to pressure balance the system and allow free drainage. Sloped headers, without pockets, assist draining.

i) Manifolding and cross-connections with drains and blow-offs from other equipment should be avoided.

j) The buffer gas purge pressure should be limited to the maximum allowable pressure for the distance piece components. Some buffer gas will flow into the compressor crankcase and should be vented.

k) Where climatic conditions require, drains should be heat-traced and insulated.



A vent, distance piece—NPS 1.50 (min.)

B buffer, pressure packing or distance piece—NPS 1.00 (min.)

C lube, pressure packing or distance piece—NPS 1.00 (min.)

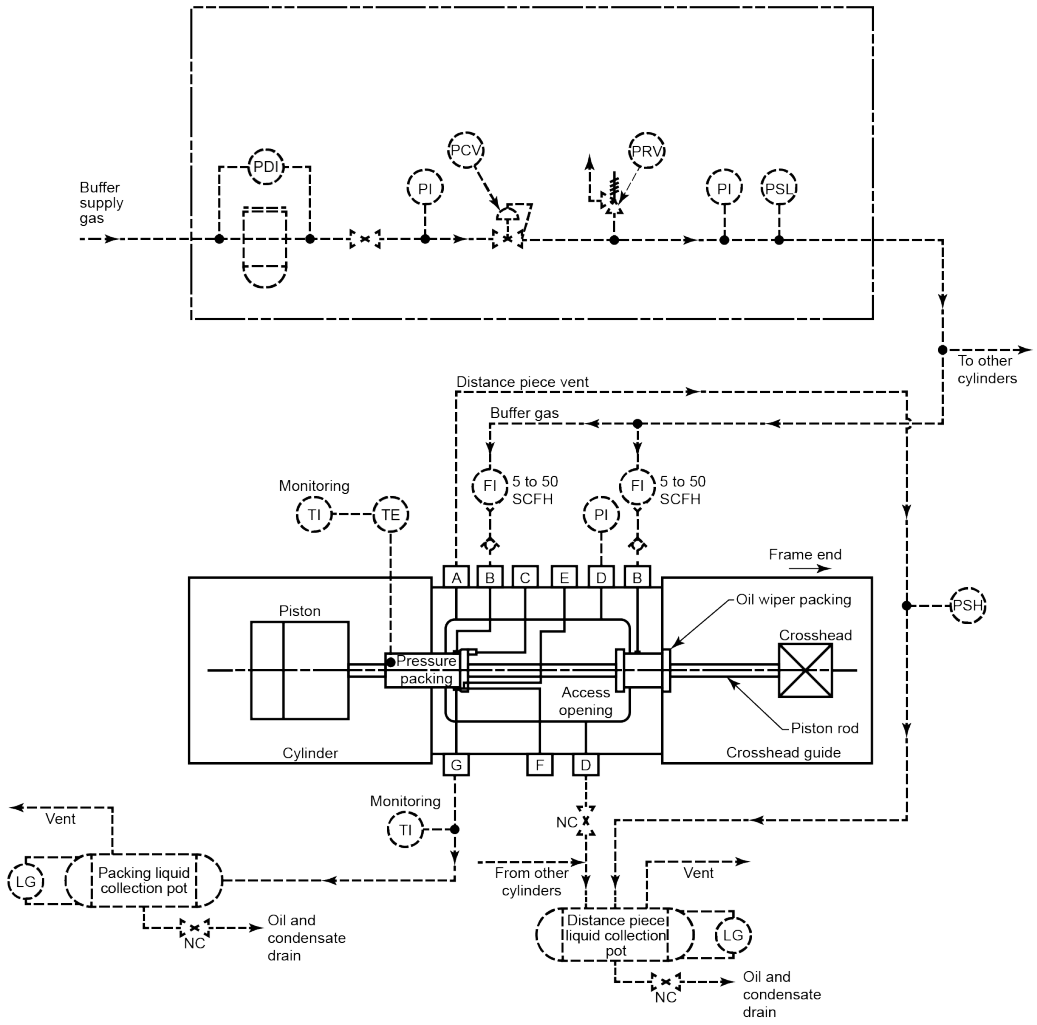
D drain distance piece—NPS 1.00 (min.)

E pressure packing coolant out—NPS 1.00

F pressure packing coolant in—NPS 1.00

G pressure packing common vent and drain—NPS 1.00

Figure H.1—Typical Buffered Single-compartment Distance Piece for Variable Vent Pressure Systems



A vent, distance piece—NPS 1.50 (min.)

B buffer, pressure packing or distance piece—NPS 1.00 (min.)

C lube, pressure packing or distance piece—NPS 1.00 (min.)

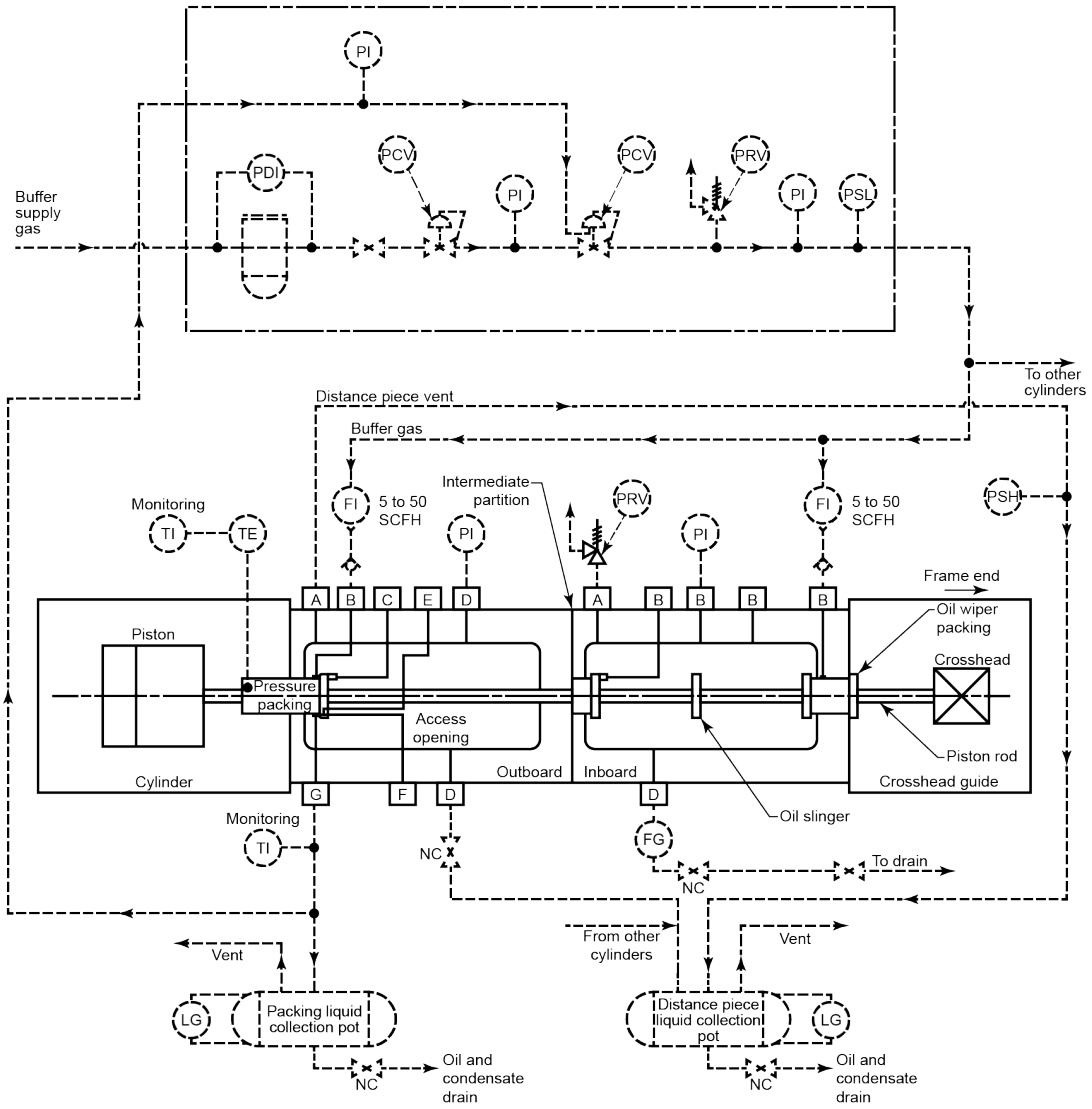
D drain distance piece—NPS 1.00 (min.)

E pressure packing coolant out—NPS 1.00

F pressure packing coolant in—NPS 1.00

G pressure packing common vent and drain—NPS 1.00

Figure H.2—Typical Buffered Single-compartment Distance Piece for Constant Vent Pressure Systems



A vent, distance piece—NPS 1.50 (min.)

B buffer, pressure packing or distance piece—NPS 1.00 (min.)

C lube, pressure packing or distance piece—NPS 1.00 (min.)

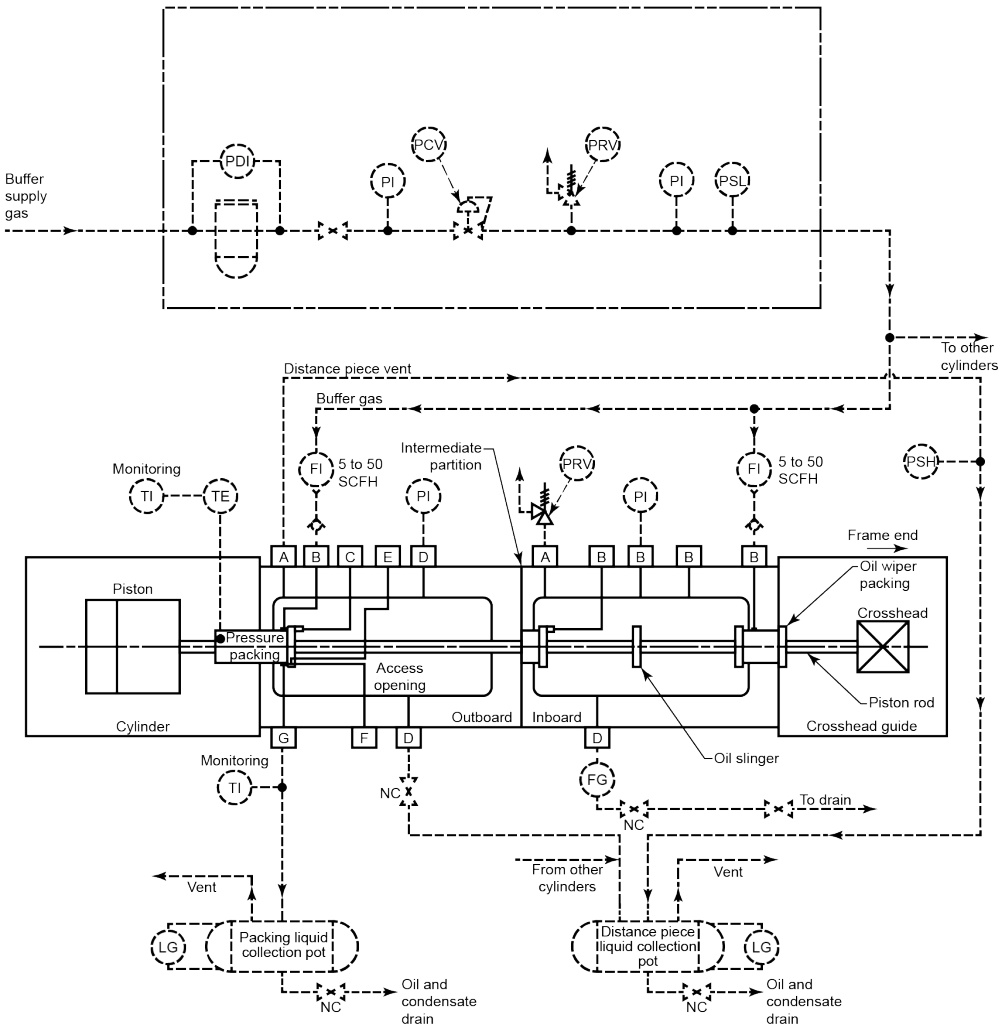
D drain distance piece—NPS 1.00 (min.)

E pressure packing coolant out—NPS 1.00

F pressure packing coolant in—NPS 1.00

G pressure packing common vent and drain—NPS 1.00

Figure H.3—Typical Buffered Two-compartment Distance Piece for Variable Vent Pressure Systems



A vent, distance piece—NPS 1.50 (min.)

B buffer, pressure packing or distance piece—NPS 1.00 (min.)

C lube, pressure packing or distance piece—NPS 1.00 (min.)

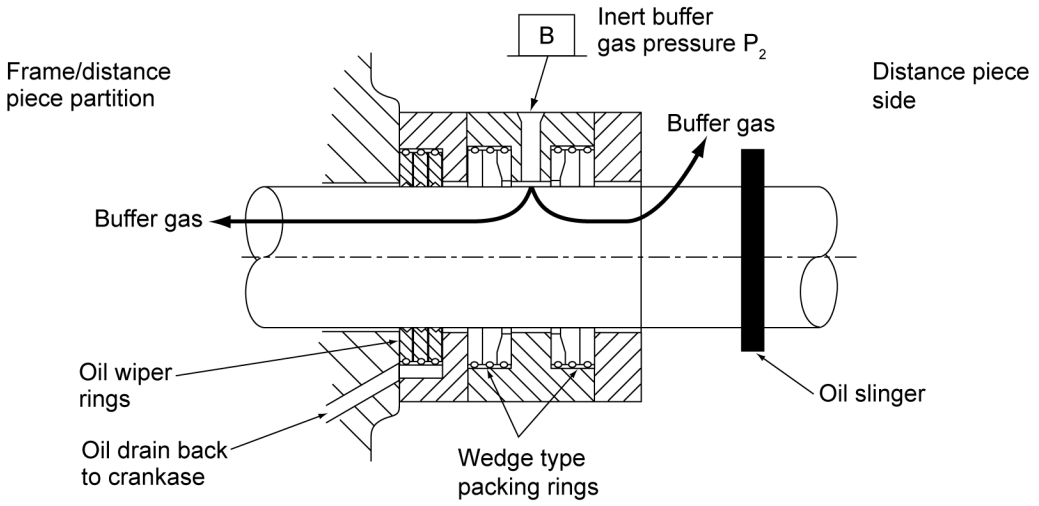
D drain distance piece—NPS 1.00 (min.)

E pressure packing coolant out—NPS 1.00

F pressure packing coolant in—NPS 1.00

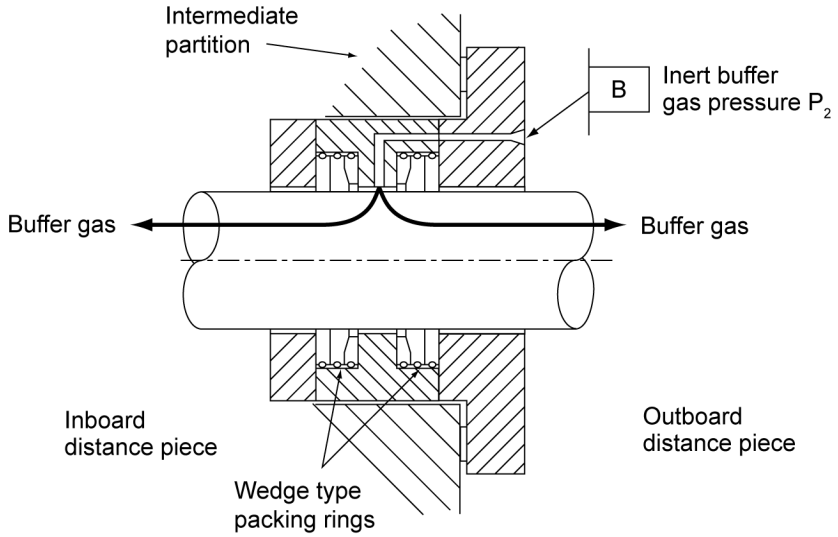
G pressure packing common vent and drain—NPS 1.00

Figure H.4—Typical Buffered Two-compartment Distance Piece for Constant Vent Pressure Systems



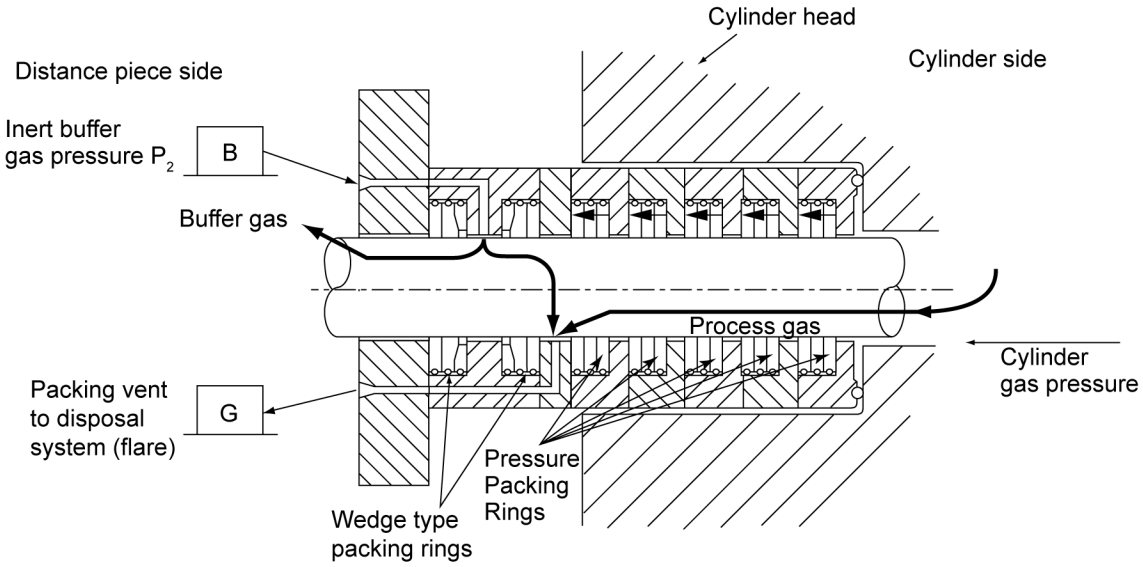
B buffer, pressure packing or distance piece—NPS 1.00 (min.)

Figure H.5—Oil Wiper Packing with Inert Buffer Gas Purge



B buffer, pressure packing or distance piece—NPS 1.00 (min.)

Figure H.6—Intermediate Partition Packing with Inert Buffer Gas Purge (Not Used with Type A and Type B Distance Pieces)



B buffer, pressure packing or distance piece—NPS 1.00 (min.)

G pressure packing common vent and drain—NPS 1.00

Figure H.7—Piston Rod Pressure Packing with Inert Buffer Gas

Annex I
(informative)

Reciprocating Compressor Nomenclature

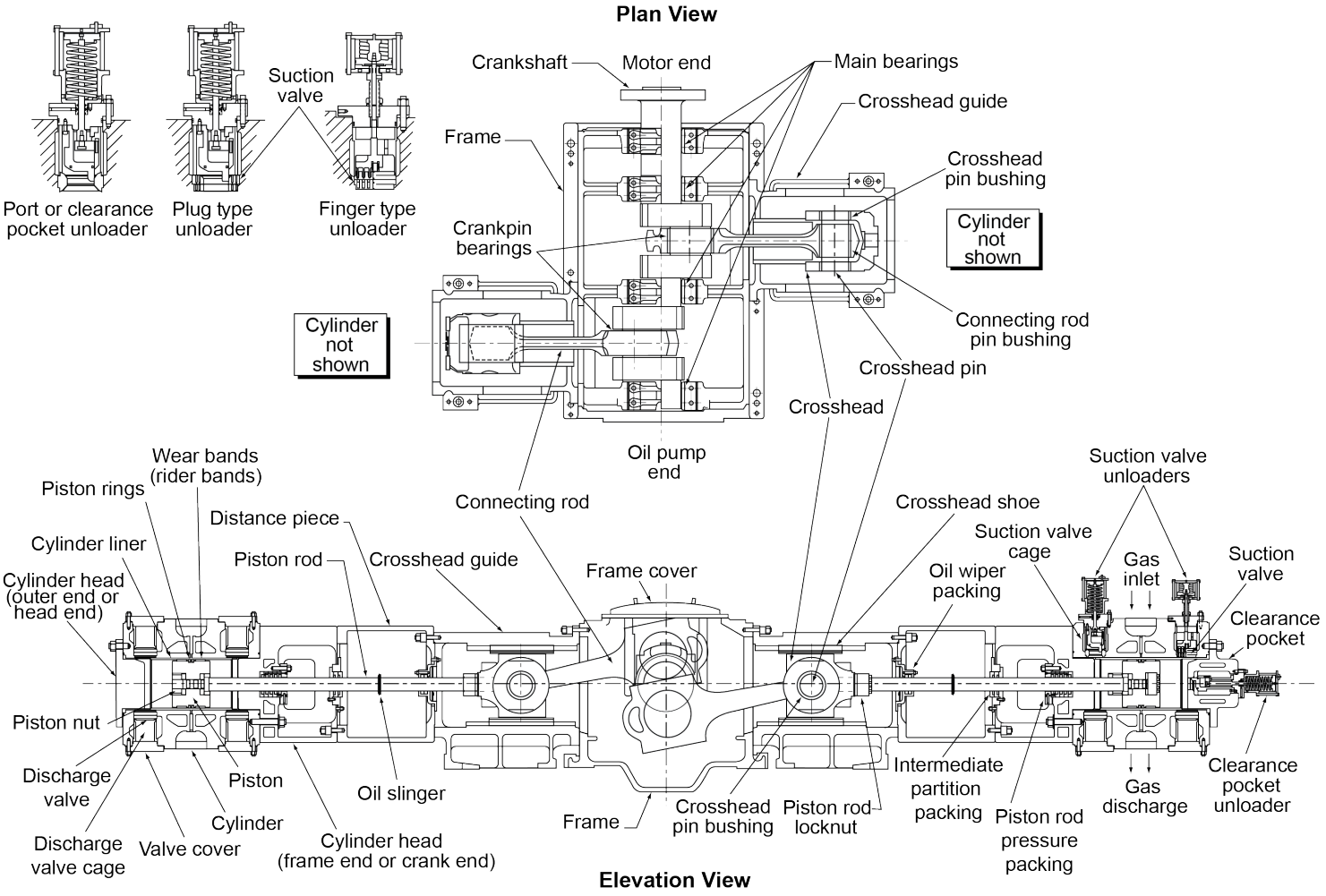


Figure I.1—Reciprocating Compressor Nomenclature

Annex J
(informative)

Inspector's Checklist

This inspector's checklist (see Table J.1) represents a summary of the potential inspection points mentioned in the main text. The final inspection plan shall be agreed between the purchaser and the vendor and reflected in the quality plan.

Table J.1—Inspector's Checklist

Item	Referenced Section, API 618	Date Inspected	Inspected by	Status
Material inspection	8.2.2.1.1			
Crankshaft ultrasonic inspection	8.2.2.3.2			
Piping fabrication and installation				
Hydrostatic test—Cylinders	8.3.2.1			
Hydrostatic test—Piping and vessels	8.3.2.1			
Gas leakage test	8.3.2.1			
Shop test	8.3.3.1			
Bar-over test piston rod runout per runout table in Annex C	8.3.4.1			
Cylinder valve leak test	8.3.4.3			
Additional tests—As specified				
Crankshaft web deflection				
Examination of internals for cleanliness:				
Piping				
Crankcase				
Pulsation suppressors				
Coolers				
Filters				
Other				
Rotation arrow	6.15.3			
Overall dimensions and connection locations [a]				
Flange dimensions and finish [a]				
Anchor bolt layout and size [a]				
Painting	8.4.5			
Corrosion protection—Exterior	8.4.5/8.4.6			
Corrosion protection—Interior	8.4.7/8.4.8			
Corrosion protection—Lubricated surfaces	8.4.8			
Closures of all openings	8.4.10/8.4.11/8.4.12			
Equipment nameplate data	6.15.1			
Packing for shipment	8.4.14			
Equipment identification	8.4.15			
Piping connections identification (tagging)	8.4.18			
Additional inspections—As specified				

[a] Check against certified drawings.

Annex K
(informative)

Typical Mounting Plate Arrangement

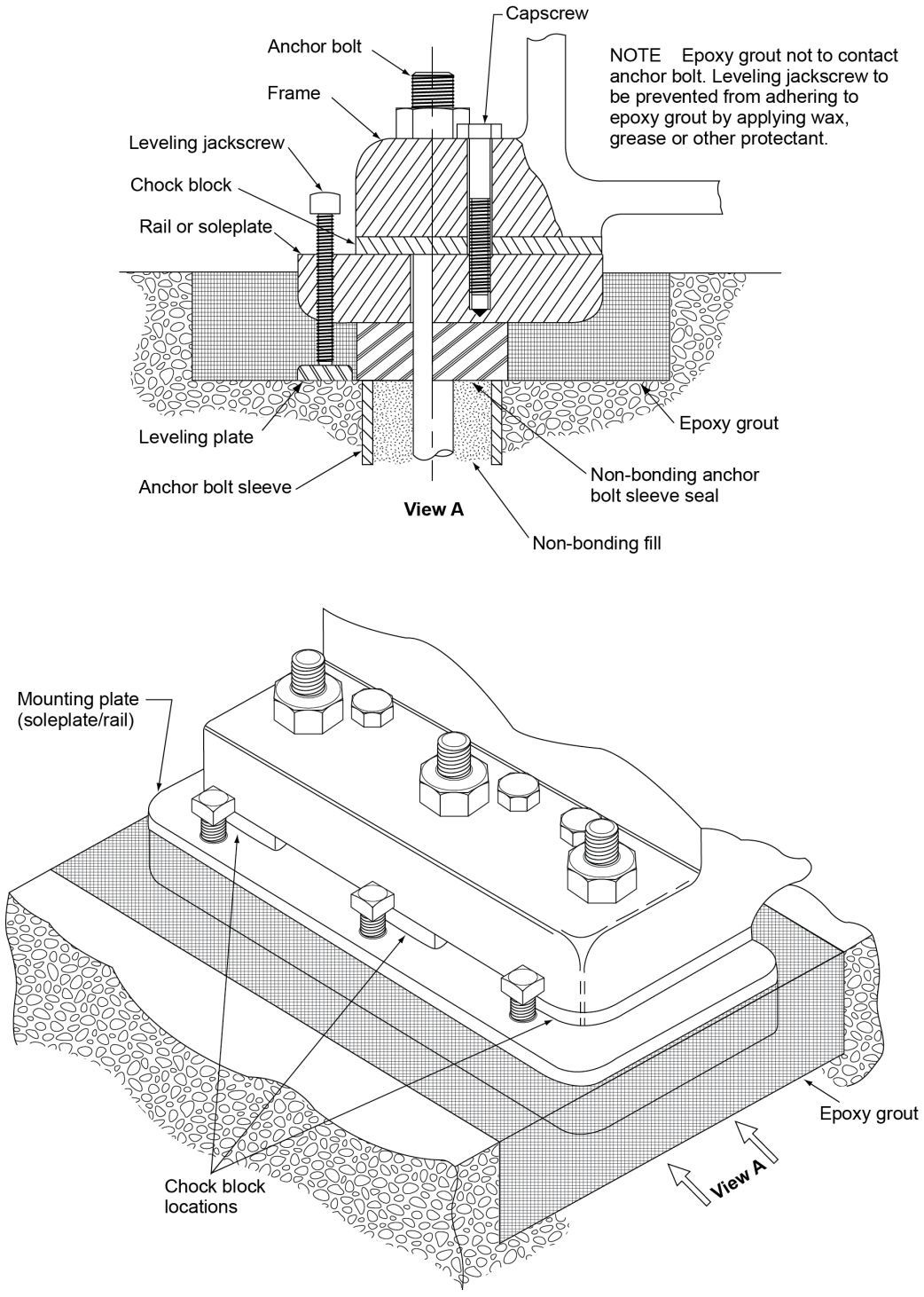


Figure K.1—Typical Mounting Plate Arrangement

Annex L
(normative)

Design Approach Work Process Flowcharts

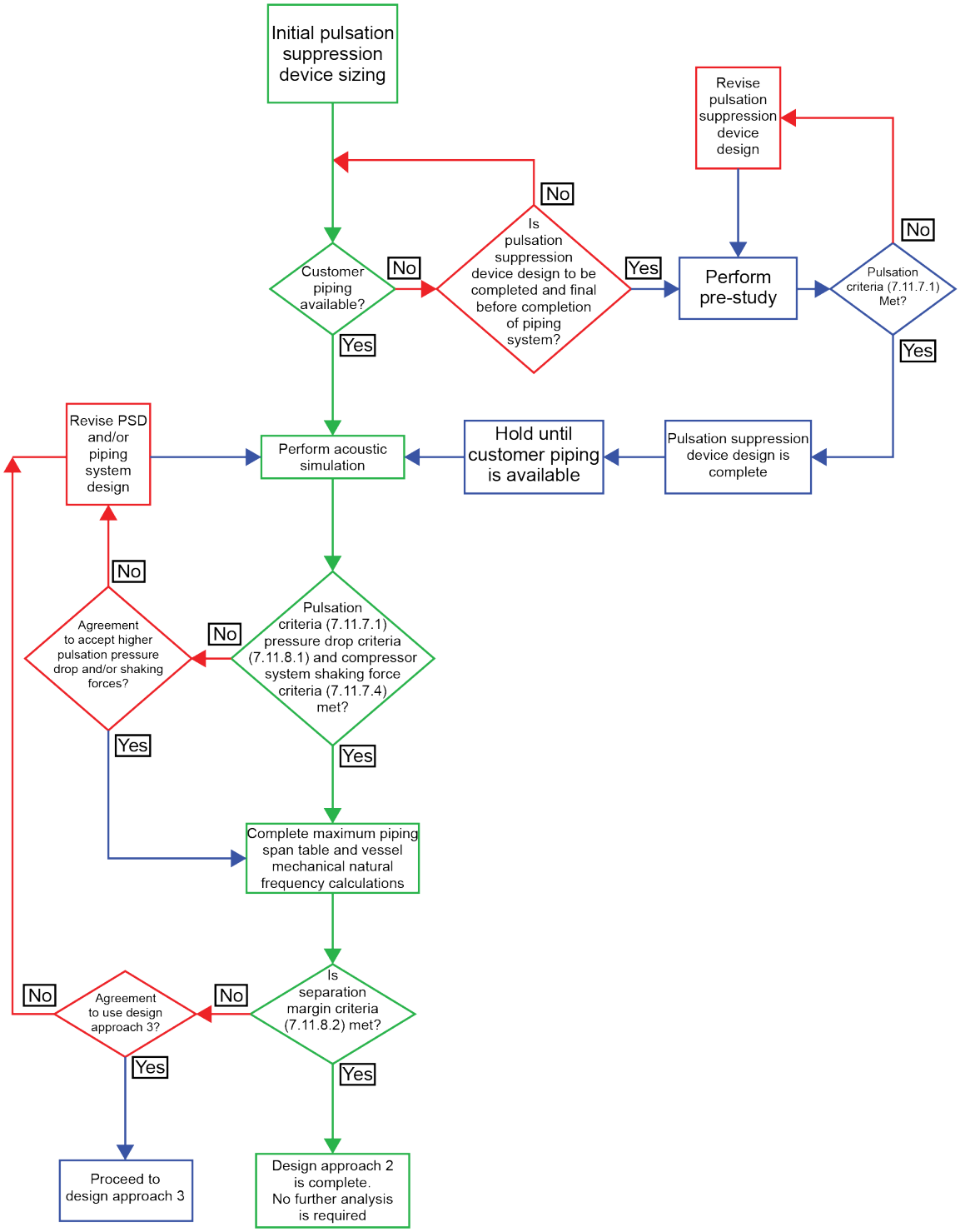


Figure L.1—Design Approach 2 Flowchart

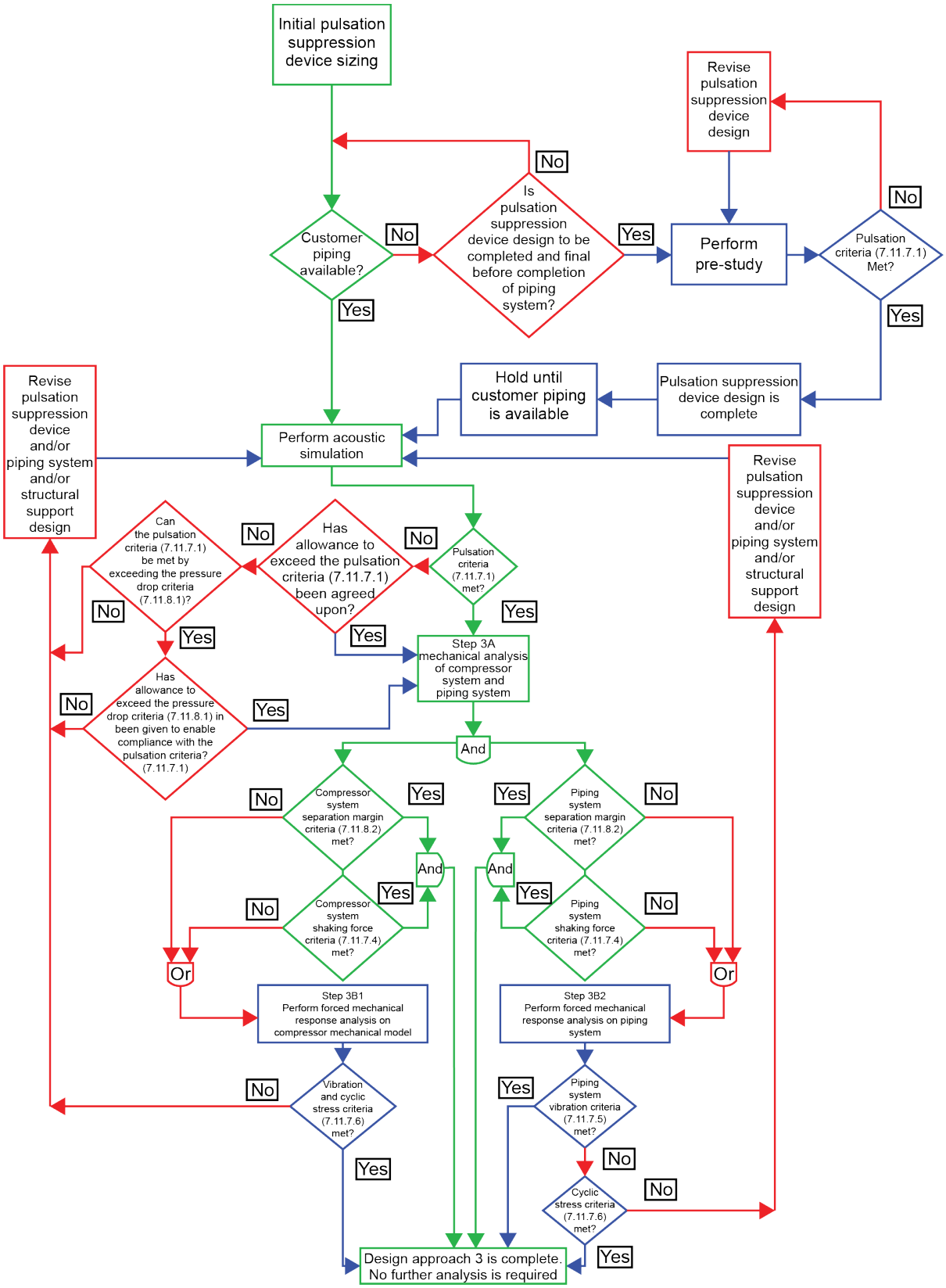


Figure L.2—Design Approach 3 Flowchart

Bibliography

[1] ISO 13443, *Natural gas—Standard reference conditions*

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