Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services

ANSI/API STANDARD 618-2008
FIFTH EDITION, DECEMBER 2007

ERRATA 1, NOVEMBER 2009
ERRATA 2, JULY 2010

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Downstream Segment

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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, D.C. 20005, standards@api.org.

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Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services

Introduction

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.

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

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.

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 non-lubricated 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 (a) integral gas-engine-driven compressors, (b) compressors with single-acting trunk-type (automotive-type) pistons that also serve as crossheads, and (c) either plant or instrument-air compressors that discharge at a gauge pressure of 9 bar (125 psig) or below.

Note 1: Requirements for packaged high-speed reciprocating compressors for oil and gas production services are covered in ISO 13631.

Note 2: A bullet (•) at the beginning of a clause indicates that either a decision is required or further information is to be provided by the purchaser. This information should be indicated on the data sheets (see Annex A); otherwise it should be stated in the quotation request (inquiry) or in the order.

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) applies.

API

RP 500	*Classification of Locations for Electrical Installation at Petroleum Facilities Classified as Class I, Division 1 and Division 2*
Std 541	*Form-wound Squirrel-cage Induction Motors—500 Horsepower and Larger*
Std 546	*Brushless Synchronous Machines—500 kVA and Larger*
Std 611	*General Purpose Steam Turbines for Petroleum, Chemical and Gas Industry Services*
Std 612	*Petroleum, Petrochemical and Natural Gas Industries—Steam Turbines—Special-purpose Applications*

Std 613	*Special Purpose Gear Units for Petroleum, Chemical and Gas Industry Services*
Std 614	*Lubrication, Shaft-sealing, and Control-oil Systems and Auxiliaries for Petroleum, Chemical and Gas Industry Services*
Std 616	*Gas Turbines for the Petroleum, Chemical and Gas Industry Services*
Std 670	*Machinery Protection Systems*
Std 671	*Special-Purpose Couplings for Petroleum, Chemical and Gas Industry Services*
Std 677	*General-Purpose Gear Units for Petroleum, Chemical and Gas Industry Services*
RP 686	*Recommended Practices for Machinery Installation and Installation Design*

Measurement of Petroleum Measurement Standards (MPMS)

Ch. 15	Guidelines for Use of the International System of Units (SI) in the Petroleum and Allied Industries

AGMA[1]

9002	*Bores and Keyways for Flexible Couplings (Inch Series)*

ANSI[2]

S2.19	*Mechanical Vibration-Balance Quality Requirements of Rigid Motors—Part 1: Determination of Possible Unbalance, Including Marine Applications*

ASME[3]

B1.1	*Unified Inch Screw Threads (UN & UNR Thread Form)*
B16.1	*Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250*
B16.5	*Pipe Flanges and Flanged Fittings NPS* $^{1}/_{2}$ *through NPS 24 Metric/Inch Standard*
B16.11	*Forged Fittings, Socket-Welding and Threaded*
B16.42	*Ductile Iron Pipe Flanges & Flanged Fittings: Classes 150 and 300*
B16.47	*Large Diameter Steel Flanges*
B31.3	*Process Piping*

Boiler and Pressure Vessel Code

Section V, “Nondestructive Examination”
Section VIII, Division 1, “Rules for Construction of Pressure Vessels”
Section IX, “Welding and Brazing Qualifications”

ASTM[4]

A 193	*Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and other Special Purpose Applications*
A 194	*Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both*
A 216	*Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service*
A 247	*Standard Test Method for Evaluating the Microstructure of Graphite in Iron Castings*
A 278	*Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650°F (350°C)*
A 307	*Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength*
A 320	*Standard Specification for Alloy-Steel And Stainless Steel Bolting Materials for Low-Temperature Service*
A 388	*Standard Practice for Ultrasonic Examination of Heavy Steel Forgings*
A 395	*Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*
A 503	*Standard Specification for Ultrasonic Examination of Forged Crankshafts*
A 515	*Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate and Higher-Temperature Service*
A 668	*Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use*

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[1] American Gear Manufacturers Association, 500 Montgomery Street, Suite 350, Alexandria, Virginia 22314-1581, www.agma.org.
[2] American National Standards Institute, 25 West 43rd Street, 4th floor, New York, New York 10036, www.ansi.org.
[3] ASME International, Three Park Avenue, New York, New York 10016-5990, www.asme.org.
[4] ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959, www.astm.org.

E 94	*Standard Guide for Radiographic Examination*
E 125	*Standard Reference Photographs for Magnetic Particle Indications on Ferrous Castings*
E 165	*Standard Test Method for Liquid Penetrant Examination*
E 709	*Standard Guide for Magnetic Particle Examination*

AWS[5]

D 1.1	*Structural Welding Code—Steel*

IEC[6]

60034 (all parts)	*Rotating Electrical Machines*
60079 (all parts)	*Electrical Apparatus for Explosive Gas Atmospheres*
60529	*Degrees of Protection Provided by Enclosures (IP Code)*
60848	*GRAFCET Specification Language for Sequential Function Charts*

ISO[7]

7-1	*Pipe threads where pressure-tight joints are made on the threads—Part 1: Dimensions, tolerances and designation*
7-2	*Pipe threads where pressure-tight joints are made on the threads—Part 2: Verification by means of limit gauges*
261	*ISO General-purpose metric screw threads—General plan*
262	*ISO General-purpose metric screw threads—Selected sizes for screws, bolts and nuts*
281	*Rolling bearings—Dynamic load ratings and rating life*
286-2	*ISO system of limits and fits—Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts*
724	*ISO General purpose metric screw threads—Basic dimensions*
965 (all parts)	*ISO General purpose metric screw threads—Tolerances*
1217	*Displacement compressors—Acceptance tests*
1940-1	*Mechanical vibration—Balance quality requirements for rotors in a constant (rigid) state—Part 1: Specification and verification of balance tolerances*
6708	*Pipework components—Definition and selection of DN (Nominal Size)*
7005-1	*Metallic flanges—Part 1: Steel flanges*
7005-2	*Metallic flanges—Part 2: Cast iron flanges*
7005-3	*Metallic flanges—Part 3: Copper alloy and composite flanges*
8501 (all parts)	*Preparation of steel substrates before application of paints and related products—Visual assessment of surface cleanliness*
10441	*Petroleum and natural gas industries—Flexible couplings for mechanical power transmission—Special purpose applications*
10437	*Petroleum, petrochemical and natural gas industries—Steam turbines—Special-purpose applications*
10438 (all parts)	*Petroleum, petrochemical and natural gas industries—Lubrication, shaft-sealing and control-oil systems and auxiliaries*
10816-6	*Mechanical vibration—Evaluation of machine vibration by measurements on non-rotating parts—Part 6: reciprocating machines with power ratings above 100 kW*
13631	*Petroleum and natural gas industries—Packaged reciprocating gas compressors*
13691	*Petroleum and natural gas industries—High-speed special-purpose gear units*
14691	*Petroleum and natural gas industries—Flexible couplings for mechanical power transmission—General purpose applications*
16889	*Hydraulic fluid power filters—Multi-pass method for evaluating filtration performance of a filter element*

NACE[8]

Corrosion Engineer’s Reference Book

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[5] American Welding Society, 550 N.W. LeJeune Road, Miami, Florida 33126, www.aws.org.

[6] International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland, www.iec.ch.

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

[8] NACE International, 1440 South Creek Drive, Houston, Texas 77084-4906, www.nace.org.

MR0175 *Petroleum and Natural Gas Industries—Materials for use in H_2S-Containing Environments in Oil and Gas Production*

NEMA[9]
MG 1 *Motors and Generators*

NFPA[10]
70 *National Electrical Code*

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

2.2 “Notes” following a clause are informative.

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

3 Definitions of Terms

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

3.1 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: The model is mathematically based upon the governing differential equations (motion, continuity, etc.). The simulation should allow for determination of pressure/flow modulations at any point in the piping model resulting from any generalized compressor excitation (see 3.1, 3.4, 3.9, 3.28, 3.39, and 3.57).

3.2 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).

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

3.4 analog simulation: A method using electrical components (inductances, capacitances, resistances and current supply devices) to achieve the acoustic simulation (see 3.1).

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

Note: See 3.13 for definition of hold down bolts. Also see Figure L-1.

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

3.7 combined rod load: The algebraic sum of gas load and inertia force on the crosshead pin.

Note: Gas load is the force resulting from differential gas pressure acting on the piston differential area. Inertia force is the force resulting from the acceleration of reciprocating mass. 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.

3.8 design: A term that may be used by the equipment manufacturer to describe various parameters such as design power, design pressure, design temperature, or design speed.

Note: This terminology should be used only by the equipment manufacturer and not in the purchaser’s specifications.

3.9 digital simulation: A method using various mathematical techniques on digital computers to achieve the acoustic simulation (see 3.1).

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[9] National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1752, Rosslyn, Virginia 22209, www.nema.org.

[10] National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-7471, www.nfpa.org.

[11] The Society for Protective Coatings, 40 24th Street, 6th Floor, Pittsburgh, Pennsylvania 1522-4656, www.sspc.org.

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

3.11 fail safe: A system which 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.

3.12 gauge board: A bracket or plate used to support and display gauges, switches, transmitters, and other instruments. A gauge board is open and not enclosed.

Note: A gauge board is not a panel. A panel is an enclosure. See 3.35 for the definition of a panel.

3.13 hold down bolts (mounting bolts): Bolts holding the equipment to the mounting plate.

3.14 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 3.32 for definition of normative.

3.15 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. To determine inlet volume flow, allowance must be made for pressure drop across pulsation suppression devices and for interstage liquid knockout.

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.

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

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

Note: The manufacturer is often a different entity from the vendor.

3.18 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.

Note: See 3.43, 3.48, and 6.1.3.

3.19 maximum allowable continuous combined rod load: The highest combined rod load at which none of the forces in the running gear (piston, piston rod, crosshead assembly, connecting rod, crankshaft, bearings etc.) and the compressor frame exceed the values in any component for which the manufacturer's design permits continuous operation.

3.20 maximum allowable continuous gas load: The highest force that a manufacturer permits for continuous operation on the static components (e.g., frame, distance piece, cylinder and bolting) of the compressor.

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

3.22 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.

3.23 maximum allowable working pressure (MAWP): The maximum continuous gauge 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.

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

3.25 minimum allowable speed: The lowest rotational speed at which the manufacturer's design permits continuous operation.

3.26 minimum allowable suction pressure (for each stage): The lowest pressure (measured at the inlet flange of the cylinder) below which the combined rod 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.

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

3.28 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).

3.29 mounting plate: Baseplates, skids, soleplates, and rails.

3.30 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.

3.31 normally open and normally closed: Refers both to the on-the-shelf state and to the installed, de-energized state of devices such as automatically controlled electrical switches and valves.

Note: The normal operating state of such devices is not necessarily the same as the on-the-shelf state.

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

3.33 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.

3.34 owner: The final recipient of the equipment.

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

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

3.36 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).

3.37 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 pressure packing on horizontal cylinders).

3.38 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 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.

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

3.40 pressure design code: The recognized pressure vessel standard specified or agreed upon by the purchaser. Example: A recognized standard for pressure vessels is ASME Section VIII.

3.41 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.

3.42 rails: Soleplates extending the full length of each side of the equipment.

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

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

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

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

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

3.48 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.

3.49 rod 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.

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

3.51 shall: Is used to state a mandatory requirement.

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

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

3.54 soleplates: Grouted plates installed under motors, bearing pedestals, gearboxes, turbine feet, cylinder supports, crosshead pedestals and compressor frames (see Annex L).

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

3.56 standard volume flow: The flow rate expressed in volume flow units at either of the standard conditions outlined:

SI flow units are typically:

Normal cubic meters per hour (Nm^3/h), or

Normal cubic meters per minute (Nm^3/min)

At ISO standard conditions of

Absolute pressure: 1.013 bar

Temperature: 0°C

U.S. customary flow units are typically:

Standard cubic feet per minute (scfm), or

Million standard cubic feet per day (mmscfd)

At customary standard conditions of

Absolute pressure: 14.7 psia

Temperature: 60°F

3.57 spectral frequency distribution: The description of the pressure pulsation harmonic amplitudes versus frequency at a selected test point location for an active or passive acoustic analysis (see 3.1).

3.58 total indicator reading (TIR), (also known as total indicated runout): 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.

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

3.60 unit responsibility: The responsibility for coordinating the manufacturing and technical aspects of 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.

3.61 vendor (also known as supplier): The agency, company, or entity that supplies the equipment.

Note 1: The vendor can be the manufacturer of the equipment or the manufacturer's agent and normally is responsible for service support.

Note 2: The API mechanical equipment documents address the responsibilities between two parties. For the purposes of these standards, these parties are defined as the purchaser (see 3.41) and the vendor or supplier (see 3.61). There are many parties that are involved in the purchase and manufacture of the equipment. These parties are given different titles depending on the location in the chain of the order. They may be called buyer, contractor, manufacturer, and sub-vendor. In all instances, however, one party is purchasing something from another party. For example, the party supplying a lube oil console may be the console vendor to the compressor manufacturer, the sub-vendor to the purchaser, and the purchaser of components within the console. All of these terms can be reduced to the purchaser and vendor or supplier. It is for this reason that only these two terms are used in the body of the standard.

3.62 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.

4 General

4.1 UNIT RESPONSIBILITY

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

4.2 UNIT CONVERSION

The factors in API *MPMS,* Chapter 15, were used to convert from U.S. customary to SI units. The resulting exact SI units were then rounded off.

4.3 NOMENCLATURE

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

5 Requirements

• 5.1 DIMENSIONS

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

5.2 STATUTORY REQUIREMENTS

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

5.3 CONFLICTING REQUIREMENTS

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

6 Basic Design

6.1 GENERAL

6.1.1 The equipment (including auxiliaries) covered by this standard shall be designed and constructed for a minimum service life of 20 years and at least three years of uninterrupted operation. Achieving these targets is the shared responsibility of the purchaser and vendor and depends on the process system design. It is understood that interruptions to the continuous operation may occur due to exceeding the lifetime of wearing parts.

Note: It is recognized that these are design criteria.

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

• **6.1.3** The equipment's normal operating point shall be as specified. Unless otherwise specified, the capacity at the normal operating point shall have no negative tolerance (see 3.18, 3.30, and 3.48).

Note: See Annex B for a discussion of capacity and the term "no negative tolerance."

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

• **6.1.5** The pressure design code shall be specified or agreed upon by the purchaser.

• **6.1.6** Control of the sound pressure level (SPL) of all equipment furnished shall be a joint effort of the purchaser and the vendor having unit responsibility. The equipment furnished by the vendor shall conform to the maximum allowable sound pressure level specified.

In order to determine compliance, the vendor shall provide both maximum sound pressure and sound power level data per octave band for the equipment.

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

6.1.7 Unless otherwise specified, the cooling water system or systems shall, as a minimum, be designed for the conditions of Table 1.

Table 1—Cooling System Conditions

Parameter	**Requirement**	
For Heat Exchanger	SI Units	USC Units
Velocity over exchanger surfaces	1.5 m/s – 2.5 m/s	(5 ft/s – 8 ft/s)
Maximum allowable working pressure (MAWP)	≥7 bar (gauge)	(100 psig)
Test pressure (≥1.5 MAWP)	10.5 bar (gauge)	(150 psig)
Maximum pressure drop	1 bar	(15 psi)
Maximum inlet temperature	30°C	(90°F)
Maximum outlet temperature	50°C	(120°F)
Maximum temperature rise	20K	(30°F)
Minimum temperature rise	10K	(20°F)
Water side fouling factor	0.35 m^2 K/kW	(0.002 hr-ft^2 °F/Btu)
Corrosion allowance for carbon steel shells	3 mm	(0.125 in.)
For Cylinder Jackets and Packing Cases		
Maximum allowable working pressure (MAWP)	≥5 bar (gauge)	(75 psig)
Test pressure (≥1.5 MAWP)	7.5 bar (gauge)	(112.5 psig)
To avoid condensation, the minimum inlet water temperature to water cooled bearing housings should preferably be above the ambient air temperature.		

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. The final selection shall be subject to purchaser's approval.

Note: The purchaser should specify the requirements for cooling systems when they are different than those listed in Table 1.

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

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

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

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

Table 2—Driver Trip Speed

Driver Type	Trip Speed (percent of rated speed)
Steam turbine, NEMA Class A[a]	115
Steam turbine, NEMA Classes B, C, D[a]	110
Gas turbine	105
Variable-speed motor	110
Constant-speed motor	100
Reciprocating engine	110
[a] Indicates governor classes as specified in NEMA SM 23.	

6.1.10 Reciprocating compressors should normally be specified for constant-speed operation in order to avoid excitation of torsional, acoustic, and/or mechanical resonances. When variable-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 variable-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.

6.1.11 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.

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

6.1.13 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.

6.1.14 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 re-assembly. This can be accomplished by such methods as shouldering, using cylindrical dowels, or keys.

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

6.1.16 Many factors can adversely affect site performance. These factors include piping loads, alignment at operating conditions, supporting structure, handling during shipment, and handling and assembly at the site. To minimize the influence of these factors, the vendor shall review and comment on the purchaser's piping and foundation drawings in accordance with the agreed schedule. This review shall not imply that the vendor has design responsibility for the content of the purchaser's drawings. The vendor's review of foundation drawings shall be limited to anchor bolt layout and the vendor's input data used for foundation design.

● **6.1.17** When specified, the purchaser and the manufacturer shall agree on the details of an initial installation check by the vendor's representative and an operating temperature alignment check at a later date. 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.

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

6.1.19 Compressors shall be capable of developing the maximum differential pressure specified (e.g., minimum specified suction to maximum specified discharge pressure).

- **6.1.20** 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 degree of winterization and/or tropicalization (e.g., allowances for insulation) shall be mutually agreed upon by the purchaser and the vendor.

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

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

At discharge conditions, mass flow shall reflect leakage, liquid condensation, and the work of compression.

6.1.23 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 his 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 non-lubricated applications.

6.1.24 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.

6.1.25 The compressor vendor shall confirm that the unit is capable of continuous operation at any full-load, part-load, or fully unloaded conditions (see 6.1.24) and that the unit is capable of start-up in accordance with 7.1.1.6.

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

Note: See 9.3.6 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 specifically 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 nut end of the exposed stud end.

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) (see 6.10.2.1).

6.3 CALCULATING COLD RUNOUT

6.3.1 For horizontal compressors, the vendor shall calculate the vertical cold runout, including rod sag (as outlined in Annex C or by other proprietary methods). These values and a runout table (see Annex C) shall be submitted to the purchaser before the shop bar-over test. The manufacturer shall disclose the details of his calculations and the assumptions on which they are based.

The shop-measured horizontal and vertical cold rod runout shall equal the predicted cold rod runout within a tolerance of ±0.015% of stroke. Horizontal (side) piston rod runout, as measured by dial indicators during the shop bar-over test, shall not exceed 0.064 mm (0.0025 in.), regardless of length of stroke (see 8.3.4.1). See 6.10.4.6 when tail rod construction is used. Piston rod runout shall be measured adjacent to the cylinder packing case flange. See Annex C for clarification of rod runout and typical rod runout table.

6.3.2 For non-horizontal cylinders, the procedures and tolerances for runout measurements shall be mutually agreed upon between the purchaser and vendor.

6.3.3 Reciprocating compressor installations shall be designed in accordance with API 686, and compressors shall be installed in accordance with API 686.

• 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 non-lubricated services should be less than those in equivalent lubricated services.

6.5 ALLOWABLE DISCHARGE TEMPERATURE

6.5.1 Unless otherwise specified and agreed, the maximum predicted discharge temperature shall not exceed 150ºC (300ºF). 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.

Special consideration shall be given to services (such as high-pressure hydrogen or applications requiring non-lubricated cylinders) where temperature limitations should be lower. Predicted discharge temperatures shall not exceed 135ºC (275ºF) for hydrogen rich services (molar mass less than or equal to 12).

Commonly, compression ratios are higher in the first and second stages for full load. When the unit is unloaded by clearance pockets in lower stages, the higher stages have the higher compression ratios. The discharge temperature should be reviewed at all loading points.

Note: The adiabatic discharge temperature is the discharge temperature that would result from adiabatic compression. The actual discharge temperature can differ from the adiabatic discharge temperature depending on such factors as the power input to a cylinder, the ratio of compression, the size of the cylinder, the surface area of the cooling passages, and the velocity of the coolant. Non-lubricated hydrogen services generally have higher discharge temperatures than lubricated hydrogen services because of slippage and the unusual characteristic of hydrogen, which can release heat when it expands. With low power and small cylinders, the actual temperature rise can be lower than adiabatic temperature, which can allow a lesser number of stages if the application is borderline. Conversely, large cylinders can result in a temperature rise higher than adiabatic rise and can require additional stages.

• **6.5.2** A high discharge temperature alarm and shutdown device shall be provided for each compressor cylinder. When specified, 100% unloading shall be furnished as part of the system by the supplier of these devices. The setpoints and the mode of operation shall be mutually agreed upon by the purchaser and the compressor vendor.

The recommended discharge temperature alarm and trip setpoints are 20 K (40ºF) and 30 K (50ºF) respectively above the maximum predicted discharge temperature; however, temperature trip setpoints shall not exceed 180ºC (350ºF). To prevent auto-ignition, lower temperature limits should be considered for air, due to oxygen content, if the discharge gauge pressure exceeds 20 bar (300 psig). Use of synthetic oils, although not intended as a means to increase the allowable discharge temperature, is recommended for additional safety (see 6.14.3.1.9).

CAUTION: Oxygen bearing gases other than air require special consideration.

6.6 ROD AND GAS LOADS

6.6.1 The combined rod load shall not exceed the manufacturer's maximum allowable continuous combined rod loading for the compressor running gear at any specified operating load step. These combined rod 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 loading shall not exceed the manufacturer's maximum allowable continuous gas loading for the compressor static frame components (cylinders, heads, distance pieces, crosshead guides, crankcase, and bolting) at any specified operating load step. These gas 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 combined rod 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. The internal pressure during the suction stroke is the suction pressure at cylinder flange minus the valve and gas passage losses. The internal pressure during the discharge stroke is the discharge pressure at cylinder flange plus the valve and gas passage losses.

6.6.4 For all specified operating load steps and the fully unloaded condition, the component of combined rod loading parallel to the piston rod shall fully reverse between the crosshead pin and bushing during each complete revolution of the crankshaft. The duration and magnitude of this reversal shall be consistent with the oil distribution design of the crosshead bushing in order to maintain proper lubrication.

Note: Some bushing designs (such as grooved bushings) have proven reliability with as little as 15 degrees of rod reversal at 3% magnitude. Simple bushing designs (un-grooved) may require a minimum of 45 degrees of rod reversal and a 20% magnitude. The manufacturer should provide the actual requirements to the purchaser at the proposal stage.

6.6.5 The compressor shall be capable of handling short duration excursions of operation involving a load increase up to 10% above the maximum allowable continuous combined rod load and/or maximum allowable continuous gas load. These excursions shall be limited to a duration of less than 30 seconds and a frequency of no more than twice in a given 24-hour period.

6.7 CRITICAL SPEEDS

6.7.1 The compressor vendor shall perform the necessary lateral and torsional studies to demonstrate the elimination of any lateral or 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 9.2.3, Item r).

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. For motor-driven compressors, torsional natural frequencies shall be separated from the first and second multiples of the electrical power frequency by 10% and 5% respectively. For synchronous motor driven compressors, refer to the requirements of 7.1.2.10.

6.7.3 For drive trains that include a turbine and gear, the requirements of ISO 10437, 13691, or API 611, 612, 613, 616, and 677, 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 affect on the driver-compressor system. The assumptions and acceptance criteria for this analysis shall be mutually agreed upon by the purchaser and the vendor.

6.8 COMPRESSOR CYLINDERS

6.8.1 General

6.8.1.1 The maximum allowable working pressure of the cylinder shall be at least equal to the specified relief valve set pressure. If a set pressure is not specified, the maximum allowable working pressure 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 pressure packing and piston ring life. See notes at 7.7.1.4.

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 suppressors.

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 must be given to ensure rod load reversals (see 6.6.4.).

6.8.1.5 The walls of cylinders without liners (see 6.8.2.2) 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 maximum allowable working pressure, the maximum allowable continuous gas load, or the maximum allowable continuous combined rod load.

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

6.8.1.7 Bolting shall be furnished as specified in 6.2.

6.8.1.8 Cylinder heads, stuffing boxes for 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. Torque values for all studs and bolting shall be included in the manufacturer's instruction manual.

CAUTION: Exceeding the manufacturer's torque values on valve covers can cause damage to the valve assembly and cylinder valve seat.

6.8.1.9 Studded connections shall be furnished with studs installed. Blind stud holes should only be drilled deep enough to allow a preferred tap depth of 1$^1/_2$ times the major diameter of the stud. The first 1$^1/_2$ threads at both ends of each stud shall be removed to allow the stud end to bottom in the hole. Class 4 and 5 fit studs shall be installed with a depth gauge and shall not bottom in the holes. Anaerobic adhesive or similar epoxy bonding agents shall not be used with Class 1 or 2 fits.

6.8.1.10 Stud markings shall be located on the exposed end of the stud.

6.8.1.11 If extended studs are provided for hydraulic tensioning, the exposed threads shall be protected by a cover.

6.8.2 Cylinder Appurtenances

6.8.2.1 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 mutually agreed upon by the purchaser and vendor. If head end cylinder supports are necessary, the design shall be such that misalignment and/or excessive rod runout do not occur. The outboard 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 suppressor shall not be used to support the compressor cylinder.

6.8.2.2 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 piston diameters up to and including 250 mm (10 in.). For piston 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: Non-contacting vertical labyrinth type pistons do not necessarily need a replaceable liner.

6.8.2.3 The surface finish of the running bore of the cylinder liners and cylinders without liners used for applications with metallic or nonmetallic wear bands and piston rings, for either lubricated or non-lubricated services, shall be 0.1 µm – 0.6 µm (4 µin. – 24 µin.) Ra (arithmetic average roughness). The actual surface finish requirement is dependant on the choice of cylinder liner material, coatings, operating conditions, and the degree of lubrication.

● **6.8.2.4** If specified, the running bore of cylinders with non-metallic, tetrafluoroethylene-based (TFE) rings 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 upon.

Note: Care should be taken during commissioning of cylinders, particularly non-lube cylinders, to monitor excessive early rider band wear which can result in damage to the cylinder liner. After the initial run-in period, rider band wear normally decreases significantly.

6.8.2.5 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.

6.8.2.6 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 J for preferred approach). Designs that utilize three or more through bolts acting on the circumference of the valve cage may be furnished with purchaser approval. If this design is furnished, the through bolts shall be self-retaining and shall be furnished with cap type nuts and gaskets to prevent gas leakage.

6.8.2.7 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 using o-rings shall include an entering bevel for the o-ring.

6.8.2.8 Valve chambers and clearance pockets shall be designed to minimize trapping of liquid.

6.8.2.9 If drain connections are provided on external bottles used as clearance pockets, drain valves shall be provided (see 7.7.6 for piping material between clearance pocket and drain valve).

6.8.3 Cylinder Cooling

6.8.3.1 General

Cylinders shall have cooling provisions as required by the conditions of service described in 6.8.3.2 through 6.8.3.4.1 (see 7.7.4 and Figure G-1).

6.8.3.2 Static-filled Coolant Systems

Static-filled coolant systems (see Figure G-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 85K (150°F).

6.8.3.3 Atmospheric Thermosyphon Coolant Systems

Atmospheric thermosyphon coolant systems (see Figure G-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 85K (150ºF).

By mutual agreement between the purchaser and the vendor, a pressurized thermosyphon system may be used. The pressurized system may only 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.

6.8.3.4 Forced-liquid Coolant Systems

6.8.3.4.1 Forced-liquid coolant systems (see Figure G-1, Plan C) shall be provided when cylinders are operated while unloaded for extended periods of time and either (a) the expected maximum discharge temperature is above 100°C (210°F) or (b) the adiabatic gas temperature rise is 85K (150°F) or greater.

Note: For sites with ambient temperatures of 45ºC (110°F) or higher, thermosyphon or static-filled systems can be unsuitable. See 6.1.24 for fully unloaded extended operation.

Non-cooled or air-cooled cylinders shall not be furnished except by mutual agreement of the purchaser and the vendor.

6.8.3.4.2 Forced-liquid coolant systems (see Figure G-1, Plan C) shall meet the requirements of 6.8.3.4.3 through 6.8.3.4.5.

6.8.3.4.3 The cylinder cooling system provided shall be adequate to prevent gas condensation. Coolant inlet temperature shall be at least 5K (10ºF) above the inlet gas temperature. The coolant system shall be such that the above requirements are satisfied under all operating and transient conditions including start-up from cold.

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

Note 2: When the purchaser cannot supply coolant with adequate inlet temperature, a closed jacket cooling system compliant with 6.6.3.5, or an inline heater as shown in Figure G-1, Plan C, should be considered.

Note 3: 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 may be considered as long as condensation is avoided.

6.8.3.4.4 When possible, coolant exit temperatures should not be higher than 17K (30°F) above gas inlet temperature.

Note: Excessively high coolant exit temperatures can result in loss of capacity and efficiency.

6.8.3.4.5 Coolant flow and velocities should be sufficient to prevent solids suspended in the cooling media from depositing and causing the fouling of jackets and passages.

6.8.3.5 Cooling Jacket Systems

6.8.3.5.1 The arrangement of the cooling jackets shall be such that failure of a gasket or other seal does not result in leakage of coolant into the cylinder or gas into the cooling system. When cooling of cylinder heads is provided, separate non-interconnecting jackets are required for cylinder bodies and cylinder heads.

● **6.8.3.5.2** If specified, a self-contained, forced circulation, closed jacket coolant system shall be furnished (see Figure G-1, Plan D of Annex G). The coolant system shall meet the requirements of 6.8.3.4.3 and 6.8.3.4.5, as well as the requirements of 6.8.3.5.3 through 6.8.3.5.5.

6.8.3.5.3 A heating unit shall be provided as part of the self-contained closed jacket system for use during cold weather operation and for bringing the system up to temperature before start-up.

6.8.3.5.4 The coolant circulated shall, if possible, be controlled to maintain a rise in coolant temperature across any individual cylinder, including the cylinder heads if cooled, of between 5K (10ºF) and 10K (20ºF).

6.8.3.5.5 The system shall be pre-piped, factory skid mounted, and complete with the various pressure and temperature indicators, alarms, and other instrumentation specified.

6.8.4 Cylinder Connections

6.8.4.1 General

6.8.4.1.1 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.

6.8.4.1.2 All connections shall be flanged or machined and studded, except where threaded connections are permitted by 6.8.4.1.5. All connections shall be suitable for the maximum allowable working pressure of the cylinder as defined in 3.23. Flanged connections may be integral with the cylinder or, for cylinders of weldable material, may be formed by a socket-welded or butt-welded pipe nipple or transition piece, and shall terminate with a welding-neck or socket-weld flange.

6.8.4.1.3 Connections welded to the cylinder shall meet the material requirements of the cylinder, including impact values, rather than the requirements of the connected piping (see 6.13.7.4). All welding of connections shall be completed before the cylinder is hydrostatically tested (see 8.3.2).

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

6.8.4.1.5 For connections other than main process connections, if flanged or machined and studded openings are impractical, threaded connections for pipe sizes not exceeding DN 40 (1$^1/_2$ NPT) may be used with purchaser's approval in the following cases:

a. on non-weldable materials, such as cast iron;
b. when essential for maintenance (disassembly and assembly).

6.8.4.1.6 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).

6.8.4.1.7 The nipple and flange materials shall meet the requirements of 6.8.4.1.3.

6.8.4.1.8 Threaded openings and bosses for tapered pipe threads shall conform to ISO 7-1 and ISO 7-2 or ASME B16.5.

6.8.4.1.9 Threaded connections shall not be seal welded.

6.8.4.1.10 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.

6.8.4.1.11 Machine and studded connections shall conform to the facing and drilling requirements of ISO 7005-1 or 7005-2 or ASME B16.1, ASME B16.5, ASME B16.42, or ASME B16.47. Studs and nuts shall be furnished installed; the first $1^1/2$ threads at both ends of each stud shall be removed.

6.8.4.1.12 Machined and studded connections and flanges not in accordance with ISO 7005-1 or 7005-2 or ASME B16.1, ASME B16.5, ASME B16.42, or ASME B16.47, except for non-circular cylinder connections described in 6.8.4.2.1, shall be approved by the purchaser. Unless otherwise specified, the vendor shall supply mating flanges, studs, and nuts for these non-standard connections.

6.8.4.1.13 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.

Note: For piping installation requirements see API 686 (see 6.3.3).

6.8.4.1.14 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.

6.8.4.1.15 The finish of the gasket contact surfaces of cast iron, ductile iron, or steel connections (flanged or machined bosses), other than ring-type joints or non-circular joints, shall be between 3.2 µm and 6.4 µm (125 µin. and 250 µin.) arithmetic average roughness (Ra). Either a serrated-concentric finish or a serrated-spiral finish having 0.6 mm – 1.0 mm pitch (24 – 40 grooves per in.) shall be used. The surface finish of the gasket grooves of ring joint connections shall conform to ISO 7005-1 or ISO 7005-2 or ASME B16.5.

● **6.8.4.1.16** If specified, each cylinder shall be provided with a DN 12 (NPT $^1/2$) indicator tap at each end. Designs similar to Figure G-2, with a corrosion-resistant sleeve arrangement inside a continuous cast-in membrane to provide a positive gas-tight seal, are acceptable for cast iron and nodular iron cylinders. Materials shall be compatible with the gas.

● **6.8.4.1.17** If specified, indicator valves shall also be provided. If indicator valves are not furnished, the tapped indicator holes shall be plugged in accordance with 6.8.4.1.10.

6.8.4.2 Flanges

6.8.4.2.1 Flanges shall conform to ISO 7005-1 or 7005-2 or ASME B16.1, B16.5, B16.42 or B16.47 Series B as applicable, except as specified in 6.8.4.2.2 through 6.8.4.2.7 (see 6.8.4.1.15 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 F). 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.

6.8.4.2.2 Cast iron flanges shall be flat faced and conform to the dimensional requirements of ISO 7005-2 or ASME B16.1 or l6.42. Class 125 flanges shall have a minimum thickness equal to Class 250 for sizes DN 200 (8 NPS) and smaller.

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

6.8.4.2.4 Non-ferrous flanges shall conform to mutually agreed upon standards such as ISO 7005-3.

6.8.4.2.5 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 non-standard (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 dampeners. Ring type joints (RTJ) and lens type joints should be discussed between the purchaser and vendor on a special requirement basis.

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

6.8.4.2.7 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.

6.8.5 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 piston area of the cylinder end or ends concerned. For a double acting cylinder, this is the area of the crank-end of the cylinder less the piston rod plus the area of the outer end of the piston in cm^2;

f is the product of the actual lift, the valve-opening periphery, and the number of inlet or discharge valves 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 actual lift, the valve-opening periphery, 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 be treated only as a general indication of valve performance and should not be confused with effective velocities based on crank angle, degree of valve lift, unsteady flow, and other factors. 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, including that for double-decked valves, 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-seat-to-cylinder gaskets shall be solid metal or metal jacketed. Valve-cover-to-cylinder gaskets shall be either solid metal, the flexible graphite type, metal jacketed, or the o-ring type. Other gasket types may be used with mutual agreement between the purchaser and the vendor.

Note: Flexible graphite-type gaskets with a suitable reinforcement have been successfully used to seal valve cover to cylinder gaskets where low mole weight gases are compressed.

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.

6.9.1.6 When discharge valve assemblies, including any cage or chair, have a mass of 15 kg (35 lb) or more, the vendor shall provide a device to facilitate removal and installation of valve assemblies for maintenance. On all under-slung valves, an arrangement shall be provided to hold the complete valve assembly in position while the cover is 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 Valve hold-downs shall bear at not less than three points on the valve assembly. The bearing points shall be arranged as symmetrically as possible (see 6.8.2.6).

● **6.9.1.9** The vendor shall conduct a computer study of the valve dynamics to optimize the valve sealing element motion during the opening and closing phase. The mathematical models being used for the valve motion calculation shall, as a minimum, take into account: valve sealing element masses, spring forces, aerodynamic drag coefficients, fluid damping, and any other factors deemed necessary by the vendor to assess valve element motion, impact, and efficiency. The study shall also include a valve dynamic response analysis of the valve component’s reactions to the piping and compressor cylinder gas passage induced pulsations. The study shall include a review of all operating gas densities and load conditions.

If specified, the vendor shall submit a written valve dynamics report to the purchaser.

6.9.1.10 Metal valve disks or plates, 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. Edges shall be suitably finished to remove stress risers. Valve seats and sealing surfaces shall also be finished to an Ra of 0.4 µm (16 µin.) or better. When non-metallic 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 non-metallic valve plate materials. These properties shall include filler type and content, specific gravity, melting temperature, glass transition temperature (where applicable), izod impact strength (notched and un-notched), water absorption and coefficient of thermal expansion. Reinforcement of non-metallic materials shall be with fibers, not with spherical beads or other shapes. Fibers shall be oriented to optimize component life (e.g., the fibers shall follow the stress path).

6.9.2 Unloaders

● **6.9.2.1** If cylinder valve unloading is specified, the type of unloader provided (valve depressor or plug-type) shall be mutually agreed upon. Valve assembly lifters shall not be used. When valve depressors are used for capacity control, all inlet valves of the cylinder end involved shall be so equipped where possible. Use of less than a full complement of suction valve depressors requires the purchaser’s approval.

Note: Special precautions may be necessary when using valve plate depressors in combination with non-metallic valve plates or discs. Special precautions are also necessary when using non-metallic valve plate depressors, with respect to unloaded or alternate conditions, which may cause higher operating temperatures.

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 must be equal to or greater than half of the total free lift area (or least flow area) of all suction valves on that end. The unloader assembly shall positively guide the plug to the seat.

6.9.2.3 When valve depressors are used only for start-up and never for capacity control, consideration shall be given to using a reduced number of unloaders. For start-up with plug unloaders, only one per cylinder end is needed.

● **6.9.2.4** Unloaders shall be pneumatically or hydraulically actuated. Individual hand-operated unloaders or manual overrides on actuated unloaders are not permitted. Remotely controlled unloaders shall be designed by the vendor in such a manner that the correct sequence of operation between stages and cylinder ends is achieved. The vendor shall provide the user with information regarding the proper sequencing for unloader operation. See 7.6.2.4.

Note: Malfunctioning and/or incorrect sequencing of unloaders can result in overload or unbalance of the compressor.

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.

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

6.9.2.7 If specified, a stainless steel protective sheet metal rain shield shall be furnished to protect exposed topside unloader parts from the elements. The rain shield shall be fabricated with a handle for easy removal and replacement. See Annex J for a sketch of the rain cover.

Note: Moisture can gather around the seals on the top of exposed unloaders and mix with airborne elements to form a corrosive mixture. The mixture can etch unloader shafts and lead to premature unloader failure, which can be erroneously contributed to moisture-laden control gas.

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 assure a minimum pre-load in the connection of 1.5 times the maximum allowable continuous rod loading (see Figure G-9).

6.10.2 Connection of Piston Rod to Crosshead

6.10.2.1 Piston rods shall be connected to the crosshead by (a) a direct connection, where the rod is threaded into the crosshead (e.g. jambnut design, or a multi-bolt design) (e.g., Figure G-6), or (b) an indirect connection, where the rod is not threaded into the crosshead (e.g., see Figures G-7 and G-8) (see Tightening Diagram Figure G-9). Positive locking of the rod shall be provided for direct connection methods.

Other proven attachment methods (e.g., Figure G-8) may be used, and in such cases they shall be noted in the proposal. Mechanical or hydraulic methods are acceptable for tightening. Slugging wrenches for this procedure shall not be used. Where pre-load is achieved by hydraulic tensioning methods, which ensure the proper pre-load, positive locking is not required.

6.10.2.2 The manufacturer’s tightening procedure shall assure a minimum preload in the connection equal to 1.5 times the maximum allowable continuous rod loading (see Figure G-9).

Note: The process for attaching the piston rod to the piston and to the crosshead should be performed in accordance with the manufacturer’s standard.

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 depressured. 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** If specified, wear bands shall be of single- or multi-piece construction designed to prevent underside pressurization (acting similarly to a piston ring). If feasible, pistons shall be segmented to facilitate wear band installation. Piston ring carriers supplied with multi-piece pistons shall be made of wear resistant material. Nonmetallic wear bands shall not overrun fully open single-hole valve ports or liner counter-bores by more than half the width of the wear band. When the cylinder configuration leads the wear 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 wear band.

For non-lubricated, horizontal cylinders, the bearing load calculated from Equation 2 on nonmetallic wear 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 120º arc of all wear bands (see Equation 2).

For lubricated horizontal cylinders, the bearing load calculated from Equation 2 on wear bands, if used, shall not exceed 0.07 N/mm^2 (10.0 lbf/in.^{2}) using the same approach described for nonmetallic wear bands.

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

where

L_B is the bearing load on wear 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 wear bands in mm (in.).

Note: When meeting the bearing load requirement results in an excessively wide wear band, multiple wear bands are preferred.

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 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.

Alternatively, an 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 AISI 4140 or better and shall be surface hardened in the packing area to a hardness of at least Rockwell C 50, 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 must be properly sealed to prevent corrosion of the base material at the interface of the coating. Fusion 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 are not recommended because of the potentially destructive stress risers left in the surface. Use of sub-coating under the main coating is not recommended.

Note: Piston rods that have been previously induction-hardened should 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 MR0175 (see 6.15.1.11). 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 non-lubricated services shall be 0.15 µm to 0.4 µm (6 µin. – 16 µin.) Ra.

Note: Smoother finishes should 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. The vendor shall state in the proposal the rod material and type of connection (see Figures G-6, G-7 or G-8). If NACE-MR0175 must be applied because of H_2S gas service (as defined in 6.13.1.11), 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.

6.10.4.6 Tail rods shall be used only with 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 CRANKCASES, CRANKSHAFTS, CONNECTING RODS, BEARINGS AND CROSSHEADS

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 equal to or less than 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 8.2.2.3.3 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: Purchasers should recognize that 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 All rolling element bearings shall be suitable for belt drive applications and shall give an L10-rated life, calculated in accordance with ISO 281-1 or AFBMA 11, of either 50,000 hours with continuous operation at rated conditions or 25,000 hours at maximum axial and radial loads and rated speed. (The rating life is the number of hours at rated bearing load and speed that 90% of the group of identical bearings will complete or exceed before the first evidence of failure.)

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 applicable AFBMA recommendations.

6.11.3 Connecting Rods

For compressors above 150 kW (200 hp), connecting rods shall be forged steel with removable caps. For compressors equal to or less than 150 kW (200 hp), ductile iron, steel plate, or cast steel connecting rods are acceptable. The 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. Crankpin bushings shall be of the replaceable precision-bored type and shall be securely locked in place. All connecting rod bolts and nuts shall be securely locked with cotter pins or wire after assembly. Connecting rod bolts shall have rolled threads.

6.11.4 Crossheads

For compressors above 150 kW (200 hp), crossheads shall be made of steel. For compressors equal to or less than 150 kW (200 hp), ductile iron is acceptable for crossheads. The crosshead top and bottom shoes or guides shall be replaceable. Facilities shall be provided for the adjustment of crosshead clearance and alignment. Field machining for adjustment of clearances shall be avoided. Adequate openings shall be provided to service crosshead assemblies.

6.11.5 Crankcases

● If specified, the crankcase shall be provided with relief devices to protect against rapid pressure rise. These devices shall incorporate downward-directed apertures (away from the operator's face), a flame-arresting mechanism, and a rapid closure device to minimize reverse flow. The ratio of the total throat area of these devices to the crankcase free volume should be no less than 70 mm^2/dm^3 (3 $in.^2/ft^3$).

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 G-3).

6.12.1.2 *Type A—short, single-compartment distance piece used only for lubricated service when oil carry-over (at the wiper packing and cylinder pressure packing) is acceptable.* In this application, part of the piston rod may alternately enter the crankcase (crosshead housing) and the gas cylinder pressure packing. This arrangement shall not be used when cylinders are lubricated with synthetic oils (see 6.14.3.1.9).

Note: Type A distance pieces are used only for nonflammable or non-hazardous gases.

6.12.1.3 *Type B—long single-compartment distance piece used for non-lubricated 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 gas cylinder pressure packing. The rod shall be fitted with an oil slinger of spark resistant material and preferably of a split design for easy access to the 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, intermediate partition packing, and the cylinder pressure packing.

Segmental packing shall be provided between the two compartments. If necessary, provisions for lubrication of the segmental 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. 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 non-flammable, non-reactive 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 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 pieces (or compartments) shall be equipped with screened safety guards, louvered weather covers, or gasketed solid metal covers as specified.

All access openings shall be surfaced and drilled to accommodate solid metal covers. Nonmetallic covers are not permitted.

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** Where solid metal distance piece covers are provided or specified, the distance piece, partitions, covers, bolting, and the intermediate partition packing shall be designed for a minimum compartment differential pressure of 2 bar (25 psi) or higher, if specified. The vendor shall indicate the maximum allowable working pressure (MAWP) of the distance piece. The purchaser shall specify the maximum allowable back pressure on the vent system.

• **6.12.2.4** Each distance piece compartment shall be provided with the following connections:

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 packing vent connection below the rod to facilitate liquid draining of the packing case;
e. when required, packing lubrication;
f. where packing case cooling is required or specified, inlet and outlet connections on the distance piece suitably arranged to facilitate draining and venting.

See Figure G-3. See Annex I 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 having an area at least equal to the area of the hole through the crank-end-head piston-rod hole minus the area of the piston rod. The vendor shall confirm that the DN 40 (NPT 1^{1}/2) free vent connection or relief device is adequate to prevent overpressure of the distance piece in the event of a packing case failure.

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

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

6.12.2.7 Internal packing vent tubing and fittings shall be of austenitic stainless steel.

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

6.12.2.9 For Type A and B distance pieces with solid metal covers, positive seal rings shall be provided at the wiper packing. For Types C and 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 cylinder pressure packing (see 6.13.1.6).

6.13 PACKING CASES AND PRESSURE PACKING

6.13.1 General

• **6.13.1.1** All oil-wiper packing, intermediate partition packing, and cylinder 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 maximum allowable working pressure (MAWP) of the cylinder. Packing case assemblies shall have positive alignment features, such as cup-to-cup pilot fits and/or sufficient body-fitted tie bolts.

6.13.1.3 For flammable, hazardous, toxic, or wet gas service, the 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 G.

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 wear bands.

6.13.1.5 Crosshead packing boxes shall employ wiper packing to effectively minimize oil leakage from the crankcase.

• **6.13.1.6** If specified, to reduce process gas emissions to an absolute minimum, the cylinder pressure packing shall include venting and buffer gas cups with side-loaded packing rings in the adjacent sealing cups. See the arrangement in Figure I-3.

Note: The buffer gas should be a non-flammable, non-reactive or inert gas such as nitrogen.

6.13.1.7 Unless otherwise specified, the manufacturer shall provide suitable devices and instructions to enable the piston rod to be passed through the completely assembled cylinder 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.

6.13.2 Pressure Packing Case Cooling Systems

6.13.2.1 Unless otherwise specified, the criteria given in 6.13.2.2 through 6.13.2.6 shall be followed for the cooling of pressure packing cases.

6.13.2.2 The manufacturer's standard design may be used for cylinder discharge gauge pressure to 100 bar (1500 psig).

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

a. all non-lubricated packing rings;
b. lubricated non-metallic rings, when the cylinder maximum allowable working pressure (MAWP) is above 35 bar (500 psig);
c. all materials, lubricated or non-lubricated, when the cylinder maximum allowable working pressure (MAWP) is above 100 bar (1500 psig).

6.13.2.4 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 – 1 mm (0.015 in. – 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; and
c. cases are to be tested for leakage on the coolant side to a gauge pressure not less than 8 bar (115 psig).

6.13.2.5 Cooling of pressure packing is not required for non-lubricated cylinders having a maximum allowable working pressure (MAWP) below 17 bar (250 psig). Coolant connections in the packing cases shall be plugged with threaded steel plugs.

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

● **6.13.2.7** When cooling of cylinder 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 coolant pressure drop through the packing case shall not exceed 1.7 bar (25 psig).

If specified, the vendor shall supply a closed liquid cooling system. If specified, and for all sour or toxic gas services, this system shall be separate from the cylinder jacket cooling system. See Figure G-4 for additional details on self-contained cooling systems for cylinder pressure packing.

Note: The inlet packing case coolant temperature should not exceed 35ºC (95ºF). Packing efficiency increases with low coolant temperature.

6.14 LUBRICATION

6.14.1 General

In addition to the requirements of ISO 10438-1 and ISO 10438-3 or API 614, Chapters 1 and 3, the following requirements apply to compressor lube oil systems:

6.14.2 Compressor Frame Lubrication

6.14.2.1 General

6.14.2.1.1 For compressors 150 kW (200 hp) and above, the frame lubrication system shall be a pressurized system. Splash lubrication systems may be used on horizontal compressors of 150 kW (200 hp), or less, with rolling element bearings. The crankcase oil temperature shall not exceed 70ºC (160ºF) for pressurized oil systems and 80ºC (180ºF) for splash systems. Cooling coils shall not be used in crankcases or oil reservoirs.

6.14.2.1.2 Unless otherwise specified, pressure lubrication systems shall be general-purpose systems designed and furnished in accordance with ISO 10438-1 and ISO 10438-3 or API 614, Chapters 1 and 3, except as modified below.

● **6.14.2.1.3** If specified, pressure lubrication systems shall be special-purpose systems designed and furnished in accordance with ISO 10438-1 and ISO 10438-2, or API 614, Chapters 1 and 2.

Note: Special-purpose systems in accordance with ISO 10438-2 or API 614, Chapter 2, are typically applied only to reciprocating compressor trains involving a large turbine driver and gear unit.

6.14.2.1.4 The basic oil system, in accordance with 6.14.2.1.2, shall contain, as a minimum, the following components:

a. reservoir—typically the compressor crankcase;
b. main oil pump—(materials in accordance with 6.14.2.1.5) which may be shaft-driven or motor driven;
c. auxiliary pump, when required, in accordance with 6.14.2.2;
d. single cooler (see 6.14.2.3);
e. dual filters (see 6.14.2.4);
f. heater—when required (see 6.14.2.5);
g. pressure relief valve for each pump (see 6.14.2.6);
h. single regulator for control of delivered oil pressure (separate from relief valves);
i. single regulator for oil temperature control (see 6.14.2.7);
j. valves—material shall be carbon steel with stainless steel trim;
k. oil piping—shall be stainless steel pipe and fittings (with the exception of cast-in-frame lines or passages); or stainless steel tubing and fittings (see 6.14.2.1.8);
l. The following instruments:

- one pressure indicator;
- two temperature indicators;
- one level indicator (on the crankcase or reservoir) (see 6.14.2.1.9);
- one pressure transmitter for low pressure alarm and auxiliary pump start;
- one low frame oil level transmitter for alarm;
- one filter high differential pressure transmitter for alarm;
- one pressure transmitter for low pressure shutdown.

See Figure G-5 for a typical schematic drawing of a lube-oil system.

6.14.2.1.5 All external oil-containing pressure components, including auxiliary pumps, shall be steel; except that crankshaft-driven lube-oil pumps may have cast iron or nodular iron casings.

6.14.2.1.6 The rated gauge 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 relief 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 27ºC (80ºF) at the normal flow rate to the bearings.

6.14.2.1.7 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.

6.14.2.1.8 Lap-joint or slip-on flanges are not allowed.

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

● **6.14.2.1.10** If specified, the oil system shall be run in the vendor's shop and inspected in accordance with 8.2.3.2.

● 6.14.2.2 Auxiliary Pump

For each unit having a nominal frame rating of more than 150 kW (200 hp), 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.

The vendor shall supply the type of driver specified. Unless otherwise specified, pump drivers shall be sized for the pump power and required starting torque at an oil kinematic viscosity of 1000 mm^2/s (5000 SSU). The purchaser shall specify if this type of lube system is to be supplied on units with frame ratings less than 150 kW (200 hp)

6.14.2.3 Cooler

The following requirements apply to lube oil coolers.

a. Unless otherwise specified, when shell and tube coolers with surface area equal to or greater than 0.5 m^2 (5 ft^2) are supplied, a removable-bundle design is required.
b. Removable-bundle coolers shall be in accordance with TEMA Class C or equivalent standard, and shall be constructed with a removable channel cover.
c. Tubes shall not have an outside diameter of less than 16 mm ($^5/_8$ in.), and the tube shall have a wall thickness of not less than 1.2 mm (18 BWG).
d. Unless otherwise specified, cooler shells, channels and covers shall be steel; tube sheets shall be brass; and tubes shall be of a copper/zinc/tin non-ferrous material such as UNS C44300.
e. U-bend tubes are not permitted.
f. Coolers shall be equipped with a high point vent and low point drain connections on their oil and water sides.

6.14.2.4 Filters

The following requirements apply to filters:

a. filters shall provide a minimum particle removal efficiency (PRE) for 10 μm particles of 90% ($\beta_{10} \geq 10$) and a minimum PRE of 99.5% for 15 μm particles ($\beta_{15} \geq 200$), in both cases in accordance with ISO 16889 when tested to a minimum terminal differential pressure of 3.5 bar (50 psig) (API 614, Chapter 3, 1.7.2);
b. cartridges shall have a minimum collapsing differential pressure of 5 bar (70 psig);
c. if size permits, each filter shall be equipped with a vent and clean- and dirty-side drain connections.

• 6.14.2.5 Heater

If specified, provisions to heat the oil for compressor start-up in cool ambient conditions shall be provided. Heating can be supplied by:

a. a removable steam-heating element external to the reservoir,
b. a thermostatically controlled electric immersion heater, and
c. steam heating connections on the cooler.

Purchaser approval is required on the heating method.

Electric immersion heaters should be interlocked to be de-energized when the oil level drops below the minimum operating level.

Note: Caution is required in using a steam heating connection on the cooler to avoid overheating the oil, or damage to the cooler.

• 6.14.2.6 Pressure Relief Valve

Each lube oil pump pressure relief 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.

6.14.2.7 Oil Temperature Regulator

An oil temperature control system with a manual over-ride or bypass shall be provided. For water-cooled services, this system shall be based on an arrangement by which a portion of the oil flow bypasses the cooler to maintain constant oil temperature to the equipment. Control valves shall be of flanged steel construction. See Figure G-5 for a typical schematic drawing of a lube oil system.

6.14.3 Cylinder and Packing Lubrication

6.14.3.1 General

• **6.14.3.1.1** The vendor shall supply either a single plunger-per-point or a divider-block mechanical lubricator system for compressor cylinder and packing lubrication, as specified.

- **6.14.3.1.2** Lubricators shall be driven by the crankshaft or driven independently, as specified. Lubricators shall be separate from the frame lubrication pump(s) and complete with necessary tubing or piping (see 7.7.3). Ratchet lubricator drives shall not be used.

6.14.3.1.3 Pumps shall be sized to permit a 100% increase and a 25% decrease in design flow. The pumps shall be designed to allow adjustments to the pumping rate while the compressor is operating.

- **6.14.3.1.4** If specified, 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 by the purchaser and vendor. When an internal heater is used it shall be fully immersed even at minimum reservoir level (see 6.14.3.2.1.2).

6.14.3.1.5 Unless otherwise specified, lubricators shall have provisions for pre-lubrication of the compressor prior to compressor start up.

- **6.14.3.1.6** Each cylinder and packing lubrication system shall be provided with a lubricator system failure alarm. If specified, additional alarm functions shall be provided (see 6.14.3.2.1.2 and 6.14.3.2.2).

6.14.3.1.7 At least one lubrication point shall be provided for each compressor cylinder bore and packing. 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 maximum allowable working pressure 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.

6.14.3.1.8 Lube oil injection passages to the cylinder bore shall be drilled through metal provided in the cylinder water jacket casting or weldment. Lubrication pipes or tubes (similar to Figure G-2) running through the metal in the water jacket are acceptable. Pipe or tubing shall be austenitic stainless steel as a minimum and may be used in the gas passages if the materials are compatible with the gas composition (see 7.7.3). Lube oil injection passages shall be drilled and tapped for all cylinders including non-lubricated services. Unused holes shall be plugged with threaded stainless steel solid plugs. Tubing connections shall be match tagged for identification at the disassembly points for all compressor components in order to facilitate re-assembly.

- **6.14.3.1.9** If specified, the compressor cylinders, the compressor frame, or both, shall be lubricated by synthetic lubricants. The lubricant specifications shall be mutually agreed between the purchaser and the vendor. Interior surfaces and non-metallic components of the lubricating system coming into contact with synthetic lubricant shall be of compatible materials agreed by the compressor manufacturer and the lubricant manufacturer. 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 recommended by the lubricant manufacturer 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.

6.14.3.1.10 Lubricator reservoir capacity shall be adequate for a minimum of 30 hours of operation at normal flow rates.

6.14.3.2 Pump-to-point Lubrication

6.14.3.2.1 General

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

6.14.3.2.1.2 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.

• 6.14.3.2.2 Divider Block Lubrication

Divider block systems shall be provided with protection and indicating devices to protect the system from overpressure and to allow operational monitoring of the functioning 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 intended to signal that the outlet is plugged;
b. the system shall be protected from overpressure with a relief device (rupture disc) located downstream of the pump(s);
c. a pressure gauge shall be provided indicating pump discharge pressure;
d. for protection against loss of flow, a cycle monitor shall be provided with a digital display showing total flow and shall be equipped with an alarm indicating no flow;
e. the cycle monitor shall be driven by a proximity switch mounted on the primary divider block.

Additional, or alternative, protection and monitoring devices may be provided as agreed on by the purchaser and the vendor.

6.15 MATERIALS

6.15.1 General

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

Annex H lists general material classes for compressors. When used with appropriate heat treatment and/or impact-testing requirements, these material classes are considered acceptable for major component parts (see 7.7 for auxiliary piping material requirements).

6.15.1.2 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 (see Clause 2). 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.

6.15.1.3 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), babbitt bearings, and precipitation-hardened stainless steels, are excluded from this requirement. Where mutually agreed between the vendor and purchaser, 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.

6.15.1.4 The vendor shall specify the optional tests and inspection procedures required to ensure that materials selected are satisfactory for the service intended. Such tests and inspections shall be listed in the proposal.

● **6.15.1.5** Additional optional tests and inspections may be specified by the purchaser.

Note: At the purchaser’s request, additional optional tests and inspections can be specified, especially for materials used in critical components or in critical services.

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

6.15.1.7 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.

● **6.15.1.8** The presence of any corrosive agents (including trace quantities) in the motive and process fluids and in the site environment, including constituents that can cause stress corrosion cracking, shall be specified by the purchaser.

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

Note 2: If chlorides are present in the process gas stream to any extent, extreme care must be taken with the selection of materials in contact with the process gas. Caution should be given to components of aluminum and austenitic stainless steel.

6.15.1.9 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.

6.15.1.10 When 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 antiseizure compound of the proper temperature specification and compatible with the specified process fluid(s).

Note: With and without the use of antiseizure compounds, the required torque loading values to achieve the necessary preload will vary considerably.

• **6.15.1.11** All materials exposed to H_2S gas service as defined by NACE MR0175 shall be in accordance with the requirements of that standard. Ferrous materials not covered by NACE MR0175 shall not have a yield strength exceeding 620 N/mm^2 (90,000 psi) nor a hardness exceeding Rockwell C 22.

Components fabricated by welding shall be postweld heat treated, if required, so that both the welds and the heat-affected zones meet the yield strength and hardness requirements.

Components expected to comply with NACE MR0175 shall include, as a minimum: all pressure-containing cylinder parts (such as the cylinder, heads, clearance pockets, valve covers) and all fasteners directly associated with those parts; all components within the cylinder (such as piston, piston rod, valves, unloaders and fasteners); components within the outboard distance piece (such as packing box, packing, and fasteners).

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 (see Annex Q).

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.

Hardness requirements for valve seats and piston rod surface can be in excess of NACE provisions (see 6.10.4.1). Similar exceptions can be made for valve plates, springs, and unloader components, where greater hardness has been proven necessary. Mutual agreement shall be reached between the vendor and the purchaser 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.

In many applications, small amounts of wet H_2S are sufficient to require materials resistant to sulfide stress corrosion cracking. 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 should automatically note on the data sheets the requirement for materials resistant to sulfide stress corrosion cracking.

6.15.1.12 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 can be created that can result in serious corrosion of the less noble material. The NACE Corrosion Engineer's Reference Book is one resource for selection of suitable materials in these situations.

6.15.1.13 Low-carbon steels can be notch sensitive and susceptible to brittle fracture at ambient or lower temperatures. Therefore, only fully killed, normalized steels made to fine-grain practice are acceptable. The use of steel made to a coarse austenitic grain size practice (such as ASTM A 515) shall be avoided.

6.15.1.14 O-ring materials shall be compatible with all specified services. Special consideration shall be given to the selection of O-rings for high-pressure services to ensure that they will 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.

6.15.1.15 The minimum quality bolting material for pressure joints shall be carbon steel such as ASTM A 307, Grade B for cast iron components, and high temperature alloy steel such as ASTM A 193, Grade B7 for steel or ductile iron components. Carbon steel nuts such as ASTM A 194, Grade 2H shall be used. For minimum allowable temperatures equal to or lower than –30°C (–20°F), low-temperature bolting material such as ASTM A 320 shall be used.

6.15.1.16 The corrosion allowance for separate carbon-steel knockout pots shall be a minimum of 3 mm ($^1/_8$ in.). The purchaser and the vendor shall agree upon the corrosion allowance for heat exchangers and alloy parts required for special services.

6.15.2 Pressure-containing Parts

6.15.2.1 Unless otherwise specified, materials for pressure-containing cylinder parts shall be used in conjunction with the maximum allowable working pressure (MAWP) in Table 3. All material selections shall be subject to review by the purchaser.

Note: Higher design pressures may be permitted based on detailed engineering analysis.

Table 3—Maximum Gauge Pressures for Cylinder Materials

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

6.15.2.2 Steel compressor cylinders shall be equipped with steel heads.

6.15.2.3 The use of fabricated cylinders shall be stated in the proposal, and requires the purchaser’s written approval.

6.15.3 Castings

6.15.3.1 General

6.15.3.1.1 Castings shall be sound and free of 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 at the foundry prior to machining.

6.15.3.1.2 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.

6.15.3.1.3 Fully enclosed cored voids, which become fully enclosed by methods such as plugging, welding, or assembly, are prohibited.

6.15.3.1.4 Unless otherwise specified, pressure-retaining castings of gray iron shall be produced in accordance with ASTM A 278, and pressure-retaining castings of steel shall be produced in accordance with ASTM A 216.

6.15.3.2 Nodular Iron Castings

6.15.3.2.1 Nodular iron castings shall be produced in accordance with an internationally recognized standard such as ASTM A 395. The production of the castings shall conform to the conditions specified in 6.15.3.2.2 through 6.15.3.2.5.

6.15.3.2.2 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.

6.15.3.2.3 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 A 247.

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

6.15.3.2.5 To verify the uniformity of the casting, Brinell hardness readings shall be made on the actual castings at 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.

6.15.4 Forgings

Pressure-containing forgings shall be in accordance with ASTM A 668.

6.15.5 Fabricated Cylinders and Cylinder Heads

6.15.5.1 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.

6.15.5.2 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 6.15.5.3 through 6.15.5.13.

6.15.5.3 Plate subjected to alternating pressure loads used in cylinders and cylinder heads shall be subjected to the procedures in 6.15.5.4 through 6.15.5.6 after being cut to shape and before weld joint preparation.

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

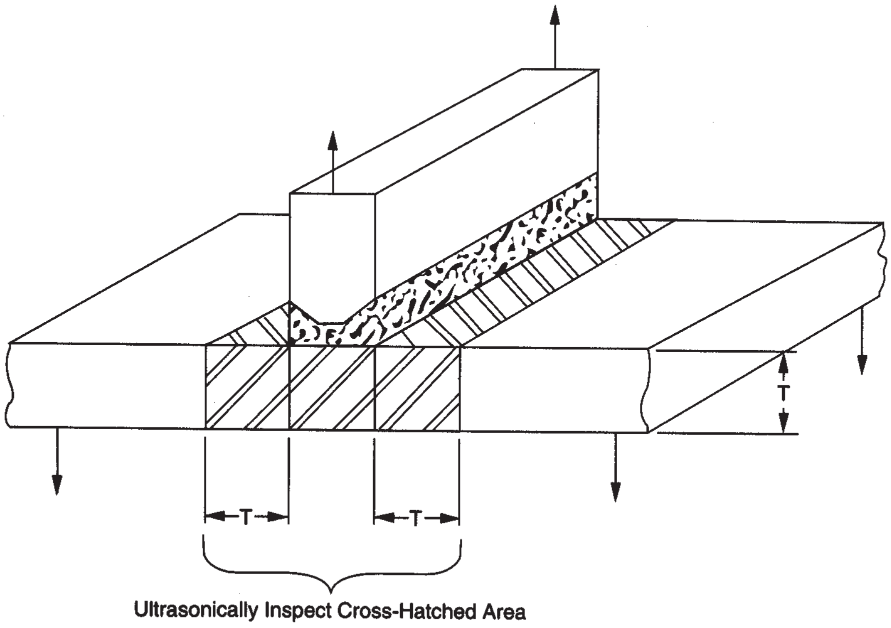

Figure 1—Plate Loaded in Tension in the Through-thickness Direction and its Area Requiring Ultrasonic Inspection

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

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

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

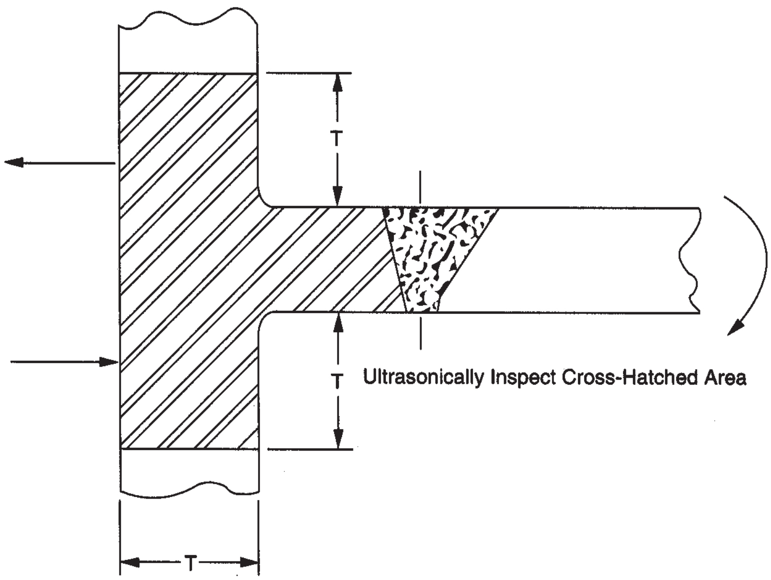

Figure 2—Plate Loaded in Bending and its Area Requiring Ultrasonic Inspection

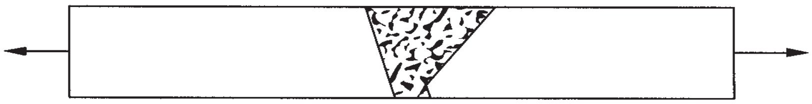

Figure 3—Axially Loaded Plate

6.15.5.7 After preparation for welding, plate edges shall be inspected by magnetic particle or liquid penetrant examination as required by the specified pressure vessel code or internationally recognized standard such as ASME Section VIII, Division 1, UG-93 (d)(3).

6.15.5.8 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.

6.15.5.9 Unless approved by the purchaser prior to the start of fabrication, pressure-containing welds, including welds to horizontal- and vertical-joint flanges, shall be full-penetration (complete-joint) welds.

6.15.5.10 All fabricated cylinders and cylinder heads shall be post-weld heat treated, regardless of thickness (see 6.15.7.7).

6.15.5.11 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 used.

● **6.15.5.12** If specified, in addition to the requirements of 6.15.7.1, specific welds shall be subjected to 100% radiography, magnetic particle inspection, or liquid penetrant inspection.

● **6.15.5.13** 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 pre-weld and post-weld heat treatments.

6.15.6 Repairs to Castings and Forgings

6.15.6.1 Major repairs to pressure-containing parts, all repairs to moving parts subject to load reversals, and all repairs to crankshafts shall not be undertaken without the purchaser's written authorization. This can include, but not be limited to, cylinder parts, piston and rod assembly components, and crosshead assembly components.

6.15.6.2 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.

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

a. sketches 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.

6.15.6.4 For non-pressure-containing components, the vendor shall make repairs in accordance with his 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 must be documented by the vendor. No repair is to be made without written approval of the vendor's engineering, quality-control, and manufacturing departments.

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

6.15.6.6 Pressure-containing castings shall not be repaired by peening, burning-in, or impregnating. Pressure-containing castings and forgings shall not be repaired by welding, plating, or plugging except as specified in 6.15.6.7 through 6.15.6.8.

6.15.6.7 Weldable grades of steel castings and forgings may be repaired by welding using a qualified welding procedure (see 6.13.7.3). 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.

6.15.6.8 Gray cast iron or nodular iron may be repaired by plugging within the limits specified in the applicable material standard such as ASTM A 278 or A 395; but shall not be repaired by welding.

Unless mutually agreed by the purchaser and the vendor, plugs shall not be used in the gas-pressure-containing wall sections of cylinders: in particular in the bore under the liner.

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.

Note: Annex D describes some repair techniques that can be considered for application to gray or nodular iron castings for compressor cylinders. These techniques should only be applied after a thorough mutual evaluation of the circumstances by the purchaser and the vendor.

6.15.7 Welding

6.15.7.1 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 Section VIII, Division l, and ASME Section IX.

6.15.7.2 Unless otherwise specified, other welding, such as welding on baseplates, non-pressure ducting, lagging, and control panels, shall be performed by welders qualified in accordance with an appropriate recognized standard such as AWS D 1.1.

6.15.7.3 The vendor shall be responsible for the review of all repairs and repair welds. The vendor shall also be responsible to ensure that all the repairs and repair welds are properly heat treated and nondestructively examined for soundness, and to ensure compliance with the applicable qualified procedures.

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

Unless otherwise specified, weld procedures for major repairs shall be subject to review by the purchaser prior to any repair.

6.15.7.4 Connections welded to pressure-containing parts shall be installed as specified in 6.15.7.5 through 6.15.7.9.

● **6.15.7.5** If specified, in addition to the requirements of 6.15.7.1, specific welds shall be subjected to 100% radiography or magnetic particle inspection or liquid penetrant inspection of welds.

● **6.15.7.6** 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 pre- and postweld heat treatments.

6.15.7.7 All welds shall be heat treated in accordance with the specified pressure vessel code or an internationally recognized standard such as the ASME 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 MR0175 (see 6.15.1.11).

6.15.7.8 If postweld heat treatment is required it shall be carried out after all welds, including piping welds, have been completed.

6.15.7.9 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.

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

6.15.8 Low-temperature Service

● **6.15.8.1** The minimum design metal temperature and concurrent pressure used to establish impact test and other material requirements shall be as specified.

Note: Minimum temperature can be caused by operating and/or environmental conditions including auto-refrigeration, and low ambient temperatures during shipping, installation, operation or shutdown.

6.15.8.2 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: Good design practice should be followed in the selection of fabrication methods, welding procedures, and materials for vendor furnished steel pressure-retaining parts that can be subject to temperatures below the ductile-to-brittle transition temperature. The published design-allowable stresses for many materials in internationally recognized standards such as the ASME *Code* and ANSI standards are based on minimum tensile properties. Some standards do not differentiate between rimmed, semi-killed, fully-killed hot-rolled, and normalized material, nor do they take into account whether materials were produced under fine- or course-grain practices. The vendor should exercise caution in the selection of materials intended for services between –30°C (–20°F) and 40°C (100°F).

6.15.8.3 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 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 Section VIII, Division l, Section UHA-51, or the specified pressure design code. For materials and thickness’ not covered by ASME Section VIII, Division l 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 the minimum design metal temperature, thermal, mechanical and cyclic loading and the governing thickness. Refer to requirements of ASME Section VIII, Division l, Section UG-20F, for example.

6.15.8.4 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. sections with increased thickness required for rigidity to mitigate shaft deflection,
    3. structural sections required for attachment or inclusion of mechanical features such as jackets or seal chambers;
c. One fourth of the nominal flange thickness (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 Section VIII, Division l, Section UG-84, or the specified pressure design code.

Note: Selecting materials that do not require impact testing is usually preferable to using materials that necessitate impact testing. Some codes (such as ASME) do not require impact tests under certain specific conditions.

6.15.8.5 The purchaser and vendor shall mutually agree upon testing requirements for highly stressed machine parts, such as shafts.

6.16 NAMEPLATES AND ROTATION ARROWS

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

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

6.16.3 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. Welding is not permitted.

6.16.4 The following data shall be clearly stamped or engraved on the frame 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.

6.16.5 Nameplates on compressor cylinders shall include the following data:

a. vendor’s name;
b. serial number;
c. bore, stroke, model number;
d. maximum allowable working pressure;
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 –20°C).

6.16.6 Induction motors used for driving reciprocating compressors shall be provided with an auxiliary nameplate stating the expected full-load current, and the expected current pulsation level based on the flywheel selection and resulting final inertia of the rotating system.

Note: The standard motor nameplate current is normally based on steady-state loads and is not always valid for the variable torque loads imposed by reciprocating compressor (see note in 7.1.2.6).

● **6.16.7** The purchaser shall specify whether USC or SI units are to be shown on nameplates.

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 inquiry.

7.1.1.3 The driver shall be capable of driving the compressor with all stages at full flow and discharging at the relevant 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, as well as 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, 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 250 kg (500 lb) shall be provided with vertical jackscrews.

7.1.2 Motor Drivers

• **7.1.2.1** 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 arrangement;
c. electrical characteristics;
d. starting conditions (including the expected voltage drop on starting);
e. the type of enclosure;
f. the sound pressure level;
g. the area classification, based on IEC 60079, API 500, or equivalent international standard;
h. the insulation class and maximum temperature rise;
i. the required service factor;
j. the ambient temperature and elevation above sea level;
k. electrical transmission losses;
l. temperature detectors, vibration sensors, and heaters specified;
m. auxiliaries (such as motor generator sets, ventilation blowers, and instrumentation);
n. vibration acceptance criteria;
o. use in variable frequency drive applications;
p. any power factor requirement;
q. applicability of the various parts of IEC 60034, API 541 or 546, or IEEE 841.

If belt drives are required, see 7.4.3.

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

Note: The 110% is a design criterion. After testing, this margin might not be available due to performance tolerances of the driven equipment.

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

- **7.1.2.4** The motor's starting torque shall meet the requirements of the driven equipment, at a reduced voltage of 80% of the normal voltage, or other specified value, and the motor shall accelerate to full speed within 15 seconds or other period of time agreed by the purchaser and the vendor. The motor starting-torque shall be sufficient to start the compressor without the need to depressurize any stage from its normal 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: low ratios of piston-to-rod diameters; high suction pressure; high settling-out gas pressure specified by the purchaser; high-pressure unloaded starts; or alternate gas unloaded starts.

7.1.2.5 Unless otherwise specified, the design of the motor shall conform to either IEC 60034-1, IEC 60079, and IEC 60529, or to NFPA 70 and NEMA MG 1.

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 (see IEC 60034 or NEMA MG1) for all specified loading conditions, including unloaded operation with cylinders pressurized to their normal suction pressures. For induction motor-compressor installations, motor current variations shall not exceed 40% of the full load current using the method described in IEC 60034 or NEMA MG1. 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 variations 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 pulsations 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 pulsations and consequently draw higher average current and higher power than standard efficiency motors when driving reciprocating compressors.

High-efficiency motors will create higher axial forces when they are not mounted on magnetic center.

High-efficiency induction motors are more suited to driving steady-state loads such as fans and blowers.

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

a. the required motor rotor inertia to satisfy the flywheel requirements of the compressor for all specified operating conditions;
b. starting-torque requirements;
c. mounting or coupling details, or both.

7.1.2.8 The rotor of a cantilevered (overhung) or 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 motor shaft 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 on all engine-type induction and synchronous motors.

Note: Motors, usually synchronous, where the shaft extension is supplied separately from the motor rotating electrical parts are typically referred to as being of engine-type construction.

7.1.2.9 Where a synchronous motor is to be connected to an electrical bus system that feeds existing synchronous motors, the purchaser shall perform an electrical system analysis and supply the compressor vendor (and the motor vendor if the motor is separately purchased) with all data necessary to permit proper design.

7.1.2.10 For synchronous-motor-driven compressors, the torsional stiffness and the inertia of all rotating parts shall provide at least a 20% difference between any inherent exciting frequency of the compressor and the torsional frequency of the motor rotor oscillation with respect to the rotating magnetic field.

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

7.1.2.12 Unless specified, cantilevered (overhung) motors shall not be supplied. If specified, cantilevered motor shafts shall have sufficient rigidity to prevent the main rotor and rotating exciter, if fitted, from contacting their stators as a result of either shaft deflection and unbalanced magnetic forces or dynamic mechanical unbalanced forces.

7.1.2.13 For cantilevered (overhung) and 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.

7.1.2.14 Motors without thrust bearings shall be provided with a permanent and evident indication of the position of the rotor relative to the axial magnetic center.

● **7.1.2.15** The bearings 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 rolling element bearings in other cases shall be subject to the purchaser's approval. The design of direct coupled motors shall be such, that the bearings can be inspected, removed and replaced in-situ.

Bearings shall be electrically insulated to prevent the circulation of stray electrical currents. Bearing supports shall have provisions for adjustment shims. 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.

Bearing housings shall be provided with shaft seals to prevent the ingress of dirt and moisture into the bearings or the leak of oil into the motor windings. If specified, for pedestal mounted bearings, an NPS $^{1}/_{4}$ drilled, tapped, and plugged hole shall be provided for connection of a dry air purge.

7.1.2.16 The motors for auxiliary equipment shall be suitable for the specified area classification in accordance with either IEC 60079 and IEC 60529, or NFPA 70, Article 500. Motor rating (exclusive of service factor) shall be at least 110% of the maximum power required for any operating condition.

7.1.3 Turbine Drivers

● **7.1.3.1** Steam turbine drivers shall conform to ISO 10436 or ISO 10437 or 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 ISO 10438-2 or API 614, Chapter 2, shall be furnished for a turbine drive train.

7.2 COUPLINGS AND GUARDS

7.2.1 Couplings

7.2.1.1 When a coupling is required between the driver and the driven equipment, it shall be supplied by the manufacturer of the driven equipment.

7.2.1.2 Unless otherwise specified, a flexible coupling shall be supplied. The coupling shall be of the all-steel, non-lubricated, flexible membrane, torsionally-rigid, spacer-type. For low speed applications, couplings may be of the elastomeric type where necessary to avoid torsional resonance problems. The coupling type, manufacturer, model, and mounting arrangement shall be mutually agreed upon by the purchaser and the vendors of the driver and driven equipment.

Note: For information on torsional damping couplings and resilient couplings see ISO 10441 or API 671, Appendix B.

● **7.2.1.3** If specified, the coupling or couplings shall be special purpose couplings conforming to ISO 10441 or API 671. Coupling mountings shall conform to ISO 10441 or API 671.

Note: The purchaser should provide a list of preferred coupling manufacturers.

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.

Stresses in the quill shaft shall be given consideration.

Note: A typical value for the mean torsional stress is approximately 15% of the yield strength of the material. The alternating stress is typically held to a value no greater than one third of the mean torsional stress.

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

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

7.2.1.6 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** If specified, couplings for auxiliary drives shall be in accordance with ISO 14691 or API 677.

7.2.1.8 Unless otherwise specified, couplings shall be mounted in accordance with the requirements of 7.2.1.9 through 7.2.1.11.

7.2.1.9 Flexible couplings shall be keyed to the shaft. Keys and keyways and their tolerances shall conform to ISO R773, normal fit or equivalent such as AGMA 9002, Commercial Class.

7.2.1.10 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.

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

7.2.2 Guards

• **7.2.2.1** Guards shall be provided by the vendor for each coupling, auxiliary drive coupling and all moving parts which might be hazardous to personnel. Guards shall comply with specified applicable safety codes.

7.2.2.2 Coupling and flywheel guards shall sufficiently enclose the coupling, flywheel, and the shafts to prevent any personnel from accessing the space between the guard and such moving parts during operation of equipment train.

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 Unless otherwise specified, guards may be constructed of either metallic or nonmetallic materials. Guards shall be easily removable, weatherproof, and of non-sparking construction. Guards shall have no openings, except that openings with removable covers shall be provided in flywheel guards for barring-over the machine and for access to indicator timing marks, wheel center (if available) and to any other parts which can require attention. Metallic guards shall preferably be fabricated from continuously welded solid sheet or plate. Guards fabricated from expanded metal or perforated sheets are acceptable, providing the size of the openings does not exceed 10 mm (0.375 in.) diameter. Guards of woven wire are not acceptable.

7.2.2.5 For outdoor installations, guards over belt and chain drives shall be weatherproofed and properly ventilated to prevent excessive heat build up. A weatherproof access door (or doors) shall be provided as necessary to allow inspection and servicing of belts and chains.

7.3 REDUCTION GEARS

• **7.3.1** Gear units shall be either special purpose units conforming to ISO 13691 or API 613, or general purpose units conforming to API 677, as specified.

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 only be used for equipment of 150 kW (200 hp) or less and require purchaser approval. Belt drives up to 225 kW (300 hp) may be proposed for purchaser's acceptance. Unless otherwise specified, timing type belts and sheaves shall be provided. 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.

If other than timing type belts are used, the details of belt tension, center distance, belt wrap and crankshaft web deflection and testing shall be mutually agreed by the vendor and purchaser.

7.4.2 The vendor shall provide a positive belt-tensioning device on all belt drives. All bearing lubrication points shall be accessible.

7.4.3 When a belt drive is to be 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 Belt drives 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 140º;
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 (ANSI S2.19, Grade 6.3).

7.5 MOUNTING PLATES

7.5.1 General

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

Note: See Appendix L for typical mounting plate and soleplate arrangements.

7.5.1.2 Machinery mounting plates shall be designed to avoid relative displacement of the frame and mounting plate.

7.5.1.3 Mounting plates shall conform to the following:

a. mounting plates shall not be drilled for equipment to be mounted by others;
b. mounting plates intended for installation on concrete shall be supplied with leveling screws;
c. outside corners of mounting plates which are in contact with the grout shall have 50 mm (2 in.) minimum radiused outside corners (in the plan view);
d. bottom corners of mounting plates 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.

7.5.2 Machined Surfaces

7.5.2.1 The upper and lower surfaces of driver bearing pedestals shall be machined parallel. The surface finish shall be 3.2 µm (125 µin.) Ra (arithmetic average roughness) or better.

7.5.2.2 When equipment is mounted directly on machined metal surfaces integral with mounting plates, such surfaces shall

a. be machined after the baseplate is fabricated.
b. be flat and parallel to all other mounting surfaces within 0.15 mm/m (0.002 in./ft), and
c. have a surface finish of 3.2 µm (125 µin.) Ra (arithmetic average roughness) or better.

7.5.3 Leveling, Alignment, and Lifting

7.5.3.1 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 450 kg (1000 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. Care shall be taken to prevent vertical jackscrews in the equipment feet from damaging 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.

7.5.3.2 Anchor bolts shall not be used to fasten drive train equipment to mounting plates, or to fasten compressors through baseplates or skids.

7.5.3.3 The vendor shall furnish stainless steel shim packs between the drive equipment feet and the mounting plates. The alignment shims shall be in accordance with API 686, Chapter 7, 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.

7.5.3.4 Fasteners for attaching the components to the mounting plates shall be supplied by the vendor.

• **7.5.3.5** If specified, chock blocks shall be supplied by the vendor (see Annex L).

7.5.3.6 Anchor bolts shall be furnished by the purchaser, unless otherwise agreed upon. The vendor shall specify the requirements for the anchor bolts.

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

7.5.3.8 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 SP6, all grout contact surfaces of the mounting plates and paint those surfaces with inorganic zinc silicate primer in preparation for epoxy grout.

Note: Inorganic zinc silicate is compatible with epoxy grout, does not exhibit limited life after application (unlike most epoxy primers), and is environmentally acceptable.

• **7.5.3.9** If specified, leveling plates shall be supplied. Leveling plates (see Annex L) shall be steel plates at least 19 mm ($^{3}/_{4}$ in.) thick.

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

7.5.4 Baseplates and Skids

• **7.5.4.1** 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.

7.5.4.2 When a baseplate(s) is provided, it shall extend under the drive-train components so that any leakage from these components is contained within the baseplate.

7.5.4.3 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.

7.5.4.4 The compressor crankcase, crosshead frame, cylinder supports and drive equipment shall be supported on load bearing structural members.

7.5.4.5 Sufficient anchor bolt holes shall be provided to ensure that forces and moments are properly transmitted to the foundation. Anchor points shall be located on internal and external load bearing structural members as necessary.

7.5.4.6 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.

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

● **7.5.4.8** If specified, the baseplate shall be suitable 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.

● **7.5.4.9** If specified, the baseplate shall be designed to facilitate the use of optical, laser based or other instruments for accurate leveling in the field. The 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 7.5.2.8) leveling pads 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. When required for long units, additional pads shall be located at intermediate points.

7.5.4.10 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.

7.5.4.11 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.

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

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

● **7.5.4.14** If specified, a dynamic analysis of the skid, 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; and,
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 or less, a maximum displacement of 100 µm 0 – peak (4 mil 0 – peak) (0.008 in peak-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 strongly recommended for equipment mounted offshore, platforms or equipment mounted on steel columns. For equipment mounted on solid concrete foundations, dynamic skid analysis may be omitted.

● **7.5.4.15** If specified, sub-soleplates, complying with 7.5.3.3 shall be provided with the baseplate by the vendor.

7.5.5 Soleplates and Rails

● **7.5.5.1** When soleplates or rails are specified, they shall be provided by the vendor, and they shall meet the requirements of 7.5.3.1.1 and 7.5.3.1.2 in addition to those of 7.5.1.

Note: See Annex L for a typical sketch.

7.5.5.2 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.

7.5.5.3 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.

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

7.5.5.5 When sub-soleplates are specified, they shall be steel plates at least 25 mm (1 in.) thick. The finish of the sub-soleplates' mating surfaces shall match that of the soleplates (see 7.5.1.5.2).

7.6 CONTROLS AND INSTRUMENTATION

7.6.1 General

7.6.1.1 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 ISO 10438-1 (or equivalents such as API 614, Chapter 1), except as modified by the following clauses.

● **7.6.1.2** The vendor shall provide all auxiliary system instrumentation as specified.

7.6.1.3 All instrumentation furnished by the compressor manufacturer requires the purchaser's review. Freestanding panels are preferred. 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.

7.6.1.4 Some controls may be shipped loose for field installation in the purchaser's piping as agreed between the purchaser and the vendor. See 8.4.6 for shipment.

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

7.6.2 Control Systems

● **7.6.2.1** 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 (manual, automatic or programmable);
b. the control signal;
c. the control range;
d. the process sensing lines handling flammable, toxic, corrosive or high-temperature fluids that require transduced signals to the instrumentation;
e. the source of the control signal and its sensitivity and range;
f. equipment to be furnished by the vendor;
g. speed of response required.

● **7.6.2.2** The configuration of the control system shall be Arrangement 1, 2 or 3, in accordance with ISO 10438-2 or API 614, Chapter 2, as specified by the purchaser.

7.6.2.3 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.).

• **7.6.2.4** The unloading arrangement for start-up and shutdown shall be stated on the data sheets and shall be agreed by the purchaser and the vendor. If specified, automatic loading-delay interlock shall be provided to prevent automatic loaded starting. 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. 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.

7.6.2.5 Capacity control for constant-speed units will normally be achieved by suction valve unloading, clearance pockets, or bypass (internal-plug type or external) or a combination of these methods. Step-less, reverse-flow capacity control acting on suction valves shall be subject to purchaser's approval. Control operation shall be either automatic or manual as specified on the data sheet. Unless otherwise specified, five-step unloading shall provide nominal capacities of 100%, 75%, 50%, 25% and 0%; three-step unloading shall provide nominal capacities of 100%, 50% and 0%, and two-step unloading shall provide capacities of 100% and 0%.

7.6.2.6 Capacity control on variable-speed units is usually accomplished by speed control, but this can be supplemented by one or more of the control methods specified in 7.6.2.5.

Note: Reciprocating compressors are usually specified for constant-speed operation (see 6.1.10).

7.6.2.7 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.

7.6.2.8 Unless otherwise specified, speed shall be adjustable by means of a hand speed changer.

7.6.2.9 Actuation of the control signal or failure of the signal or actuator shall neither prevent the governor from limiting the speed to the maximum permissible nor prevent manual regulation with the hand speed changer.

7.6.2.10 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.

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

a. a positive-detent-type master selector device (one for each service on multi-service compressors) to provide the specified load steps and,
b. indicators to show at which step the machine is operating.

7.6.3 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.

7.6.4 Instrumentation

• 7.6.4.1 General

Instruments shall be furnished and mounted locally, on a gauge board, or on a panel, as specified.

• 7.6.4.2 Tachometers

If specified, a tachometer shall be provided for variable 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% – 125% of maximum continuous speed.

7.6.4.3 Temperature Measurement

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

7.6.4.3.2 A heat transfer compound shall be used between thermowells and sensing elements.

• **7.6.4.3.3** Packing or piston rod temperature indication, as recommended by the vendor, shall be provided for cylinders operating at or above a gauge pressure of 35 bar (500 psig) and for all cylinders with liquid cooled packing (see 6.13.2.1). The vendor shall supply thermocouples or resistance temperature detectors (RTD), as specified.

Note: See 7.6.8.1 for temperature monitoring systems.

• **7.6.4.3.4** If specified, main bearing and/or valve temperature detectors shall be supplied. Details of the monitoring requirements and auxiliary equipment to be furnished (thermocouples, resistance temperature detectors (RTD), intrinsically safe systems, etc.) shall be jointly agreed to by the purchaser and the vendor.

Note: See 7.6.8 for temperature monitoring systems.

7.6.5 Relief Valves

Relief valves shall be set to operate at not more than the maximum allowable working pressure, 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.

7.6.6 Alarms and Shutdowns

7.6.6.1 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.

7.6.6.2 The vendor shall provide the alarms and trips, as specified by the purchaser. Minimum requirements are listed in Table 5.

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

• **7.6.6.4** The vendor shall supply the alarm and shutdown system to the extent specified.

Note: This can conveniently be achieved by the use of a responsibility matrix. See ISO 10438-1 (Annex C) or API 614, Chapter 1 (Appendix C), for a typical responsibility matrix chart).

7.6.6.5 Transmitters (except vibration transmitters) shall be installed so that the vibration of the equipment will not cause the transmitter to malfunction.

• **7.6.6.6** 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.

• **7.6.6.7** If specified, crossheads shall be equipped with a high crosshead-pin temperature alarm to protect the crosshead-pin bushing.

Note: The system may consist of a spring-loaded eutectic device, which shall de-energize a pneumatic or hydraulic circuit on alarm.

Table 5—Minimum Alarm and Shutdown Requirements

Condition	Alarm	Shutdown
High gas discharge temperature for each cylinder	X	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 level in separator	X	X
Jacket coolant system failure	X	—
Note: The "X" indicates when the condition occurs, alarm or shutdown is required; "—" indicates when the condition occurs, alarm or shutdown is not required.		

7.6.7 Vibration and Position Detectors

● **7.6.7.1** The vendor shall furnish and mount a vibration detection and transducing device to provide the shutdown signal required by 7.6.6.2. Each device shall have a velocity or accelerometer-type detector, and each shall provide for each of the following functions:

a. continuous vibration measurement;
b. alarm;
c. shutdown.

The device and its mounting shall conform to API 670. Ball-and-seat or magnetic-type switches are unacceptable. If specified, additional devices shall be provided. The purchaser and the vendor shall agree on the type, number, and location of the devices to be mounted on the compressor frame (and on gear units, if applicable).

● **7.6.7.2** If specified, the vendor shall furnish and mount piston rod drop detectors of the non-contacting type to measure the vertical movement of each piston rod (piston rod drop). If specified, a non-contacting device shall also be installed to measure the horizontal movement of each piston rod. If a proximity-type probe is used for rod position indication, the probe and the associated oscillator-demodulator and connecting cable shall be installed and calibrated in accordance with API 670. Unless otherwise specified, each probe shall be mounted adjacent to the packing. Terminal boxes containing oscillator-demodulators shall not be mounted on the compressor. If the piston rod is coated, calibration of the device shall make allowances for the coating. See Annex C.

● **7.6.7.3** A one-event-per-revolution machined mark on the crankshaft shall be provided to permit synchronization on top dead center with a cylinder performance analyzer and/or rod drop detector. If specified, or when a non-contacting device is installed to indicate piston rod position, a corresponding phase-reference transducer(s) shall be provided. The transducer(s) shall be supplied, installed and calibrated in accordance with API 670.

● **7.6.7.4** If specified, the vendor shall furnish and mount piston rod drop detectors of the contact type, such as a mechanical roller or fuse metal plug (eutectic) type. The detail of the system shall be agreed between the vendor and the purchaser. Unless otherwise specified, each detector shall be mounted on the packing gland. An inert gas, instrument air, or hydraulics shall be used to pressurize the system. Diaphragm type pressure switches shall be used to sense loss of pressure.

● 7.6.8 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:

a. main bearing temperatures;
b. valve temperatures;
c. packing temperatures;
d. crosshead pin bearing temperatures.

7.7 PIPING AND APPURTENANCES

7.7.1 General

7.7.1.1 Piping and installation shall first conform to the purchaser's specifications. Unless otherwise specified, in the absence of purchaser specifications, piping shall comply with the requirements of ISO 10438-1 or API 614, Chapter 1, and ISO 10438-3 or API 614, Chapter 3, except as modified by the following clauses.

● **7.7.1.2** The extent of process and auxiliary piping to be supplied by the vendor shall be as specified by the purchaser.

7.7.1.3 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 gasketing to be installed by others. The purchaser shall be advised of this situation in the proposal.

Note: Cylinder connections are discussed in 6.8.4.

● **7.7.1.4** If specified, piping, pulsation suppression devices and knockout vessels at the initial and interstage suction points shall have provisions for heat tracing and insulation.

Note 1: During certain atmospheric conditions, air can be at or close to saturated conditions; also, multi-stage air or hydrocarbon gas compressors will usually have saturated conditions following intercooling.

Note 2: The user should ensure that the quantity of liquid carried into the inlet system is minimized and that any such carry-over does not collect in the inlet system and form slugs.

Note 3: The design of a compressor inlet system for operation with a gas at or near saturation should consider the following factors:

—liquid separator close to the compressor suction;
—separator efficiency over the operating flow range;
—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;
—insulation to minimize heat loss; and
—heat tracing to maintain the gas at or above the dew point.

7.7.1.5 The following items shall terminate with flanged connections at the edge of the base:

a. connections for interconnecting piping between equipment groupings, and off-base facilities,
b. connections for air, water, steam, and other utility services to a base area,
c. other purchaser connections.

Vendor-supplied piping systems shall terminate in flanged connections. Instrument tubing connections shall terminate in a flange or a threaded connection in accordance with standard. Piping and component drains and vents shall terminate with a plugged or blind-flanged valve, accessible from the edge of the base or from a work area. This is to keep work areas and walkways as free as possible from obstructions. 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.

● **7.7.1.6** If specified, the vendor shall review drawings of all piping, appurtenances (pulsation suppression devices, intercoolers, aftercoolers, separators, knockouts, air intake filters and expansion joints) and vessels immediately upstream and downstream of the equipment and supports. The purchaser and the vendor shall agree on the scope and consequences of this review.

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

7.7.1.8 Connections DN 40 ($1^1/2$ 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. Bracing shall be arranged to occupy minimum space.

Note 1: Slip-on flanges are not used on piping and appurtenances around reciprocating compressors due to their insufficient fatigue life.

Note 2: The attention of the user of this standard is drawn to the possibility of hazardous situations arising from the incompatibility of ISO and ANSI pipe thread standards.

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

Note: For the purposes of this clause the term compressor flanges does not include faced and studded bosses.

7.7.1.10 Threaded piping joints shall not be used for flammable or toxic fluids, unless otherwise agreed, in accordance with 6.8.4.1.5. Where threaded joints are permitted, they shall not be seal welded.

Note: Threaded joints are typically only allowed for connections to non-weldable materials such as cast iron, instruments, or locations that must be disassembled for maintenance.

7.7.1.11 Control valves shall have flanged ends.

7.7.1.12 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.

Note: Flared tubing fittings are not recommended for reciprocating compressor applications.

● **7.7.1.13** 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.

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

7.7.1.15 All flanges shall be socket-weld or weld-neck flanges. Lap-joint or slip-on flanges shall not be used.

7.7.2 Frame Lubrication Oil Piping

7.7.2.1 For lubricating oil piping systems (with its mounted appurtenances) located within the confines of the main unit base area, the vendor shall supply a complete system, including any assembly (console) base and any packaged unit accessory. The vendor shall provide interconnecting piping when auxiliary equipment is specified to be located immediately adjacent to the compressor in the vendor’s recommended location (see 6.14.2 and 7.7.1.5).

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

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

7.7.2.4 After fabrication, oil lines shall be thoroughly cleaned.

● **7.7.2.5** Heads of oil-actuated control valves shall be vented back to the reservoir. If specified, instrument sensing lines to shutdown switches shall have a continuous through-flow of oil.

7.7.3 Forced-feed Lubricator Tubing

7.7.3.1 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 6.14.3.1.7 for check valves.

Note: For high-pressure compressors, heavier wall thickness tubing can be required.

7.7.3.2 Tubing shall be run together where possible. When winterization is specified, the tubing shall stand off from the machine to allow insulation.

7.7.4 Coolant Piping

7.7.4.1 Unless otherwise specified, the vendor shall supply piping with a single inlet and a single outlet connection on each cylinder requiring cooling (see Figure G-1, Plan C).

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

• **7.7.4.3** When the purchaser specifies the vendor to supply coolant piping on the compressor, the vendor shall supply a piping system for all equipment mounted on the compressor or compressor base. The piping shall be arranged to provide a single inlet connection and a single outlet connection for each water circuit operating at different inlet temperature levels and shall include a coolant control valve and a flow indicator as noted in 7.7.4.2. Series-type circuits shall have the necessary valved bypasses to provide temperature control.

7.7.4.4 Where a thermosyphon or a static cooling system is provided (see 6.8.3), 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 coolant (see Figure G-2, Plans A and B). A thermometer is required for a thermosyphon system.

7.7.5 Instrument Piping

Initial connections for remote mounted pressure instruments shall comprise an isolation valve conforming to the same requirements as the system to which it is connected. Beyond the initial isolation valve, piping or tubing not less than 10 mm ($^{3}/_{8}$ in.) outside diameter may be used. Where convenient, 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 switches, common connections are required for the pressure gauge and associated switches.

7.7.6 Process Piping

• **7.7.6.1** The vendor may be required to supply process piping to the extent and requirements specified by the purchaser. See ISO 10438-1 or API 614, Chapter 1.

7.7.6.2 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.

• **7.7.6.3** When the screens are supplied by the vendor, the design, location, and orientation of the screens shall be agreed by both the purchaser and the vendor prior to manufacture or purchase.

• **7.7.6.4** 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.

7.7.7 Distance Piece Vent and Drain Piping

7.7.7.1 The vendor shall supply distance piece vent and drain piping to the extent and requirements specified.

7.7.7.2 Drain and vent piping serving individual cylinders shall not be less than DN 25 (NPS 1) or 20 mm ($^{3}/_{4}$ in.) outside diameter if tubing is used. 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.). See Annex I for a typical distance piece vent and drain system.

7.8 INTERCOOLERS, AFTERCOOLERS, AND SEPARATORS

7.8.1 Intercoolers and Aftercoolers

• **7.8.1.1** If specified, the vendor shall furnish an intercooler between each compression stage.

Unless otherwise specified, intercoolers shall comply with ISO 10438-1 or API 614, Chapter 1.

• **7.8.1.2** If specified, aftercoolers shall be furnished by the vendor.

Unless otherwise specified, aftercoolers shall comply with ISO 10438-1 or API 614, Chapter 1.

Note: Intercooling and after cooling of gasses from reciprocating compressors present some unique phenomena to be considered in the design of exchangers.

Caution should be exercised regarding:

—whether the gas should be on the tube side or on the shell side; very small pressure pulsation levels multiplied by the larger areas of the pass separation plates can possibly produce very high vibratory forces in the tube bundle;

—the use of shell side rupture discs, relief valves or similar devices;

—the use of air-cooled heat exchangers because of their susceptibility to pulsation-induced vibration in systems and structures;

—the susceptibility of heat exchangers and their supporting structures to pulsation-induced vibration. Mechanical natural frequencies should not be coincident with pulsation frequencies in the heat exchanger systems.

7.8.1.3 Unless otherwise specified, the water side of heat exchangers shall be designed in accordance with 6.1.7.

7.8.1.4 The choice of water on the tube or shell side of shell and tube heat exchangers shall be agreed between the vendor and purchaser, with due consideration to pulsations, pressure levels, corrosion and maintainability.

Note: The purchaser may specify that the vendor shall furnish the fabricated piping between the compressor stages and the intercoolers and aftercoolers. See ISO 10438-1 or API 614, Chapter 1.

7.8.2 Separators

● **7.8.2.1** If specified, liquid separation and collection facilities in accordance with 7.8.2.2 through 7.8.2.8 shall be provided upstream of the compressor, and after every intercooler.

Note: Intercooling may result in condensation. See 6.8.1.2 and 7.7.1.4 and associated notes.

7.8.2.2 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 mutually agreed upon by the vendor and purchaser. In the case of cylinders handling gases that are or can become saturated, appropriate means should be used, in addition to the integral moisture removal section, to prevent liquid carry over into the compressor cylinder. Special attention should be paid to integral separators in pulsation dampener 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.

7.8.2.3 The liquid separation device shall remove 99% of all droplets of 10 microns or larger. Pressure drop shall be as defined in 7.9.2.6.3.1.

7.8.2.4 Integral moisture removal sections shall have a drain sump or boot extending below the device shell into which the separated liquid is directed.

7.8.2.5 Unless otherwise agreed, the capacity of the sump or boot of an integral separator, or lower part of the separate 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.

7.8.2.6 The liquid separation device shall be equipped with a drain connection of not less than DN 25 (1 NPS), gauge glass connections, and a level shutdown switch connection. The connections shall be flanged and fitted with blinds.

● **7.8.2.7** 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.

● **7.8.2.8** If specified, the drain sump or boot or lower part of the separate separation vessel shall be provided with a level indicator and alarm and shutdown devices. Where a high level alarm and a high level shutdown are specified, the capacity of the vessel or boot between the levels shall be equivalent to the maximum expected liquid flow for not less than 5 minutes.

7.9 PULSATION AND VIBRATION CONTROL

7.9.1 General

7.9.1.1 The objective of the requirements of this subclause is to avoid problems with

a. vibration,
b. performance,
c. reliability, and
d. flow measuring error caused by acoustical interaction between the compressor and the system in which it operates.

7.9.1.2 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.

Note: Completion of purchaser requirements for pulsation suppressors (data sheet page 4, lines 15 through 26, and pages 13 and 14) is essential for the vendor to quote and fabricate these accessories.

• 7.9.2 Alternate Operating Conditions

Operation with alternative gases, alternative conditions of service, or alternative start-up conditions shall be as specified. Pulsation suppression devices shall be mechanically suitable for all specified conditions and gases.

When a compressor is to be operated on two or more gases of dissimilar molecular weights (for example, hydrogen and nitrogen), pulsation levels shall be optimized for the gas on which the unit must operate for the greater length of time.

Pulsation levels shall be reviewed for all specified alternative gases, operating conditions, and loading steps to assure that pulsation levels will be acceptable under all operating conditions. By mutual agreement, the pulsation level criteria of 7.9.4.2.5.2 may be exceeded for alternative conditions, however, the other design criteria of 7.9.4.2.5.2 shall be met.

Note: For the purposes of screening the need for reviewing alternate gases, a significant gas change is one that results in either a 30% change in the speed of sound, or a molar mass change in the ratio of 1.7:1.

7.9.3 Multiple Unit Additive Effects

• **7.9.3.1** The purchaser shall specify when the compressor is to be operated in conjunction with other compressor units and their associated piping systems. In this case, the additive effect of pressure pulsations from multiple units shall be addressed. The scope of the analysis shall be based on agreement between the purchaser and vendor. If the additive effect indicates a requirement for modifications to an existing system to obtain acceptable pulsation levels, such modifications shall be based on agreement between the purchaser and the vendor.

Note: In some cases it may be necessary to impose tighter limits for each new compressor than those defined in 7.9.4.2.5 in order for the combined system to achieve acceptable pulsation levels.

• **7.9.3.2** For preliminary sizing, and, if specified, for Design Approach 1 (see 7.9.4.2.2), 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

$$V_s = 8.1 \times PD\left(\frac{kT_s}{M}\right)^{\frac{1}{4}} \tag{3}$$

$$V_d = 1.6\left(\frac{V_s}{r^{\frac{1}{k}}}\right) \tag{4}$$

$$V_s \text{ and } V_d \geq 0.03 \qquad (5)$$

In USC units

$$V_s = 7 \times PD\left(\frac{kT_s}{M}\right)^{\frac{1}{4}}$$

$$V_d = 1.6 \times \left(\frac{V_s}{r^{\frac{1}{k}}}\right)$$

$$V_s \text{ and } V_d \geq 1.0$$

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 molar mass;
PD	is the total net displaced volume per revolution of all compressor cylinders to be manifolded in the surge volume in m^3/r (ft^3/r).

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.

Equations 3, 4 and 5 are intended to ensure that reasonably sized pulsation suppression devices are included with the compressor vendor's proposal and should provide satisfactory sizes for most applications. In some instances, the sizes should 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.

Some compressor applications require the use of properly designed low-pass acoustic filters. A low-pass acoustic filter consists of two volumes connected by a choke tube. The volumes can be made up of two separate suppressors or one suppressor with an internal baffle. A procedure for preliminary sizing of low-pass acoustic filters is presented in Annex O. The design shall be confirmed by an acoustic simulation.

7.9.4 Design and Documentation

7.9.4.1 Design Approach Selection

7.9.4.1.1 Unless otherwise specified, Table 6 shall be utilized to determine the Design Approach. For applications above an absolute pressure of 350 bar (5000 psia), the purchaser and the vendor shall agree on the criteria for pulsation suppression.

Note: A detailed description of the three design approaches is given in 7.9.4.2.

● **7.9.4.1.2** 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.

7.9.4.2 Design Approaches

7.9.4.2.1 General

The design approach choices are:

a. Design Approach 1—Empirical Pulsation Suppression Device Sizing.
b. Design Approach 2—Acoustic Simulation and Piping Restraint Analysis.
c. Design Approach 3—Acoustic Simulation and Piping Restraint Analysis plus Mechanical Analysis (with Forced Mechanical Response Analysis if necessary).

Unless otherwise specified, each design approach includes all of the elements of preceding approaches, unless superseded by more comprehensive methods. Elements of the various design approaches are summarized in 7.9.4.2.2, 7.9.4.4, and 7.9.4.5. Flowcharts detailing work processes for each Design Approach can be found in Annex M.

Table 6—Design Approach Selection

Absolute 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)
$P < 35$ bar ($P < 500$ psi)	1	2	2
35 bar < P < 70 bar (500 psi < P < 1000 psi)	2	2	3
70 bar < P < 200 bar (1000 psi < P < 3000 psi)	2	3	3
200 bar < P < 350 bar (3000 psi < P < 5000 psi)	3	3	3

Note: API 688 provides a discussion of the different operating and mechanical parameters that should be taken into account when considering a design approach different from that indicated by Table 6, especially if less analysis is contemplated.

7.9.4.2.2 Design Approach 1—Empirical Pulsation Suppression Device Sizing

Pulsation suppression devices shall be designed using proprietary and/or empirical analytical techniques to meet line side pulsation levels required in 7.9.4.2.5.2.2.1, and the maximum pressure drop allowed in 7.9.4.2.5.3.1, based on the normal operating condition. Acoustic simulation analysis is not performed when using this design approach.

7.9.4.2.3 Design Approach 2—Acoustic Simulation and Piping Restraint Analysis

7.9.4.2.3.1 General

Design Approach 2 is pulsation control through the use of pulsation suppression devices and proven acoustic techniques in conjunction with mechanical analysis 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.

7.9.4.2.3.2 Compressor System Model

Pulsation suppression devices (or dampers) are initially sized using Design Approach 1, and analyzed using acoustic simulation. The compressor system model normally includes piston and valve kinematics, 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.

7.9.4.2.3.3 Piping System Model

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 non-reflective line. The allowable design limits of 7.9.4.2.3.4 apply. This step is called a pre-study and is also referred to as a “bottle check” or “damper check.” For applications where the piping system is defined, the pre-study may be omitted. The piping model replaces the acoustically non-reflective line in the simulation model.

7.9.4.2.3.4 Pre-study

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 80% of the allowable value defined by Equation 8 for single pulsation suppression devices, and 70% of the allowable value defined by Equation 8 when two or more pulsation suppression devices are attached to common piping.

Note: A single pulsation device means a device that is not connected to another by common piping. Examples include: a single cylinder first stage suction device of a single unit; a single cylinder discharge pulsation device of a single unit; and, single unit first stage suction or final stage discharge device that manifolds all the cylinders that generate pulsation in the particular piping system. Examples of two or more pulsation suppression devices attached by common piping are: interstage devices (even with intercoolers); single units with multiple pulsation suppression devices for first stage suction or for final stage discharge piping systems; and multiple units attached to common piping systems.

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 pre-study 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. Therefore, it should be noted, that if the pulsation suppression devices are fabricated prior to finalizing the piping configuration the only remaining system design optimization methods available to the designer is the installation of orifices, piping modifications, and stiffening of the piping system. This sometimes leads to the need to order different pulsation suppression devices to provide an adequate system, with a consequent negative impact on schedule.

7.9.4.2.3.5 Acoustic Simulation

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 7.9.4.2.5 or to identify changes necessary to achieve compliance.

7.9.4.2.3.6 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 7.9.4.2.5.2.3.3.

Note 1: In the piping design, when clamps are used to avoid mechanical resonances, the thermal flexibility effects should also be considered.

Note 2: To accurately predict and avoid piping resonances, the supports and clamps must dynamically restrain the piping. Piping restraints are only considered to be dynamically restraining when they have either enough mass or stiffness to enforce a vibration node at the restraint. This requirement is difficult to achieve with overhead piping and/or the use of simple supports, hangers, and guides.

7.9.4.2.4 Design Approach 3—Acoustic Simulation and Piping Restraint Analysis Plus Mechanical Analysis— (with Forced Mechanical Response Analysis if Necessary)

7.9.4.2.4.1 General

This approach is identical to Design Approach 2, with the addition of a mechanical analysis of the compressor cylinder, compressor pulsation suppression devices and associated piping systems including interaction between acoustic and mechanical system responses. Forced mechanical response is included when necessary. Both acoustic and mechanical methods are used to arrive at the most efficient and cost effective plant design.

7.9.4.2.4.2 Step 3a—Mechanical Natural Frequency Analysis of the Compressor and Piping System to Avoid Coincidence with Significant Shaking Forces

a. The starting point of the mechanical model is either the crankcase-to-foundation interface or the crosshead guide-to-crankcase interface. For modeling accuracy, this location shall be relatively rigid when compared to the rest of the compressor mechanical model and/or it shall be accurately described by a six degree of freedom spring. The compressor mechanical model end point is the second pipe clamp on the suction and discharge piping moving away from the line side nozzles of the pulsation suppression devices. The factors that can influence the accuracy of the model are discussed in more detail in API 688. If specified, this modeling will also include an analysis of the stresses found in the pulsation suppression device internals in accordance with 7.9.5.1.22 and 7.9.5.1.23.

Note 1: The intent is to avoid mechanical resonance of the compressor cylinders, pulsation suppression devices, and piping system at frequencies where high shaking forces also exist.

Note 2: In some cases the compressor frame, crosshead guides and cylinders, mounted on a concrete foundation, can be considered to be relatively rigid, and can be modeled using rigid elements.

Note 3: The compressor and pulsation suppression device mechanical model was formerly known as the compressor manifold model.

b. 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 7.9.4.2.5.3.2 and the shaking forces shall not exceed the limits found in 7.9.4.2.5.2.3.

Note: Geometrically-complex areas of the system such as cylinders, distance pieces, crosshead guides, frames, pulsation suppression device nozzles, and piping, where span calculations cannot be applied accurately, are analyzed to determine mechanical natural frequencies, usually with vendor proprietary methods, shop measured data, or finite element methods; with the intent of avoiding mechanical resonances at frequencies where significant shaking forces also exist

7.9.4.2.4.3 Step 3b1—Forced Mechanical Response Analysis of the Compressor Mechanical Model

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 7.9.4.2.5.2.5 shall apply. The compressor vendor shall supply the allowable vibration limits for compressor components such as cylinders, distance pieces and crankcases.

Note: The allowable compressor vibration levels are generally the limiting design criteria. This analysis predicts the cyclic stress in the pulsation suppression devices and associated piping. 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. The compressor manufacturer is expected to provide vibration criteria to ensure that no fatigue failures or premature wear of compressor components occur, in accordance with 6.1.1.

7.9.4.2.4.4 Step 3b2—Forced Mechanical Response of the Piping System

When the excitation frequency separation margins or 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 7.9.4.2.5.2.4 and 7.9.4.2.5.2.5 respectively shall apply. The model end points shall be defined by the analyst in agreement with the purchaser; in general, the piping system model should include all of the piping that was included in the acoustic model. Factors that can influence the accuracy of the model are discussed in more detail in API 688.

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.

7.9.4.2.5 Design Criteria

7.9.4.2.5.1 General

Pulsation suppression devices and techniques applied in accordance with Design Approaches 1, 2, and 3 shall satisfy the basic criteria in 7.9.4.2.5.2, and the other criteria in 7.9.4.2.5.3.

7.9.4.2.5.2 Basic Criteria

To evaluate compliance with the basic criteria, the following procedure applies:

1. Preliminary pulsation suppression device sizing. Determine pressure drop across the pulsation suppression device. The criteria as described in 7.9.4.2.5.2.2.1 and 7.9.4.2.5.3.1 shall be met. Design Approach 1 is complete.

For Design Approaches 2 and 3:

2. Pre-study of pulsation suppression devices (if required). Determine pulsations at the compressor cylinder flanges, and at the line side nozzle of the pulsation suppression device. The criteria as described in 7.9.4.2.5.3.1, 7.9.4.2.5.2.1, and 7.9.4.2.5.2.2.2 de-rated as in accordance with 7.9.4.2.3.4 shall be met. The criteria for pulsation suppression device non-resonant shaking force are described in 7.9.4.2.5.2.3.3.
3. After the layout of the piping system is completed, pulsation analysis of the complete pipe system is undertaken. The criteria for maximum pressure drop and pulsations are given in 7.9.4.2.5.3.1, 7.9.4.2.5.2.1, and 7.9.4.2.5.2.2.2. The criteria for pulsation suppression device non-resonant shaking forces are given in 7.9.4.2.5.3.3.

If these criteria are met and Design Approach 2 is specified then Step 4 shall be performed. If Design Approach 3 is specified then proceed directly to Step 5.

4. Specify maximum piping spans and determine vessel mechanical natural frequencies utilizing piping tables and basic vessel calculations. The minimum allowable mechanical natural frequencies are given in 7.9.4.2.5.3.2.

If the criteria for Step 3 and Step 4 are met, Design Approach 2 analysis is complete. If the criteria under Steps 3 or 4 are not met then either a redesign or, Steps 5 and 6 shall be performed:

5. Develop a mechanical model and determine mechanical natural frequencies; the minimum separation margins are in 7.9.4.2.5.3.2.
6. Determine the maximum allowable shaking forces in accordance with 7.9.4.2.5.2.3 and check whether these are higher than the acoustic shaking forces calculated by acoustic simulation.

If the criteria for Step 5 and Step 6 are met, Design Approach 3 analysis is complete.

For the compressor system, if the criteria in Step 5 or Step 6 are not met, either a redesign or, Step 8 shall be performed.

For the piping system, if the criteria in Step 5 or Step 6 are not met, either a redesign or Step 7 shall be performed.

7. Determine pipe vibrations based on the maximum calculated acoustic shaking forces. Criteria for maximum allowable pipe vibrations are in 7.9.4.2.5.2.4.

If the vibration criteria in Step 7 are not met, either a redesign or Step 8 shall be performed:

8. Calculate dynamic stresses in the compressor system or piping system, as required. Maximum allowable cyclic stresses are in 7.9.4.2.5.2.5. For the compressor system, also compare the vibration levels calculated to those supplied by the compressor vendor.

If the criteria for Step 7 or Step 8 are met, Design Approach 3 analysis is complete. If the criteria are not met, redesign is required.

Note: The calculations to determine the criteria for allowable shaking forces in Step 6 of this subclause may be omitted if the piping vibration analysis is performed according to Step 7 directly after Step 5.

7.9.4.2.5.2.1 Maximum 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 average 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 average absolute line pressure at the compressor cylinder flange;

R is the stage pressure ratio.

Note: Where maximum pulsation levels exceed these values and reasonable modifications are used, higher limits may be agreed on by the purchaser and the compressor vendor.

Note 2: The frequencies, phase relationships, and amplitudes of pressure pulsation at the compressor valves can significantly affect compressor performance and valve life. Pulsation levels measured at the compressor cylinder flange will usually not be the same as those levels existing at the valves. Experience has shown, however, that pulsation limits at the cylinder flanges, as specified above, result in compressor performance within the tolerances stated in this standard.

7.9.4.2.5.2.2 Maximum Allowable Pulsation Limits at and Beyond Line-side Nozzles of Pulsation Suppression Devices

7.9.4.2.5.2.2.1 Pulsation suppression devices used in accordance with Design Approach 1 shall limit peak-to-peak pulsation levels at the line side of the pulsation suppression device to a value determined by Equation 7.

In SI units

$$P_1 = \frac{4.1}{(P_L)^{\frac{1}{3}}}\% \qquad (7)$$

In USC units

$$P_1 = \frac{10}{(P_L)^{\frac{1}{3}}}\%$$

where

P_1 is the maximum allowable peak-to-peak pulsation level at any discrete frequency, expressed as a percentage of average mean absolute pressure;

P_L is the average mean absolute line pressure, in bar (psia).

7.9.4.2.5.2.2.2 Unless otherwise specified, for Design Approaches 2 and 3, 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 a and b.

a. For systems operating at absolute line pressures between 3.5 bar and 350 bar, (50 psia and 5000 psia), the peak-to-peak pulsation level of each individual pulsation component shall be limited to that calculated by Equation 8.

In SI units

$$P_1 = \sqrt{a/(350)}\left(\frac{400}{(P_L \times D_I \times f)^{0.5}}\right) \qquad (8)$$

In USC units

$$P_1 = \sqrt{a/1150}\left(\frac{300}{(P_L \times D_I \times f)^{0.5}}\right)$$

where

P_1 is the maximum allowable peak-to-peak level of individual pulsation components corresponding to the fundamental and harmonic frequencies, 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 bar (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 9.

$$f = \frac{N \times z}{60} \tag{9}$$

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 bar (50 psia), the peak-to-peak levels of individual pulsation components need only meet the levels calculated for an absolute pressure of 3.5 bar (50 psia).

Note: At pressures below 3.5 bar (50 psia) it is impractical to impose the stringent requirements of Equation 8.

7.9.4.2.5.2.2.3 When mutually agreed between the purchaser and vendor, the pulsation levels may exceed the limits defined by 7.9.4.2.5.2, provided that requirements in 7.9.4.2.5.2.3 through 7.9.4.2.5.2.5 are satisfied, as noted in 7.9.4.2.5.2.1.

Note: The default design philosophy is based on minimizing pulsation and pressure drop utilizing proven acoustic control techniques. For applications where the user may desire to relax the criteria, API 688 should be used as guidance to understand the risks and benefits that might be encountered.

● **7.9.4.2.5.2.2.4** If specified, flow pulsations in systems which include elements sensitive to such phenomena shall be limited to mutually agreed criteria, for example flow meters, check valves, and cyclone separators. Allowance for the presence of any such sensitive elements outside the vendor's scope of supply shall be as specified.

7.9.4.2.5.2.3 Maximum Allowable Acoustic Shaking Force

7.9.4.2.5.2.3.1 General

The maximum allowable non-resonant shaking force based on the design vibration guideline can be determined from Equation 10.

$$SF_k = k_{\text{eff}} \times V \tag{10}$$

where

SF_k is the non-resonant shaking 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 Annex P for a detailed discussion of k_{eff}.

V is the design vibration peak-to-peak guideline in mm (in.) (see Figure 4).

The shaking force guideline (SF_k) applies to non-resonant vibration, therefore, 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. See Annex P for conventions and a more detailed discussion of the maximum allowable shaking forces.

Various support types provide ranges of support stiffness approximately as follows:

elevated un-braced tack supports	900 N/mm – 2700 N/mm	(5000 lbf/in. – 15,000 lbf/in.)

grade level typical supports and clamps	2700 N/mm – 27,000 N/mm	(15,000 lbf/in. – 150,000 lbf/in.)
grade level heavy supports and clamps	27000 N/mm – 45,000 N/mm	(150,000 lbf/in. – 250,000 lbf/in.)

7.9.4.2.5.2.3.2 Maximum Allowable Piping System Non-resonant Acoustic Shaking Force

The maximum allowable piping non-resonant shaking forces shall be the lower of the values calculated from Equation 10 or from Equation 11.

In SI units

$$SF_{p\max} = 45 \times \mathrm{NPS} \tag{11}$$

In USC units

$$SF_{p\max} = 250 \times \mathrm{NPS}$$

where

$SF_{p\max}$ is the maximum piping non-resonant shaking peak-to-peak force guideline based on support strength N (lbf);

NPS is the nominal pipe size in mm. (in.).

7.9.4.2.5.2.3.3 Maximum Allowable Cylinder Mounted Pulsation Suppression Device Non-resonant Shaking Force

The maximum allowable non-resonant 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 maximum allowable level shall be 1% of Equation 12.

In SI units

$$SF_{d\max} = 45000 \tag{12}$$

In USC units

$$SF_{d\max} = 10000$$

where

$SF_{d\max}$ is the maximum pulsation suppression device non-resonant shaking peak-to-peak 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. Other shaking forces that can be affected by the pulsation suppression device design such as (but not limited to) those acting parallel to the compressor cylinder nozzles and those acting within the cylinder internal passages must also be evaluated. The evaluation criterion relative to the cylinder varies and should be mutually agreed upon by the purchaser and compressor manufacturer.

7.9.4.2.5.2.4 Piping Design Vibration Criteria

The predicted piping vibration magnitude shall be limited to the design level in Figure 4. The diagram in Figure 4 is based on the following:

a. a constant allowable vibration amplitude of 0.5 mm peak-to-peak (20 mils peak-to-peak) for frequencies below 10 Hz (the frequency of 10 Hz is also according to ISO 10816);
b. a constant allowable vibration velocity of approximately 32 mm/s peak-to-peak (1.25 in./s peak-to-peak) for frequencies between 10 and 200 Hz.

The limits in Figure 4 are intended as a design trigger point for analysis in accordance with 7.9.4.2.5.2.1. These values should not be used as field acceptance criteria.

Note: The requirements in this subclause are considered to be conservative. There are however situations in which high stress risers and unbraced 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.

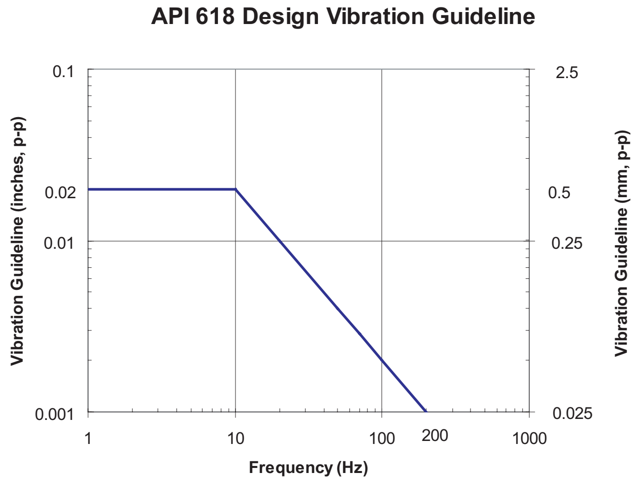

Figure 4—Piping Design Vibration at Discrete Frequencies

7.9.4.2.5.2.5 Maximum Allowable Cyclic Stress

7.9.4.2.5.2.5.1 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 example, for carbon steel pipe with an operating temperature below 370°C (700°F), the peak-to-peak cyclic stress range 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.

It is not considered necessary to demonstrate compliance with this clause for Design Approaches 1 and 2.

● **7.9.4.2.5.2.5.2** If specified, a piping system flexibility analysis that predicts forces 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 frame growth and component properties.

7.9.4.2.5.3 Other Criteria

7.9.4.2.5.3.1 Maximum Allowable Pressure Drop

For all design approaches:

a. Unless otherwise specified, the pressure drop for each operating case, based on steady flow through a pulsation suppression device at the manufacturer’s rated capacity, shall not exceed 0.25% of average absolute line pressure at the device, or the value determined by Equation 13, whichever is higher. These 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 flow plus dynamic flow components, provided that the static component still meets the above criteria.

$$\Delta P = 1.67\left(\frac{R-1}{R}\right)\% \tag{13}$$

where

$\triangle P$ is the maximum pressure drop based on steady flow through a pulsation suppression device expressed as a percentage of mean absolute line pressure at the inlet of the device;

R is the stage pressure ratio.

b. When a moisture separator is an integral part of the pulsation suppression device, the pressure drop for each operating case, based on steady flow through such a device at the manufacturer’s rated capacity, shall not exceed 0.33% of the mean absolute line pressure at the device, or the percentage determined by Equation 14, whichever is higher. These 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 flow plus dynamic flow components.

$$\Delta P = 2.17\left(\frac{R-1}{R}\right)\% \tag{14}$$

c. Pressure drops specified in this clause may be exceeded by mutual agreement between purchaser and vendor, when this is the consequence of the preferred solution to piping resonance problems. The effects of dynamic interaction between compressor cylinders, pulsation suppression devices and attached piping on cylinder performance are evaluated and pulsation-induced power and capacity deviations are determined for the recommended design. This analysis should optimize pulsation related compressor performance.

7.9.4.2.5.3.2 Separation Margins

Unless otherwise specified, both of the following guidelines are to be used together 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 maximum rated speed.

Note 1: The intent is to be above twice running speed, because there is almost always sufficient excitation energy at the first and second orders to excite resonances to a dangerous level.

Note 2: In certain compressor configurations, there can be significant excitation energy at higher orders of running speed and the system design shall take this into account. When the minimum mechanical natural frequency guideline is not met or when there is significant excitation energy at higher orders, the separation margins as defined in b) shall be maintained.

b. The predicted mechanical natural frequencies shall be designed to be separated from significant excitation frequencies by at least 20%.

Note: The intent is that at least 10% separation for the actual system is achieved, and due to modeling limitations, if 20% is used for predicted designs then 10% for the actual system will generally be attained.

Note 2: The ability to accurately predict resonance, and therefore separation margin, is greatly effected by the stiffness of the system. Elevated rack-mounted piping systems will be inherently less stiff than grade-mounted pipe on concrete sleepers. In general, the stiffer the system, the lower the sensitivity of the model to stiffness variability, and therefore the more accurate the prediction of the natural frequencies and avoidance of coincidence with excitation frequencies.

7.9.4.2.5.3.3 Flow Measurement Error

Unless otherwise specified, for flow meters located in the specified piping system, the maximum flow measurement error caused by pulsation shall not exceed the following:

a. For Non-custody Transfer meters: 1.00% error.
b. For Custody Transfer meters: 0.125% error.

Note: See API 688 for a discussion on flow measurement error.

7.9.4.2.6 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 includes 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.

7.9.5 Pulsation Suppression Devices

7.9.5.1 General

• **7.9.5.1.1** As a minimum, 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 *Code*) and registered with the required jurisdiction.

7.9.5.1.2 The maximum allowable working pressure 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).

CAUTION: Purchasers should be aware of the overpressure hazards of closing suction block valves on idle compressors. Suction-side equipment between the block valve and the compressor cylinder should be rated for discharge pressure or have a protective relief valve.

7.9.5.1.3 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 on the data sheet.

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 Data section in Annex F, Item 17).

• **7.9.5.1.4** If specified, all butt welds shall be 100% radiographed.

7.9.5.1.5 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 assure compliance with 7.9.4.2.5.2.5.

7.9.5.1.6 Suction pulsation suppression devices, not provided with an integral moisture removal section, shall be designed to prevent trapping of liquid.

• **7.9.5.1.7** If specified, the suction pulsation suppression device(s) shall include a final moisture removal section as an integral part of the vessel. This device shall be equipped as detailed in 7.8.

7.9.5.1.8 The nozzle length from the shell of the pulsation suppression device to the cylinder flange shall be held to a minimum that is consistent with thermal flexibility and pulsation requirements. The nozzle area shall be at least equal to the area for the nominal compressor cylinder flange size. Adequate space shall be allowed for access to and maintenance of the cylinder's working parts.

7.9.5.1.9 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 on by the purchaser and the vendor.

• **7.9.5.1.10** 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 where practical. Where multiple drains are impractical, 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. The effect of such drain openings on the performance of the pulsation suppression device must be considered. Arrangement of internals shall ensure that liquids will flow to drain connections under all operating conditions.

• **7.9.5.1.11** The cylinder nozzle of each discharge pulsation suppression device shall be provided with two connections located 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.

7.9.5.1.12 Flanged connections DN 25, (NPS 1) and smaller, although reinforced in accordance with 7.9.5.1.5, shall be designed to minimize overhung weight and shall be gusseted back to the main pipe or reinforcing pad in at least two planes to avoid breakage resulting from vibration.

7.9.5.1.13 Unless otherwise specified, main connections to the compressor cylinder(s) and to process line shall be weld-neck flanges. For non-standard connections, see 6.8.4.2.1 and 6.8.4.1.12.

7.9.5.1.14 Pulsation suppressors 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 suppressors 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.

Note: For higher pressure flange ratings, the internal diameter of standard nozzles is less than the nominal sizes shown above. The purchaser should determine if the actual size is adequate to accommodate inspection procedures.

7.9.5.1.15 Unless otherwise specified or approved by the purchaser, pulsation suppression device connections other than those covered by 7.9.5.1.13 and 7.9.5.1.14 shall also be weld neck flanges. When threaded fittings are provided, they shall have a minimum rating of Class 6000.

7.9.5.1.16 Flanges shall be in accordance with ISO 7005-1 or ASME B16.5; however, lap-joint and slip-on flanges shall not be used. The finish of the gasket contact surface for flanged or machined bosses, other than the ring joint type shall be between 3.2 µm and 6.4 µm (125 µin and 250 µin.) arithmetic average roughness (Ra). Either a serrated-concentric finish or a serrated-spiral finish having a pitch in the range of 0.6 mm – 1.0 mm (24 grooves/in. – 40 grooves/in.) shall be used. The surface finish of the gasket grooves of ring joint connections shall comply with ASME B16.5.

● **7.9.5.1.17** If specified, provisions shall be made for attaching insulation. All connections and nameplates shall be arranged to clear the insulation.

7.9.5.1.18 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 welds shall be used for the attachment of the baffles to the pulsation suppressor shell.

7.9.5.1.19 All butt welds shall be full penetration welds.

● **7.9.5.1.20** 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.

7.9.5.1.21 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.

● **7.9.5.1.22** 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 7.9.4.2.4.

7.9.5.1.23 If required by the specified pressure vessel code, such as ASME Section 8, Division 2, 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.

7.9.5.2 Fabrication and Thermally Induced Stresses in the Pulsation Suppression Device

7.9.5.2.1 Manufacturing tolerances and fit-up procedures for pulsation suppression devices, compressor cylinder nozzle connections and line connections, shall be adequate to allow bolting of flanges without strain which may result in excessive nozzle stresses, changes to component alignment or changes to rod runout. 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 assure proper final alignment and to minimize residual stresses. This procedure is especially important for ring joint flanges.

Note: An alignment fixture may be necessary on larger, block-mounted units.

7.9.5.2.2 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.

● 7.9.6 Supports for Pulsation Suppression Devices

If specified, supports for the pulsation suppression devices and vendor-supplied piping 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: To the extent possible, the foundation of the supports should be integral with the compressor foundation. When noncompliant adjustable supports are used, they should be adjusted by the purchaser at normal operating conditions.

7.10 AIR INTAKE FILTERS

● **7.10.1** For air compressors taking suction from the atmosphere, a dry-type air intake filter-silencer suitable for outdoor mounting shall be provided by the vendor, unless otherwise specified. Special design details, if any, shall be as specified by the purchaser. The vendor shall bring to the purchaser’s attention any hazards that he believes could result from complying with the purchaser’s specification.

7.10.2 As a minimum, the following features shall 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.

7.11 SPECIAL TOOLS

7.11.1 When special tools and fixtures are needed to disassemble, assemble or maintain the unit, they shall be included in the quotation and furnished as part of the initial supply of the machine, together with complete instructions for their use. For multiple-unit installation, the quantities of special tools and fixtures shall be agreed by the purchaser and the vendor. These or similar special tools shall be used during shop assembly and post-test disassembly of the equipment.

● **7.11.2** Special tools for reciprocating compressors shall include, as a minimum:

a. mandrels for fitting solid wear bands on non-segmental pistons;
b. a lifting and lowering device for removal and insertion of valve assemblies with a mass greater than 15 kg (33 lb);
c. a crosshead removal and installation tool;
d. sleeve/cone to enable piston rod to be passed through completely assembled packing (see 6.13.1.7);
e. if specified, hydraulic tensioning tools.

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

7.11.4 All compressors shall be provided with suitable means of barring for maintenance. For compressors with a rated 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 power driven barring device shall be furnished. The vendor shall furnish a complete description of the barring device including, such factors as method of operation (for example, manual engagement and automatic disengagement on start of compressor), lockout signals required, location, guards and power required.

● **7.11.5** 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.

Note: The purchaser should interlock this limit switch with the driver.

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 (Annex K) 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 sub-vendor plants where manufacturing, testing or inspection of the equipment is in progress.

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

8.1.5 The vendor shall provide sufficient advance notice to the purchaser before conducting any inspection or test that has been specified to be witnessed or observed.

● **8.1.6** The amount of advanced notification required for a witnessed or observed inspection or test shall be as specified. Five working days are usually considered adequate notice for inspections and tests. An observed test shall not be conducted until the specified time.

Note: For an observed test, the purchaser should expect to be in the factory longer than is required for a witnessed test.

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

8.1.8 Prior to a witnessed mechanical running or performance test, confirmation of the successful completion of the applicable preliminary test shall be provided.

8.1.9 Equipment, materials and utilities for the specified inspections and tests shall be provided by the vendor.

8.1.10 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 in the normal course of manufacture or as part of a repair procedure;
d. results of quality control tests and inspections;
e. details of all repairs;
● f. if specified, final assembly maintenance and running clearances;
g. other data specified or required by applicable codes and regulations (see 5.2 and 9.3.1.1).

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 6.15.7.1, the purchaser may specify the following:

a. parts that shall 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.

8.2.2.1.2 The vendor shall review the design of the equipment and impose more stringent criteria than the generalized limits required in 8.2.2, if appropriate.

8.2.2.1.3 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.

Note: Care should be taken in the use of acceptance criteria for iron castings. Criteria developed for other materials are often not applicable.

8.2.2.2 Radiography

8.2.2.2.1 Radiography shall be performed in accordance with ASTM E 94.

8.2.2.2.2 The acceptance standard used for welded fabrications shall be the specified pressure code or ASME Section VIII, Division 1, UW-51 (for 100% radiography) and UW-52 (for spot radiography). The acceptance standard used for castings shall be the specified pressure code or ASME Section VIII, Division 1, Appendix 7.

8.2.2.3 Ultrasonic Inspection

8.2.2.3.1 Ultrasonic inspection shall be in accordance with the specified pressure code or ASME Section V, Articles 5 and 23.

8.2.2.3.2 The acceptance standard used for welded fabrications shall be the specified pressure code or ASME Section VIII, Division 1, Appendix 12. The acceptance standard used for castings shall be the specified pressure code or ASME Section VIII, Division 1, Appendix 7.

The acceptance criteria for steel forgings shall be determined by the manufacturer in accordance with ASTM A 388M.

8.2.2.3.3 All crankshafts shall be ultrasonically tested in accordance with ASTM A 503 after machining, but before drilling.

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 E 709.

8.2.2.4.2 The acceptance standard used for welded fabrications shall be the specified pressure code or ASME Section VIII, Division 1, Appendix 6 and Section V, Article 25. The acceptability of defects in castings shall be based on a comparison with the photographs in ASTM E 125. For each type of defect, the degree of severity shall not exceed the limits specified in Table 7.

Table 7—Maximum Severity of Defects in Castings

Type	Defect	Maximum Severity Level
I	Linear discontinuities	1
II	Shrinkage	2
III	Inclusions	2
IV	Chills and chaplets	1
V	Porosity	1
VI	Welds	1

8.2.2.5 Liquid Penetrant Inspection

8.2.2.5.1 Liquid penetrant inspection shall be in accordance with the specified pressure code or with ASME Section V, Article 6 (see ASTM E 165).

8.2.2.5.2 The acceptance standard used for welded fabrications shall be the specified pressure code or ASME Section VIII, Division 1, Appendix 8 and Section V, Article 24. The acceptance standard used for castings shall be the specified pressure code or ASME Section VIII, Division 1, Appendix 7.

8.2.3 Mechanical Inspection

8.2.3.1 During assembly of the equipment, all components (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, (see 6.14.2.1.10) it shall meet the test screen cleanliness requirements specified in ISO 10438-1 or API 614, Chapter 1, and ISO 10438-3 or API 614, Chapter 3.

● **8.2.3.3** If specified, the purchaser may inspect the equipment and all piping and appurtenances for cleanliness before heads are welded onto vessels, openings in vessels or exchangers are closed or piping is finally assembled.

● **8.2.3.4** If specified, the hardness of parts, welds and heat affected zones shall be verified as being within the allowable values by testing. The method, extent, documentation and witnessing of the testing shall be mutually agreed by the purchaser and the vendor.

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 can be specified are described in 8.3.4.

8.3.1.2 At least six weeks before the first scheduled running test the vendor shall submit to the purchaser, for his review and comment, detailed procedures for the mechanical running test and all specified running optional tests (8.3.4) including acceptance criteria for all monitored parameters.

8.3.1.3 The vendor shall notify the purchaser not less than five working days before the date that the equipment will be ready for testing. If the testing is rescheduled, the vendor shall notify the purchaser not less than 5 working days before the new test date.

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 maximum allowable working pressure, but not less than a gauge pressure of 1.5 bar (20 psig);
b. cylinder cooling jackets and packing cases: $1^1/2$ times maximum allowable working pressure;
c. piping, pressure vessels, filters and other pressure-containing components: $1^1/2$ times maximum allowable working pressure 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 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 molar mass 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 maximum allowable working pressure. 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 maximum allowable working pressure. Zero leakage is required (see 8.3.2.6). In the case of testing by helium probe, the procedure, the sensitivity of the instrument and the acceptance criteria shall be by prior agreement between the purchaser and the vendor.
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.

8.3.2.3 If the part tested is expected to operate at a temperature at which the strength of a material is below the strength of that material at the testing temperature, the hydrostatic test pressure shall be multiplied by a factor obtained by dividing the allowable working stress for the material at the testing temperature by that at the rated operating temperature. For piping, the stress values used shall be those given in ASME B31.3. For vessels, the stress values used shall be those in the specified pressure code or in ASME Section VIII, Division 1 for vessels. The pressure obtained from the aforementioned calculation shall then be used as the minimum pressure at which the hydrostatic test is performed. The data sheets shall list actual hydrostatic test pressures.

Note: The applicability of this requirement to the material being tested should be verified before hydrostatic test, as the properties of many grades of steel do not change appreciably at temperatures up to 200ºC (400ºF).

8.3.2.4 Where applicable, tests shall be in accordance with the standard used to design the part. In the event that a discrepancy exists between the test pressure in the standard used to design the part and the test pressure in this standard, the higher pressure shall be used.

8.3.2.5 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.

8.3.2.6 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. Seepage past internal closures required for testing of segmented cases and operation of a test pump to maintain pressure are acceptable.

8.3.2.7 Test gaskets shall be identical to those required for the service conditions.

8.3.3 Mechanical Running Test

8.3.3.1 All compressors, drivers, and gear units shall be shop tested in accordance with the vendor’s standard.

● **8.3.3.2** If specified, the shop test of the compressor shall comprise a 4-hour unloaded running test.

● **8.3.3.3** 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 upon by the purchaser and the vendor.

8.3.3.4 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.

8.3.3.5 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.

● **8.3.3.6** 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 upon by the purchaser and the vendor.

● **8.3.3.7** The purchaser shall specify if dismantling for inspection (other than that required by evidence of malfunctioning during testing) is required.

8.3.4 Other 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 6.10.4.6). Bar-over test results shall become a part of the purchaser’s records (Annex F, 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.

8.4 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, Chapter 3.

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 8.4.18.

8.4.4 Equipment shall be completely free of water prior to any shipment preparation.

8.4.5 Except for machined surfaces, all exterior surfaces that can corrode during shipment, storage or in service, shall be given at least one coat of the manufacturer's standard paint. The paint shall not contain lead or chromates.

Note: Austenitic stainless steels are typically not painted.

8.4.6 Exterior 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.

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.

8.4.9 Any paint exposed to lubricants shall be oil-resistant. When synthetic lubricants are used or specified (6.14.3.1.9), special precautions shall be taken to ensure compatibility with the paint.

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. Each opening shall be car sealed so that the protective cover cannot be removed without the seal being broken.

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. 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 wrapped with waterproof moldable waxed cloth or volatile-corrosion-inhibitor paper. The seams shall be sealed with oil proof adhesive tape.

8.4.18 Exterior surfaces of pulsation suppressors, piping and vessels shall be cleaned free of pipe scale, welding spatter and other foreign objects.

Immediately after cleaning, external surfaces shall be painted with at least one coat of lead and chromate free primer.

8.4.19 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.

8.4.20 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.

8.4.21 Component parts, loose parts and spare parts associated with a specific major item of equipment shall be individually packed for shipment and shall not be mixed with similar parts associated with another major item of equipment. For example, parts for the compressor shall not be packed together in the same crate with similar parts for the driver.

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

9 Vendor’s Data

9.1 GENERAL

9.1.1 VDDR Form

The information to be furnished by the vendor is specified in 9.2 and 9.3. The vendor shall complete and return the Vendor Drawing and Data Requirements (VDDR) form (see Annex F) to the address(es) noted on the inquiry or order. This form shall detail the schedule for transmission of drawings, curves, data and manuals as agreed to at the time of the proposal or order as well as the number and type of copies required by the purchaser.

9.1.2 Data Identification

The data shall be identified on the transmittal (cover) letters and the title blocks or title pages with the following information:

a. purchaser/user’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.

9.1.3 Coordination Meeting

Unless otherwise agreed, a coordination meeting shall be held, preferably at the vendor’s plant, within 4 – 6 weeks after the purchase commitment. The purchaser and vendor shall jointly agree on an agenda for this meeting which, as a minimum, shall include the following items:

a. purchase order, scope of supply and sub-vendor items (including spare parts);
b. review of applicable specifications and previously agreed exceptions to specifications;
c. data sheets;
d. compressor performance (including operating limitations);
e. pulsation suppression devices;
f. schematics and bills of material (for major items) of lube-oil systems, cooling systems, distance pieces and similar auxiliaries;
g. preliminary physical orientation of the equipment, piping and auxiliary systems;
h. drive arrangement and driver details;
i. instrumentation and controls;
j. scope and detail of pulsation and vibration analysis and control requirements (see Annexes M and N and 7.9.4.1);
k. identification of items for stress analysis review by purchaser (see 6.15.5.1);

l. inspection, expediting and testing reports;
m. details of functional testing;
n. other technical items;
o. start-up planning and training;
p. schedules for (1) transmittal of data, (2) production, (3) testing, and (4) delivery;
q. review details of vendor's quality control program.

9.2 PROPOSALS

9.2.1 General

The vendor shall forward the original proposal, with the specified number of copies, to the addressee specified in the inquiry documents. The proposal shall include, as a minimum, the data specified in 9.2.2 through 9.2.4, and a specific statement that the equipment and all its components and auxiliaries are in strict accordance with this standard. If the equipment or any of its components or auxiliaries is not in strict accordance, the vendor shall include a list that details and explains each deviation. The vendor shall provide sufficient detail to enable the purchaser to evaluate any proposed alternative designs. All correspondence shall be clearly identified in accordance with 9.1.2.

9.2.2 Drawings

9.2.2.1 The drawings indicated on the Vendor Drawing and Data Requirements (VDDR) form (see Annex F) 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 the lube-oil system, the cooling system, and the distance-piece vent-and-drain system (when supplied). Auxiliary system schematic diagrams shall be marked to show which portions of the system are integral with or mounted on the major equipment and which are separate.
d. Sketches showing 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.)

9.2.2.2 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.

9.2.3 Technical Data

The data described below shall be included.

a. Copies of the purchaser’s data sheets complete with the vendor’s information required for the proposal and literature to fully describe details of the offering(s).
b. The noise data as required by the purchaser in the inquiry.
c. A copy of the Vendor Drawing and Data Requirements form (see Annex F) indicating the schedule according to which the vendor agrees to furnish the data requested by the purchaser (see 9.3).
d. Net and maximum operating weights, maximum shipping and erection weights with identification of the item and the maximum normal maintenance weight with identification of the item. These data shall be stated individually where separate shipments, packages, or assemblies are involved. Approximate data shall be clearly identified as such. These data shall be entered on the data sheets where applicable.
e. For a compressor with a variable-speed drive, the speed range over which the unit can be operated continuously under the specified operating conditions.
f. The vendor shall specifically identify volumetric efficiency of the active end of any cylinder if it is less than 40% at any specified operating condition.

Note: Performance predictions with volumetric efficiencies below 40% are often not reliable.

g. A schedule for shipment of the equipment in weeks after receipt of the order.
h. A list of major wearing components showing interchangeability with other purchaser units.

i. A list of “start-up” spares, to include as a minimum, three lube-oil filter cartridge sets, plates and springs for each valve, one set of packing rings for each rod, one set of rings and wear 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. The vendor shall add any items that his experience indicates are likely to be required on start-up.

j. Complete tabulation of utility requirements, such as steam, water, electricity, air, gas and lube oil; including the quantity of lube oil required and the supply pressure, 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 defined and clearly identified as such. This information shall be entered on the data sheets.

k. A description of the tests and inspection procedures of materials in accordance with 8.2.2.

l. Complete details of any proposed air-cooled oil cooler.

● m. A list of spare parts recommended that the purchaser should stock for normal maintenance purpose. (Any special requirements for long term storage shall be as specified).

n. An itemized list of the special tools included in the offering.

o. A clear description of the metallurgy of all major components of the compressor (see 6.15.1.1 and 6.15.1.2).

p. A full description of the standard shop tests identified in 8.3. Special tests as specified shall also be fully described.

q. A list of relief valves, specifying those furnished by the vendor, as required by ISO 10438-1 or API 614, Chapter 1.

r. A description of the vendor’s intended response to any special requirements, such as those outlined in 6.7.1.

● s. If specified, a list of similar machines installed and operating under analogous conditions to that proposed.

t. Any start-up, shutdown, or operating restrictions required to protect the integrity of the equipment.

u. An outline of all necessary special weather and winterizing protection required by the equipment, its auxiliaries and the driver (if furnished by the vendor) for start-up, operation and idleness. The vendor shall list separately the protective items he proposes to furnish.

v. Preliminary rod and gas load tabulation in accordance with 6.6.3.

9.2.4 Optional Tests

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

9.3 CONTRACT DATA

9.3.1 General

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

9.3.1.2 Each drawing shall have a title block in the lower right-hand corner with the date of certification, identification data specified in 9.1.2, revision number and data and title. Similar information shall be provided on all other documents including sub-vendor items.

● **9.3.1.3** The time allowed for the purchaser’s review of vendor’s data shall be as specified and agreed. Purchaser’s review of vendor’s data shall not constitute permission to deviate from any requirements in the order unless specifically agreed upon in writing. After the data have been reviewed and accepted, the vendor shall furnish certified copies in the quantities specified.

Note: The purchaser should promptly review the vendor's data upon receipt.

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

9.3.2 Drawings

The drawing(s) furnished shall contain sufficient information so that when combined with the manuals covered in 9.3.7, the purchaser can properly install, operate and maintain the ordered equipment. Drawings shall be clearly legible and reproducible. (8-point minimum font size even if reduced from a larger size drawing). Drawings made specifically for the order shall be identified in accordance with 9.1.2.

9.3.3 Performance Data

● **9.3.3.1** 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 mutually agreed between the vendor and the purchaser.

9.3.3.2 Rod load and gas load charts for each load step, complete in accordance with 6.6, including inertial forces and rod reversal magnitude and duration shall be furnished.

● **9.3.3.3** If specified, the vendor shall furnish the data required for independent rod load, gas load, and reversal calculations.

● **9.3.3.4** If specified, the effect of valve failure on rod loads and reversal shall be calculated and furnished. The required specifics of this study shall be mutually agreed upon by the purchaser and vendor.

9.3.3.5 Curves of starting torque vs. speed shall be furnished for the compressor, for the motor at rated voltage and 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.

9.3.4 Technical Data

Data shall be submitted in accordance with the VDDR form. The vendor shall provide full information to enable completion of the data sheets, first “as purchased” and then “as built”. This shall be done by correcting and filling out the data sheets and submitting copies.

If any drawing comments or specification revisions lead to a change in the data, the vendor shall reissue data sheets. This will result in reissue of the complete, corrected data sheets by the purchaser as part of the order specifications.

9.3.5 Progress Reports

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

Note: See the description of item 42 in Annex F for content of these reports.

9.3.6 Recommended Spares

9.3.6.1 The vendor shall submit complete parts lists for all equipment and accessories supplied. These lists shall include part names, manufacturers’ unique part numbers, materials of construction (identified by applicable international standards). Each part shall be completely identified and shown on appropriate cross-sectional, assembly-type cutaway or exploded-view isometric drawings. Interchangeable parts shall be identified as such. Parts that have been modified from standard dimensions or finish to satisfy specific performance requirements shall be uniquely identified by part number. Standard purchased items shall be identified by the original manufacturer's name and part number.

9.3.6.2 The vendor shall indicate on each of these complete parts lists all those parts that are recommended as start-up or maintenance spares, and the recommended stocking quantities of each. These should include spare parts recommendations from sub-suppliers that were not available for inclusion in the vendor's original proposal

9.3.7 Installation, Operation, Maintenance and Technical Data Manuals

9.3.7.1 General

The vendor shall provide sufficient written instructions and all necessary drawings to enable the purchaser to install, operate, and maintain all of the equipment covered by the purchase order. This information shall be compiled in a manual or manuals with a cover sheet showing the information listed in 9.1.2, an index sheet, and a complete list of the enclosed drawings by title and drawing number. The manual or manuals shall be prepared specifically for the equipment covered by the purchase order. “Typical” manuals shall not be provided.

9.3.7.2 Installation Manual

All information required for the proper installation of the equipment shall be compiled in a manual that must be issued no later than the time of issue of final certified drawings. The installation manual may be separate from the operating and maintenance instructions. The installation 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. All drawings and data specified in 9.2.2 and 9.2.3 that are pertinent to proper installation shall be included as part of this manual (see description of line item 64 in Annex F).

9.3.7.3 Operating and Maintenance Manuals

A manual containing all required operating and maintenance instructions shall be supplied no later than two weeks after all specified tests have been successfully completed. In addition to covering operation at all specified process conditions, this manual shall also contain separate sections covering operation under any specified extreme environmental conditions (see description of line item 65 in Annex F).

9.3.7.4 Technical Data Manual

The vendor shall provide the purchaser with a technical data manual within 30 days of completion of shop testing (see description of line item 66 in Annex F for minimum requirements of this manual).

Annex A
(informative)

Data Sheets

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
U.S. CUSTOMARY UNITS

JOB NO. ______ ITEM NO. ______
PURCHASE ORDER NO. ______
SPECIFICATION NO. ______
REVISION NO. ______ DATE ______
PAGE 1 OF 17 BY ______

Revision

1 APPLICABLE TO: ○ PROPOSALS ○ PURCHASE ○ AS BUILT
2 FOR/USER ______ SITE/LOCATION ______ SERVICE ______ NO. REQ'D ______
3 NOTE: ○ INDICATES INFO. TO BE COMPLETED BY PURCH. ☐ BY MANUFACTURER WITH PROPOSAL ◇ BY MANUFACTURER AFTER ORDER ◎ BY MANUFACTURER OR PURCHASER AS APPLICABLE
4
5 COMPR. MFGR ______ TYPE MODEL NO(S) ______ SERIAL NO(S) ______
6 COMPR.THROWS: TOTAL NO. ______ NO. WITH CYLS. ______ NOMINAL FRAME RATING ______ BHP @ RATED R/MIN OF ______
7 ☐ MAX/MIN ALLOWABLE SPEED ______ / ______ r/min
8 DRIVER MFGR. ______ DRIVER NAMEPLATE HP/OPERATING R/MIN ______ / ______
9 DRIVE SYSTEM: ○ DIRECT COUPLED ○ GEARED & COUPLED ○ V-BELT
10 TYPE OF DRIVER: ○ IND. MOTOR ○ SYN. MOTOR ○ STEAM TURBINE ○ GAS TURBINE ○ ENGINE ○ OTHER ______
11 CYLINDERS CONSTRUCTION: ○ LUBE ○ NON-LUBE
12
13 ○ MAX ACCEPTABLE AVG PISTON SPEED ______ ft/min

14 **OPERATING CONDITIONS (EACH MACHINE)**

15	○ SERVICE OR ITEM NO.						
16	○ STAGE						
17	○ NORM. OR ALT. CONDITION						
18	○ CERTIFIED PT. (X) MARK ONE						
19	○ MOLECULAR WEIGHT						
20	○ C_P/C_V (K) @ 150°F OR ______ °F						

21 **INLET CONDITIONS:** AT INLET TO: ○ PULSE DEVICES ○ COMPRESSOR CYLINDER FLANGES
22 NOTE: ○ SIDE STREAM TO ______ STAGE(S), THESE INLET PRESS. ARE FIXED

23	○ PRESSURE (psia) @ PUL. SUPP. INLET						
24	◎ PRESSURE (psia) @ CYL. FLANGE						
25	○ TEMPERATURE (°F)						
26	○ REF: SIDE STREAM TEMPS (°F)						
27	☐ COMPRESSIBILITY (Z_S)						

28 **INTERSTAGE:** INTERSTAGE Δ P INCL: ○ PULSE DEVICES ○ PIPING ○ COOLERS ○ SEPARATORS ○ OTHER ______

29	◎ ΔP BETWEEN STAGES, %/psi	/	/	/	/	/

30 **DISCHARGE CONDITIONS:** AT OUTLET FROM: ○ PULSE DEVICE ○ COMP. CYL. FLANGES ○ OTHER ______

31	◎ PRESSURE (psia) @ CYL. FLANGE						
32	○ PRESS. (psia) @ PUL. SUPP. OUTLET						
33	☐ TEMP., ADIABATIC, °F						
34	☐ TEMP., PREDICTED, °F						
35	☐ COMPRESSIBILITY (Z_2) OR (Z_{AVG})						

36 *** CAPACITY AT INLET TO COMPRESSOR, NO NEGATIVE TOLERANCE (-0%)**

37	○ lb/h CAPACITY SPECIFIED						
38	IS ○ WET ○ DRY						
39	○ MMSCFD/SCFM (14.7 psia & 60°F)						

40 *** MFGR.'S RATED CAPACITY (AT INLET TO COMPRESSSOR & BHP @ CERTIFIED TOLERANCE OF ±3% FOR CAP. & ±3% FOR BHP)**

41	☐ lb/h CAPACITY SPECIFIED						
42	IS ○ WET ○ DRY						
43	☐ INLET VOLUME FLOW (ICFM)						
44	☐ MMSCFD/SCFM (14.7 psia & 60°F)						
45	☐ BHP/STAGE						
46	☐ TOTAL BHP @ COMPRESSOR SHAFT						
47	☐ TOTAL HP INCLUDING						
48	V-BELT & GEAR LOSSES						

49 *** CAPACITY FOR NNT** **REMARKS:** ______
50 MANUFACTURER'S = REQUIRED ÷ 0.97 ______
51 THEREFORE REQUIRED = MFR'S x 0.97 ______

Figure A-1—Reciprocating Compressor Data Sheet (U.S. Customary Units)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
U.S. CUSTOMARY UNITS

JOB NO. ______ ITEM NO. ______
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1–2	**GAS ANALYSIS AT OPERATING CONDITIONS** **MOLE % (BY VOLUME) ONLY**							
3	○ SERVICE/ITEM NO.							
4	○ STAGE							
5	○ NORMAL OR ALT							
6			M.W.					
7	AIR		28.966					
8	OXYGEN	O_2	32.000					
9	NITROGEN	N_2	28.016					
10	WATER VAPOR	H_2O	18.016					
11	CARBON MONOX.	CO	28.010					
12	CARBON DIOX.	CO_2	44.010					
13	HYDRO. SULFIDE	H_2S	34.076					
14	HYDROGEN	H_2	2.016					
15	METHANE	CH_4	16.042					
16	ETHYLENE	C_2H_4	28.052					
17	ETHANE	C_2H_6	30.068					
18	PROPYLENE	C_3H_6	42.078					
19	PROPANE	C_3H_8	44.094					
20	I-BUTANE	C_4H_{10}	58.120					
21	n-BUTANE	C_4H_{10}	58.120					
22	I-PENTANE	C_5H_{12}	72.146					
23	n-PENTANE	C_5H_{12}	72.146					
24	HEXANE PLUS							
25	AMMONIA	NH_3	17.031					
26	HYDRO. CHLOR.	HCl	36.461					
27	CHLORINE	Cl_2	70.914					
28	CHLORIDES - TRACES							
29								
30								
31								
32	☐ CALCULATED MOL WT.							
33	☐ C_p/C_v (K) @ 150° OR ______ °F							

REMARKS

APPLICABLE SPECIFICATIONS

● API 618-RECIPROCATING COMPRESSORS
FOR PETROLEUM, CHEMICAL AND GAS
INDUSTRY SERVICES

NACE MR-O175 (6.15.1.11)

○ ______
○ ______
○ ______
○ ______
○ ______
○ ______
○ ______
○ ______

34 NOTE: IF WATER VAPOR AND/OR CHLORIDES ARE PRESENT, EVEN MINUTE
35 TRACES, IN THE GAS BEING COMPRESSED, IT MUST BE INCLUDED ABOVE.
36 ○ SITE/LOCATION CONDITIONS
37 ELEVATION ______ FT BAROMETER ______ PSIA AMBIENT TEMPS: MAX ______ °F MIN ______ °F
38 ○ MIN DESIGN METAL TEMP ______ °F (6.15.8.1) RELATIVE HUMIDITY: MAX ______ % MIN ______ %
39 COMPRESSOR LOCATION: ○ INDOOR ○ HEATED ○ UNHEATED ○ AT GRADE LEVEL ○ ELEVATED: ______ ft
40 ○ OUTDOOR ○ NO ROOF ○ UNDER ROOF ○ PARTIAL SIDES ○ PLATFORM: ○ ON-SHORE
41 ○ OFF-SHORE ○ WEATHER PROTECTION REQ. ○ TROPICALIZATION REQ.
42 ○ WINTERIZATION REQUIRED
43 UNUSUAL CONDITIONS: ○ CORROSIVES ○ DUST ○ FUMES ○ OTHER ______
44 ______
45 ELECTRICAL CLASSIFICATIONS
46 HAZARDOUS NON-HAZARDOUS
47 MAIN UNIT ○ CLASS ______ GROUP ______ DIVISION ______ ○
48 L.O. CONSOLE ○ CLASS ______ GROUP ______ DIVISION ______ ○
49 CW CONSOLE ○ CLASS ______ GROUP ______ DIVISION ______ ○
50
51

Figure A-1—Reciprocating Compressor Data Sheet (U.S. Customary Units) (continued)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
U.S. CUSTOMARY UNITS

JOB NO. ______ ITEM NO. ______
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1 **PART LOAD OPERATING CONDITIONS**

2 CAPACITY CONTROL BY: ○ MFG'S CAP. CONTROL ○ PURCHASERS BY-PASS ○ BOTH ○ OTHER ______

3 FOR: ○ PART LOAD COND. ○ START-UP ONLY ○ BOTH

4 WITH: ○ AUTO LOADING DELAY INTERLOCK (7.6.2.4) ○ AUTO IMMEDIATE UNLOADING

5 USING: ○ FIXED VOLUME POCK. ○ SUCTION VALVE UNLOADERS: ○ FINGER ○ PLUG ○ OTHER

6 ACTION: ○ DIRECT (AIR-TO-UNLOAD) ○ REVERSE (AIR-TO-LOAD/FAIL SAFE)

7 NUMBER OF STEPS: ○ ONE ○ THREE ○ FIVE ○ OTHER ______

8 ○ RAIN COVER REQUIRED OVER UNLOADERS

9 **ALL UNLOADING STEPS BASIS MANUFACTURERS CAPACITY SHOWN ON PAGE 1.**

10 **INLET AND DISCHARGE PRESSURE ARE** ○ **AT CYLINDER FLANGES** ○ **PULSATION SUPPRESSOR FLANGES**

11	○ SERVICE OR ITEM NO.						
12	⧇ STAGE						
13	⧇ NORMAL OR ALTERNATE CONDITION						
14	○ PERCENT CAPACITY						
15	○ WEIGHT FLOW, lb/h						
16	⧇ MMSCFD/SCFM (14.7 psia & 60°F)						
17	☐ POCKETS/VALVES OPERATION *						
18	☐ POCKET CLEARANCE ADDED %						
19	☐ TYPE UNLOADERS, PLUG/FINGER						
20	⧇ INLET TEMPERATURE, °F						
21	⧇ INLET PRESSURE, psia						
22	⧇ DISCHARGE PRESSURE, psia						
23	☐ DISCHARGE TEMP., ADIABATIC °F						
24	☐ DISCHARGE TEMP., PREDICTED °F						
25	☐ VOLUMETRIC EFF.,%HE/%CE	/	/	/	/	/	/
26	☐ CALC. GAS ROD LOAD, lb, C **						
27	☐ CALC. GAS ROD LOAD, lb, T **						
28	◇ COMB. ROD LOAD, lb, C (GAS & INERTIA)						
29	◇ COMB. ROD LOAD, lb, T (GAS & INERTIA)						
30	◇ ROD REV., DEGREES MIN @ X-HD PIN ***						
31	☐ BHP/STAGE						
32	☐ TOTAL BHP @ COMPRESSOR SHAFT						
33	☐ TOTAL HP INCL. V-BELT & GEAR LOSSES						
34							

35 * SHOW OPERATION WITH THE FOLLOWING SYMBOLS:

36 SUCTION VALVE(S) UNLOADED = S
37 HEAD END = HE OR
38 OR PLUS FIXED POCKET OPEN = F
39 CRANK END = CE OR
40 VARIABLE POCKET OPEN = V

41

42 EXAMPLE: HE-F/CE-S = HEAD END FIXED POCKET OPEN / CRANK END SUCTION VALVE(S) UNLOADED.

43 * * C = COMPRESSION T = TENSION *** X - HD = CROSSHEAD

44 ☐ MINIMUM PRESSURE REQUIRED TO OPERATE CYLINDER UNLOADING DEVICES, ______ psig

45 CYLINDER UNLOADING MEDIUM: ○ AIR ○ NITROGEN ○ OTHER ______

46 ○ PRESSURE AVAILABLE FOR CYLINDER UNLOADING DEVICES, MAX/MIN ______ / ______ psig

47 **REMARKS, SPECIAL REQUIREMENTS, AND/OR SKETCH**

48

49

50

51

Figure A-1—Reciprocating Compressor Data Sheet (U.S. Customary Units) (continued)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
U.S. CUSTOMARY UNITS

JOB NO. ____________ ITEM NO. ____________

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1 ○ **SCOPE OF BASIC SUPPLY**

2 PURCHASER TO FILL IN (☐ ○ ⬡) AFTER COMMODITY TO INDICATE: ☐ BY COMPR. MFR. ○ BY PURCH. ⬡ BY OTHERS

3 ○ DRIVER (☐ ○ ⬡): ○ VARIABLE SPEED SPEED RANGE ____________ r/min TO ____________ r/min

4 ○ INDUCTION MOTOR ○ SYNCHRONOUS MOTOR ○ STEAM TURBINE ○ ENGINE ○ OTHER ________

5 ○ API 541 ○ API 546 ○ API 611 ○ API 612

6 ○ OUTBOARD BEARING ○ PROVISION FOR DRY AIR PURGE FOR OUTBOARD BEARING.

7 ○ SLIDE BASE FOR DRIVER (☐ ○ ⬡) SOLE PLATE FOR DRIVER (☐ ○ ⬡)

8 ○ MOTOR STARTING EQUIPMENT (☐ ○ ⬡); DEFINE ____________________________________

9 ○ GEAR (☐ ○ ⬡): ○ BASEPLATE FOR GEAR ○ API 613 ○ API 677

10 ○ COUPLING(S) (☐ ○ ⬡): ○ LOW SPD. ○ HI-SPD. ○ QUILL SHAFT ○ KEY-LESS DRV. ○ KEY'D DRV. ○ OTHER ________

11 ○ API 671

12 ○ V-BELT DRIVE (☐ ○ ⬡): ○ SHEAVES & V-BELTS (☐ ○ ⬡) ○ STATIC CONDUCTING V-BELTS ○ BANDED V-BELTS

13 ○ DRIVE GUARD(S) (☐ ○ ⬡): ○ MANUFACTURER'S STD. ○ NON-SPARKING ○ CALIF CODE ○ API 671, ANNEX G

14 ○ OTHER

15 ○ PULSATION SUPPRESSORS (☐ ○ ⬡): ○ INITIAL INLET & FINAL DISCHARGE ○ SUPPORTS (☐ ○ ⬡)

16 ○ INTERSTAGE ○ SUPPORTS (☐ ○ ⬡)

17 ○ SUPPRESSOR(S) TO HAVE MOISTURE REMOVAL SECTION: ○ INITIAL INLET ○ ALL INTERSTAGE INLET

18 ○ ACOUSTICAL SIMUL. STUDY (☐ ○ ⬡): DESIGN ○ 1, EMPIRICAL PULSATION SUPRESSION DEVICE SIZING

19 APPROACH ○ 2, ACOUSTIC SIMULATION AND PIPING RESTRAINT ANALYSIS

20 CHECK ONLY ONE, SEE 7.9.4.1.1, TABLE 6) ○ 3, ACOUSTIC SIMULATION AND PIPING RESTRAINT ANALYSIS

21 STUDY TO CONSIDER: PLUS MECHANICAL ANALYSIS

22 ALL SPECIFIED LOAD COND., INCL. ○ SINGLE ACT., PLUS ○ COMP.OPER.IN PARALLEL ○ ALTERNATE GASES

23 ○ CRITICAL FLOW MEASUREMENT (7.9.4.2.5.3.3) ○ WITH EXISTING COMP. AND PIPING SYSTEMS

24 ○ PULSATION SUPRESS'N DEVICE LOW CYCLE FATIGUE ANALYSIS ○ PIPING SYSTEM FLEXIBILITY

25 ○ VENDOR REVIEW OF PURCHASER'S PIPING ARRANGEMENT

26 NOTE: SEE APPENDIX N FOR INFORMATION REQUIRED FOR STUDY

27 PACKAGED: ○ NO ○ YES (☐ ○ ⬡) DEFINE BASIC SCOPE OF PACKAGING IN REMARKS SECTION, PAGE 5

28 ○ DIRECT GROUTED ○ CEMENTED/MORTAR GROUT ○ EPOXY GROUT; MFG/TYPE ____________ / ____________

29 ○ RAILS ○ CHOCK BLOCKS ○ SHIMS ○ BASEPLT. ○ SKID ○ SOLEPLT. ○ BOLTS OR STUDS FOR SOLEPLT. TO FRAME

30 ○ SUITABLE FOR COLUMN MOUNTING (UNDER SKID AND/OR BASEPLATE)

31 ○ LEVELING SCREWS ○ NON-SKID DECKING ○ SUB SOLEPLATES

32 ○ INTERCLR(S) (☐ ○ ⬡) ○ OFF MOUNTED ○ MACHINE MTD. ○ AFTERCLR(S) (☐ ○ ⬡)

33 ○ SEPARATOR(S) (☐ ○ ⬡) ○ CONDENSATE SEPARATION & COLLECTION FACILITY SYSTEM (7.8.2.1)

34 ○ INTERSTAGE PIP. (☐ ○ ⬡): ○ FINAL DISC. PIP. (☐ ○ ⬡): ○ PARTIAL PRE FAB, FIELD FIT ○ SHOP FITTED

35 FLANGE FINISH ○ API 618 FLANGE FINISH > 125 < 250 (7.9.5.1.16) ○ FLANGE FINISH PER ANSI 16.5 ○ SPECIAL FINISH

36 ○ SPECIAL PIPING REQUIREMENTS (7.7.1.13). (DEFINE IN REMARKS SECTION NEXT PAGE)

37 ○ INITIAL INLET, ○ INTERSTAGE SUCTION PIPING ARR'D FOR: ○ INSULATION (☐ ○ ⬡) ○ HEAT TRACING (☐ ○ ⬡

38 ○ INLET STRAINER(S) (☐ ○ ⬡): ○ INITIAL INLET ○ SIDESTREAM INLET ○ SPOOL PIECE FOR INLET STRAINERS

39 ○ MANIFOLD PIPING; ○ DRAINS ○ VENTS ○ RELIEF VALVES ○ AIR/GAS SUPPLY

40 ○ RELIEF VALVE(S) (☐ ○ ⬡): ○ INITIAL INLET ○ INTERSTAGE ○ FINAL DISCHARGE

41 ○ RUPTURE DISC(S) (☐ ○ ⬡) ○ THRU STUDS IN PIPING FLANGES

42 ○ FOR ATMOSPHERIC INLET AIR COMPR. ONLY: ○ INLET AIR FILTER (☐ ○ ⬡) ○ INLET FILTER -SILENCER (☐ ○ ⬡)

43 ○ PREFERRED TYPE OF CYLINDER COOLING (☐ ○ ⬡): ○ FORCED ○ THERMOSYPHON ____________ STAGE CYL'(S)

44 NOTE: MANUFACTURER SHALL RECOMMEND ○ STATIC (STAND-PIPE) ____________ STAGE CYL'(S)

45 BEST TYPE OF COOLING AFTER ○ CYL. COOLANT PIPING BY (☐ ○ ⬡) ○ MATCH M'RKED

46 FINAL ENGINEERING REVIEW OF ALL ○ SINGLE INLET/OUTLET MANIFOLD & VALVES ○ SIGHT GL'SS(ES)

47 OPERATING CONDITIONS ○ INDIVIDUAL INLET/ OUTLET PER CYL. ○ VALVE(S)

48 ○ CLOSED SYSTEM WITH PUMP, COOLER, SURGE TANK, & PIPING

49

50

51

Figure A-1—Reciprocating Compressor Data Sheet (U.S. Customary Units) (continued)

RECIPROCATING COMPRESSOR
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U.S. CUSTOMARY UNITS

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○ **SCOPE OF BASIC SUPPLY (Con't)**

○ SEPARATE COOLING CONSOLE (☐ ○ ⬡): ○ ONE FOR EA. UNIT ○ ONE CMMN TO ALL UNITS ○ DUAL PUMPS (AUX .& MAIN)
○ ARRANGED FOR HEATING JACKET WATER AS WELL AS COOLING ○ SHOP RUN
○ ROD PRESS. PACKING COOLING SYSTEM (☐ ○ ⬡): ○ SEPARATE CONSOLE ○ COMBINE WITH JKT SYSTEM ○ FILTERS
○ FRAME LUBE OIL SYSTEM (☐ ○ ⬡): ○ AUX. PUMP ○ DUAL FILTERS WITH TRANSFER VALVE ○ SHOP RUN
○ CONTINUOUS FLOW IN SENSING LINE TO PRESSURE SWITCHES
○ SEPARATE LUBE OIL CONSOLE (☐ ○ ⬡): ○ EXTENDED TO MOTOR OUTBOARD BEARING ○ SHOP RUN
NOTE: PIPING BETWEEN ALL CONSOLES AND COMPRESSOR UNIT BY PURCHASER

○ CAPACITY CONTROL (☐ ○ ⬡): ○ SEE DATA SHEET PAGE 3 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)
SEE INSTRUMENTATION DATA SHEETS FOR DETAILS OF PANEL, ADDITIONAL REMARKS, AND INSTRUMENTATION.
NOTE: ALL TUBING, WIRING, & CONNECTIONS BETWEEN OFF-UNIT FREE STANDING PANELS AND COMPRESSOR UNIT BY PURCHASER.

○ HEATERS (☐ ○ ⬡): ○ FRAME LUBE OIL ○ CYL. LUBRICATORS ○ COOLING WATER ○ DRIVER(S) ○ GEAR OIL
○ ELECTRIC ○ STEAM

○ BARRING DEVICE (☐ ○ ⬡): ○ MANUAL ○ PNEUMATIC ○ ELECTRIC ○ FLYWHEEL LOCKING DEVICE (☐ ○ ⬡)
○ CRANKCASE RAPID PRESSURE RELIEF DEVICE(S) (☐ ○ ⬡)
○ SPECIAL CORROSION PROTECTION: ○ NO ○ YES ○ MFR'S STANDARD ○ OTHER ________
○ HYDRAULIC TENSIONING TOOLS ○ NO ○ YES
○ MECHANICAL RUN TEST: ○ NO ○ YES ○ MFG'S STANDARD ○ OTHER ________
○ COMPLETE SHOP RUN TEST OF ALL MACHINE MOUNTED EQUIPMENT, PIPING & APPURT.'(S)

PAINTING: ○ MANUFACTURER'S STANDARD ○ SPECIAL ________
NAMEPLATES: ○ U.S. CUSTOMARY UNITS ○ SI UNITS
SHIPMENT: ○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQUIRED (☐ ○ ⬡)
○ STANDARD 6 MONTH STORAGE PREPARATION (☐ ○ ⬡), PER SPEC ________
○ OUTDOOR STORAGE FOR OVER 6 MONTHS (☐ ○ ⬡), PER SPEC ________
○ INITIAL INSTALLATION AND OPERATING TEMP ALIGNMENT CHECK AT JOBSITE BY VENDOR REPRESENTATIVE
○ COMPRESSOR MANUFACTURER'S USER'S LIST FOR SIMILAR SERVICE
○ COMPRESSOR VALVE DYNAMIC RESPONSE
○ PERFORMANCE DATA REQUIRED (9.3.3): ○ BHP VS. SUCTION PRESSURE CURVES
○ ROD LOAD/GAS LOAD CHARTS
○ VALVE FAILURE DATA CHARTED
○ SPEED/TORQUE CURVE DATA
○ BHP VS. CAPACITY PERFORMANCE CURVES OR TABLES REQUIRED FOR UNLOADING STEPS AND/OR VARIABLE SUCTION/DISCHARGE PRESSURES

REMARKS: ________

Figure A-1—Reciprocating Compressor Data Sheet (U.S. Customary Units) (continued)

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API 618 5TH EDITION DATA SHEET
U.S. CUSTOMARY UNITS

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1 **UTILITY CONDITIONS**

2 ELECTRICAL POWER: AC VOLTS / PHASE / HERTZ DC VOLTS AC VOLTS / PHASE / HERTZ DC VOLTS
3 ○ MAIN DRIVER ____ / ____ / ____ ____ INSTRUMENT ____ / ____ / ____ / ____
4 ○ AUXILIARY MOTORS ____ / ____ / ____ ____ ALARM & SHTDWN ____ / ____ / ____ / ____
5 ○ HEATERS ____ / ____ / ____ ____ ____ ____ / ____ / ____ / ____
6
7
8 INSTRUMENT AIR: NORMAL PRESSURE psig MAX/MIN / psig
9 NITROGEN: NORMAL PRESSURE ____ psig MAX/MIN ____ / ____ psig

10 **STEAM** FOR: **DRIVERS** **HEATERS**
11 INLET: PRESS ____ psig MAX/MIN ____ / ____ psig INLET: PRESS ____ psig MAX/MIN ____ / ____ psig
12 (NORM.) TEMP ____ °F MAX/MIN ____ / ____ °F (NORM.) TEMP ____ °F MAX/MIN ____ / ____ °F
13 EXH'ST: PRESS ____ psig MAX/MIN ____ / ____ psig EXH'ST:PRESS ____ psig MAX/MIN ____ / ____ psig
14 (NORM.) TEMP ____ °F MAX/MIN ____ / ____ °F (NORM.) TEMP ____ °F MAX/MIN ____ / ____ °F
15
16

17 **COOLING WATER** FOR: **COMPRESSOR CYLINDERS** **COOLERS**
18 TYPE WATER ____ TYPE WATER ____
19 SUPP.: PRESS ____ psig MAX/MIN ____ / ____ psig SUPP.: PRESS ____ psig MAX/MIN ____ / ____ psig
20 (NORM.) TEMP ____ °F MAX/MIN ____ / ____ °F (NORM.) TEMP ____ °F MAX/MIN ____ / ____ °F
21 R'T'RN: PRESS ____ psig MAX/MIN ____ / ____ psig R'T'RN: PRESS ____ psig MAX/MIN ____ / ____ psig
22 (NORM.) TEMP ____ °F MAX/MIN ____ / ____ °F (NORM.) TEMP ____ °F MAX/MIN ____ / ____ °F
23

24 COOLING FOR ROD PACKING:
25 TYPE FLUID ____ SUPPLY PRESS ____ psig @ ____ °F RETURN ____ psig @ ____ °F

26 FUEL GAS: NORMAL PRESSURE ____ psig MAX/MIN ____ / ____ psig LHV ____ BTU/ft^3
27 COMPOSITION ____
28

29 **REMARKS/SPECIAL REQUIREMENTS:** ____
30
31 ____
32 ____
33 ____
34 ____
35 ____
36 ____
37 ____
38 ____
39 ____
40 ____
41 ____
42 ____
43 ____
44 ____
45 ____
46 ____
47 ____
48 ____
49 ____
50 ____
51

Figure A-1—Reciprocating Compressor Data Sheet (U.S. Customary Units) (continued)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
U.S. CUSTOMARY UNITS

JOB NO. ______ ITEM NO. ______
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1	○ **CYLINDER DATA AT FULL LOAD CONDITION**						
2	SERVICE/ITEM NO.						
3	STAGE						
4	INLET PRESSURE, psia } @ CYLINDER						
5	DISCHARGE PRESSURE, psia FLANGES						
6	CYLINDERS PER STAGE						
7	SINGLE OR DOUBLE ACTING (SA OR DA)						
8	BORE, in.						
9	STROKE, in.						
10	RPM: RATED / MAX ALLOW	/					
11	PISTON SPEED, ft/min: RATED / MAX ALLOW	/					
12	CYLINDER LINER, YES/NO						
13	LINER NOMINAL THICKNESS, in.						
14	PISTON DISPLACEMENT, ft^3/min						
15	CYLINDER DESIGN CLEARANCE, % AVERAGE						
16	VOLUMETRIC EFFICIENCY, % AVERAGE						
17	VALVES, INLET/DISCHARGE, QTY PER CYL.	/	/	/	/	/	/
18	TYPE OF VALVES						
19	VALVE LIFT, INLET/DISCHARGE, in.	/	/	/	/	/	/
20	VALVE VELOCITY, ft/min						
21	SUCTION VALVE(S)						
22	DISCHARGE VALVE(S)						
23	ROD DIAMETER, in.						
24	MAX ALLOW. COMBINED ROD LOADING, lb, C *						
25	MAX ALLOW. COMBINED ROD LOADING, lb, T *						
26	CALCULATED GAS ROD LOAD, lb, C *						
27	CALCULATED GAS ROD LOAD, lb, T *						
28	COMBINED ROD LOAD (GAS + INERTIA), lb, C *						
29	COMBINED ROD LOAD (GAS + INERTIA), lb, T *						
30	ROD REV., DEGREES MIN @ X-HD PIN**						
31	RECIP WT. (PISTON, ROD, X-HD & NUTS), lb**						
32	MAX ALLOW. WORKING PRESSURE, psig						
33	MAX ALLOW. WORKING TEMPERATURE, °F						
34	HYDROSTATIC TEST PRESSURE, psig						
35	GAS LEAKAGE TEST PRESSURE, psig						
36	INLET FLANGE SIZE/RATING	/	/	/	/	/	/
37	FACING						
38	DISCHARGE FLANGE SIZE/RATING	/	/	/	/	/	/
39	FACING						
40	DISCHARGE RELIEF VALVE SETTING DATA AT INLET PRESSURES GIVEN ABOVE:						
41	RECOMMENDED SETTING, psig						
42	GAS ROD LOAD, lb, C *						
43	GAS ROD LOAD, lb, T *						
44	COMBINED ROD LOAD, lb, C *						
45	COMBINED ROD LOAD, lb, T *						
46	ROD REVERSAL, °MIN @ X-HD PIN**						
47	NOTE: CALCULATED AT INLET PRESSURES						
48	GIVEN ABOVE & RECOMMENDED SETTING.						
49	○ SETTLE-OUT GAS PRESSURE						
50	(DATA REQUIRED FOR STARTING)	* C = COMPRESSION	* T = TENSION	**X-HD = CROSSHEAD			
51	**NOTES/REMARKS:**						

Figure A-1—Reciprocating Compressor Data Sheet (U.S. Customary Units) (continued)

RECIPROCATING COMPRESSOR
(API 618-5TH) DATA SHEET
U.S. CUSTOMARY UNITS

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1	☐ **CONSTRUCTION FEATURES**						
2	SERVICE ITEM NO.						
3	STAGE						
4	CYLINDER SIZE (BORE DIA), in.						
5	ROD RUN-OUT: NORMAL COLD VERTICAL						
6	(per Annex C)						
7	CYLINDER INDICATOR VALVES REQUIRED	○	○	○	○	○	○
8	INDICATOR CONNECTIONS ABOVE 5000 PSI	○	○	○	○	○	○
9	FLUOROCARBON SPRAYED CYLINDER	○	○	○	○	○	○
	MATERIALS OF CONSTRUCTION						
10	CYLINDER(S)						
11	CYLINDER LINER(S)						
12	PISTON(S)						
13	PISTON RINGS						
14	WEAR BANDS ○ REQUIRED						
15	PISTON ROD(S): MATERIAL/YIELD, PSI	/	/	/	/	/	/
16	THREAD ROOT STRESS @ MACRL * @ X-HD END						
17	PISTON ROD HARDNESS, BASE MATERIAL, Rc						
18	PISTON ROD COATING ○ REQUIRED						
19	COATING HARDNESS, Rc						
20	VALVE SEATS / SEAT PLATE						
21	VALVE SEAT MIN HARDNESS, Rc						
22	VALVE GUARDS (STOPS)						
23	VALVE DISCS						
24	VALVE SPRINGS						
25	ROD PRESSURE PACKING RINGS						
26	ROD PRESSURE PACKING CASE						
27	ROD PRESSURE PACKING SPRINGS						
28	SEAL / BUFFER PACKING, DISTANCE PIECE						
29	SEAL / BUFFER PACKING, INTERMEDIATE						
30	WIPER PACKING RINGS						
31	MAIN JOURNAL BEARINGS, CRANKSHAFT						
32	CONNECTING ROD BEARING, CRANKPIN						
33	CONNECTING ROD BUSHING, X-HD END						
34	CROSSHEAD (X-HD) PIN BUSHING						
35	CROSSHEAD PIN						
36	CROSSHEAD						
37	CROSSHEAD SHOES						
38	INSTRUMENTATION IN COLD SIDE						
39	CONTACT W/PROCESS GAS HOT SIDE						
40	* MACRL = MAXIMUM ALLOWABLE COMBINED ROD LOAD						

41	☐ COMPRESSOR CYLINDER ROD PACKING	DISTANCE PIECE(S): ○ TYPE A ○ TYPE B ○ TYPE C ○ TYPE D
42	○ FULL FLOATING PACKING	REF. FIGURE G-3
43	○ VENTED TO: ○ FLARE @ ______ psig ○ ATMOS.	COVERS: ○ SOLID METAL ○ SCREEN ○ LOUVERED
44	○ SUCTION PRESSURE @ ______ psig	CYLINDER COMPARTMENT: ○ VENTED TO ______ psig
45	○ FORCED LUBRICATED ○ NON-LUBE	(Outboard Distance Piece) ○ PURGED AT ______ psig
46	☐ WATER COOLED, ______ STAGE(S), ______ GPM REQ'D	○ PRESSURIZED TO ______ psig
47	☐ OIL COOLED, ______ STAGE(S), ______ GPM REQ'D	○ WITH RELIEF VALVE
48	○ WATER FILTER ○ PROV.FUTURE WATER/OIL COOLING	FRAME COMPARTMENT: ○ VENTED TO ______ psig
49	○ VENT/BUFFER GAS SEAL PACKING ARR. (REF. FIG I-1)	(Inboard Distance Piece) ○ PURGED AT ______ psig
50	○ CONSTANT OR ○ VARIABLE DISPOSAL SYSTEM	○ PRESSURIZED TO ______ psig
51	○ BUFFER GAS PRESSURE, ______ psig	○ WITH RELIEF VALVE
52	○ SPLASH GUARDS FOR WIPER PACKING	☐ DISTANCE PIECE MAWP ______ psig

Figure A-1—Reciprocating Compressor Data Sheet (U.S. Customary Units) (continued)

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1	▣ **CONSTRUCTION FEATURES (CONTINUED)**	
2	○ FABRICATED CYLINDER, HEADS, & CONNECTION	○ BUFFER GAS PACKING ARR. REF: ANNEX I
3	SKETCHES FOR DESIGN REVIEW	○ OIL WIPER PACKING PURGE FIGURES I-1, I-2 & I-3
4	BY PURCHASER. (6.15.5.13)	○ INTERMEDIATE PARTITION PURGE
5		INERT BUFFER PURGE GAS: ○ N_2 ○ OTHER
6		○ VENT, DRAIN, PURGE PIPING BY MFG'R ○ NO ○ YES
7	▣ **COUPLING(S)** ○ LOW-SPEED ○ HI-SPEED	☐ **V-BELT DRIVE** DRIVEN SHEAVE DRIVE SHEAVE
8	Between Compressor Between Driver &	(COMPRESSOR SHAFT) (DRIVER SHAFT)
9	& Driver or Gear Gear	RPM (EXPECTED)
10	◇ BY MANUFACTURER	PITCH DIA. (IN.)
11	◇ MODEL	◇ QTY & GROOVE X-SEC.
12	◇ TYPE	POWER TRANSMITT'D
13		Incl. Belt Losses
14	API-671 APPLIES ○ YES ○ NO	DRIVER NAMEPLATE HP RATING
15	○ **INSPECTION AND SHOP TESTS (REF. 8.1.5)**	◇ CENTER DISTANCE (IN.)
16	REQ'D WITN. OBSER.	◇ QTY, TYPE,
17	*SHOP INSPECTION ○ ○ ○	X-SEC., & LENGTH BELTS
18	ACTUAL RUNNING CLEARANCES ○ ○ ○	◇ BELT SERVICE FACTOR (RELATIVE TO
19	AND RECORDS	DRIVER NAMEPLATE HP RATING)
20	MFG STANDARD SHOP TESTS ○ ○ ○	▣ **CYLINDER LUBRICATION**
21	CYLINDER HYDROSTATIC TEST ○ ○ ○	○ NON-LUBE STAGE(S)/SERVICE
22	CYLINDER PNEUMATIC TEST ○ ○ ○	○ LUBRICATED STAGE(S)/SERVICE
23	CYLINDER HELIUM LEAK TEST ○ ○ ○	TYPE OF LUBE OIL: ○ SYNTHETIC
24	CYL. JACKET WATER HYDRO TEST ○ ○ ○	○ HYDROCARBON
25	*MECHANICAL RUN TEST (4 HOUR) ○ ○ ○	LUBRICATOR ☐ COMP. CRANKSHAFT, DIRECT
26	BAR-OVER TO CHECK ROD RUNOUT ○ ○ ○	DRIVE BY: ☐ CHAIN, FROM CRANKSHAFT
27	*LUBE OIL CONSOLE RUN/TEST (4 HOUR) ○ ○ ○	▣ ELECTRIC MOTOR
28	*COOLING H_2O CONSOLE RUN/TEST ○ ○ ○	▣ OTHER
29	RADIOGRAPHY BUTT WELDS ○ ○ ○	◇ LUBRICATOR MFR
30	○ GAS ○ OIL ○ FAB CYLS.	◇ MODEL
31	MAG PARTICLE/LIQUID ○ ○ ○	TYPE LUBRICATOR: ○ SINGLE PLUNGER PER POINT
32	PENETRANT OF WELDS	(6.14.3) ○ DIVIDER BLOCKS
33	SPECIFY ADDITIONAL	◈ COMPARTM'T, TOTAL QTY.
34	REQUIREMENTS (8.2.1.3)	◈ PLUNGERS (PUMPS), TOTAL QTY.
35	○ ○ ○	◈ SPARE PLUNGERS, QTY.
36	SHOP FIT-UP OF PULSATION SUPPL. ○ ○ ○	◈ SPARE COMPARTM'T W/OUT PLUNGERS
37	DEVICES & ALL ASSOCIATED	○ HEATERS: ○ ELECTRIC W/THERM.(S) ○ STEAM
38	GAS PIPING	☐ **ESTIMATED WEIGHTS AND NOMINAL DIMENSIONS**
39	*CLEANLINESS OF EQUIP., PIPING, ○ ○ ○	☐ TOTAL COMPR. WT, LESS DRIVER & GEAR lb
40	& APPURTENANCES	◇ WT, OF COMPLETE UNIT, (LESS CONSOLES) lb
41	*HARDNESS OF PARTS, WELDS & ○ ○ ○	◇ MAXIMUM ERECTION WEIGHT lb
42	HEAT AFFECTED ZONES	◇ MAXIMUM MAINTENANCE WEIGHT lb
43	*NOTIFICATION TO PURCHASER OF ○	◇ DRIVER WEIGHT/GEAR WEIGHT / lb
44	ANY REPAIRS TO MAJOR	◇ LUBE OIL/COOLANT CONSOLE / lb
45	COMPONENTS	◇ FREE STANDING PANEL
46	○ ○ ○	SPACE REQUIREMENTS-FEET: LENGTH WIDTH HEIGHT
47	○ ○ ○	◇ COMPLETE UNIT
48	*SPECIFIC REQUIREMENTS TO BE DEFINED,	◇ LUBE OIL CONSOLE
49	FOR EXAMPLE, DISMANTLING, AUX EQUIPMENT	◇ CYLINDER COOLANT CONSOLE
50	OPERATIONAL & RUN TESTS.	◇ FREE STANDING PANEL
51	ANNEX K COMPLIANCE: ○ VENDOR	☐ PISTON ROD REMOVAL DIST.
52	○ PURCHASER	OTHER EQUIPMENT SHIPPED LOOSE (DEFINE)
53		◇ PULSATION SUPP., WEIGHT lb
54		◇ PIPING lb
55		◇ INTERSTAGE EQUIPMENT lb

Figure A-1—Reciprocating Compressor Data Sheet (U.S. Customary Units) (continued)

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1	☐ **UTILITY CONSUMPTION**					
2						
3	**ELECTRIC MOTORS**					
4						
5		FOR INDUCTION	NAMEPLATE	LOCKED ROTOR	FULL LOAD	MAIN DRIVER NON-STEADY
6		MOTORS SEE NOTE	HP	AMPS	STEADY STATE	STATE AMPS AT COMPRES-
7		OF 7.1.2.6 AND			AMPS	SOR RATED HORSEPOWER
8		MOTOR DATA SHEET				(INDUCTION MOTORS ONLY)
9	◇ MAIN DRIVER					AMPS
10	◇ MAIN LUBE OIL PUMP					@ COMPRESSOR RATED
11	◇ AUX LUBE OIL PUMP					HP OF
12	◇ MAIN CYLINDER COOLANT PUMP					@ CURRENT PULSATIONS
13	◇ AUX CYLINDER COOLANT PUMP					OF %
14	◇ MAIN ROD PKG COOLANT PUMP					
15	◇ AUX ROD PKG COOLANT PUMP					
16	◇ CYLINDER LUBRICATOR					
17						
18						
19						

20	**ELECTRIC HEATERS**			
21		WATTS	VOLTS	HERTZ
22	◇ FRAME OIL HEATER(S)			
23	◇ CYLINDER COOLANT HEATER(S)			
24	◇ CYL. LUBRICATOR HEATER(S)			
25	◇ MAIN DRIVER SPACE HEATER(S)			
26				
27				
28				

29	**STEAM**								
30		FLOW		PRESSURE		TEMPERATURE		BACK PRESSURE	
31	◇ MAIN DRIVER		lb/h @		psig		°FTT TO		psig
32	◇ FRAME OIL HEATER(S)		lb/h @		psig		°FTT TO		psig
33	◇ CYL. LUB. HEATER(S)		lb/h @		psig		°FTT TO		psig
34			lb/h @		psig		°FTT TO		psig
35			lb/h @		psig		°FTT TO		psig
36									

37	**COOLING WATER REQUIREMENTS**						
38		FLOW	INLET TEMP	OUTLET TEMP	INLET PRESS	OUTLET PRESS	MAX PRESS
39		GPM	°F	°F	psig	psig	psig
40	☐ CYLINDER JACKETS						
41	◇ CYLINDER COOLANT CONSOLE						
42	◇ FRAME LUBE OIL COOLER						
43	◇ ROD PRESSURE PACKING*						
44	◇ PACKING COOLANT CONSOLE						
45	◇ INTERCOOLER(S)						
46	◇ AFTERCOOLER						
47							
48	◇ TOTAL QUANTITY, GPM						

49 **REMARKS/SPECIAL REQUIREMENTS:**
50 *ROD PACKING COOLANT MAY BE OTHER THAN WATER
51

Figure A-1—Reciprocating Compressor Data Sheet (U.S. Customary Units) (continued)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
U.S. CUSTOMARY UNITS

JOB NO. ________ ITEM NO. ________
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◎ **FRAME LUBE OIL SYSTEM**

◎ **BASIC LUBE OIL SYSTEM FOR FRAME:** ◎ SPLASH ◎ PRESSURE (FORCED) ○ HEATERS REQUIRED:
☐ REF: TYPE MAIN BEARINGS: ◎ TAP'RD ROLL'R ◎ PRECISION SL'VE ○ ELEC. W/THERMOSTAT(S) ○ STEAM
◎ **PRESSURE SYSTEM:** ○ MAIN OIL PUMP DRIVEN BY: ○ COMP. CRANKSHAFT ○ ELEC. MOTOR ○ OTHER ________
☐ PSV FOR MAIN PUMP EXTERNAL TO CRANKCASE ○ CHECK VALVE ON MAIN PUMP (FIG G-5)
○ AUX OIL PUMP DRIVEN BY: ○ ELEC. MOTOR ○ OTHER ________
☐ HAND OPERATED PRE-LUBE PUMP FOR STARTING ○ OPERATIONAL TEST & 4 HOUR MECH RUN TEST
○ CONTINUOUS OIL FLOW THROUGH SWITCH SENSING LINE (7.7.2.5)
○ **SEP. CONSOLE FOR PRESS. LUBE SYS:** ○ ONE CONSOLE FOR EA. COMP. ○ ONE CONSOLE FOR ______ COMPRESSORS
Note: Instrumentation to be listed on Instrumentation Data Sheets. ○ CONSOLE TO BE OF DECK PLATE TYPE CONSTRUCTION SUITABLE FOR MULTI-POINT SUPPORT AND GROUTING WITH GROUT & VENT HOLES.
○ ELECTRICAL CLASSIFICATION : CLASS ______ , GROUP ______ , DIV ______ ○ NON-HAZARDOUS

☐ **BASIC SYS. REQ'MTS (NORM. OIL FLOWS & VOLUMES)**

☐ LUBE OIL	FLOW gpm	PRESSURE psig	VISCOSITY SSU @ 100°F	 SSU @ 210°F	SUMP VOLUME gal
☐ COMPRESSOR FRAME					
◇ DRIVER					
◇ GEAR					

☐ SYSTEM PRESSURES: ☐ DESIGN ______ psig ☐ HYDROTEST ______ psig
☐ PRESSURE CONTROL VALVE SETTING ______ psig ☐ PUMP REL'F VALVE(S) SET ______ psig

○ **PIPING MATERIALS:**	CARBON STEEL	STAINLESS STEEL WITH SS FLANGES	STAINLESS STEEL WITH CARBON STEEL FLANGES
○ UPSTREAM OF PUMPS & FILTERS	○	○	○
○ DOWNSTREAM OF FILTERS	○	○	○
○ ________	○	○	○
○ ________	○	○	○

☐ **PUMPS** (Gear or Screw Type Only)	◇ RAT'D FL'W gpm	◇ PRESSURE psig	◇ COLD START REQ'D BHP	◇ DRIVER HP	◇ SPEED r/min	COUPLING REQ'D	MECH. SEAL REQ'D
MAIN						○	○
AUXILIARY						○	○

☐ PUMP CASING MATERIAL (Ref. 6.14.2.1.5): MAIN PUMP ________ AUX PUMP ________
○ GUARD(S) REQ. FOR COUPLING(S): ○ MAIN PUMP ○ AUX PUMP ○ GUARD TYPE OR CODE ________
○ AUXILIARY PUMP CONTROL: ○ MANUAL ○ AUTOMATIC ○ ON-OFF-AUTO SEL. SWITCH: ○ BY PURCH. ○ BY MFR.
○ WIRING TO TERMINAL BOX: ○ BY PURCH. ○ BY MFR.
○ SWITCHES ○ RTD'S/THERMOCOUPLES

○ **COOLERS:** ○ SHELL & TUBE ○ SINGLE ○ DUAL W/TRANSFER VALVE ○ MFG'S STD. ○ TEMA C ○ TEMA R (API 660)
○ REMOVABLE BUNDLE ○ WATER COOLED ○ AIR COOLED W/AUTO TEMP CONTROL (API-661) Data Shts - Attached
○ W/BYPASS & TEMP CONTROL VALVE: ○ MANUAL ○ AUTO
○ SEE SEPARATE HEAT EXCHANGER DATA SHEETS FOR DETAILS, SPECIFY % GLYCOL ON COOLING WATER SIDE

◎ **FILTER(S)** ○ SINGLE ○ DUAL W/TRANSFER VALVE ○ ASME CODE DESIGN ○ ASME CODE STAMPED
☐ DESIGN PRESSURE, ______ psig ☐ ΔP P CLEAN, ______ psi ☐ ΔP COLLAPSE, ______ psi
☐ MICRON RATING, ________ ☐ CARTRIDGE MATERIAL, ________ ◇ CARTRIDGE P/N ________
☐ BONNET MATERIAL, ________ ☐ CASING MATERIAL, ________ ○ FURN.SPARE CARTR.,QTY ______

☐ **SYS. COMPONENT SUPP.**	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)			◇ ________		

Figure A-1—Reciprocating Compressor Data Sheet (U.S. Customary Units) (continued)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
U.S. CUSTOMARY UNITS

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1 ▣ COOLANT SYSTEM

2 ○ **BASIC COOLING SYS. FOR:** ○ COMPRESSOR CYL.(S) ○ ROD PACKING(S) ○ PROCESS COOLER(S) ○ OIL COOLER(S)

3 ○ HEATERS REQ.'D FOR PRE-HEATING: ○ ELEC.,W/ THERMOSTAT(S) ○ STEAM

4 ○ **PRESSURE FORCED CIRCULATING SYS:** ○ OPEN, PIPING BY: ○ PURCH. ○ MFR ○ CLOSED, PIPING BY MFR.

5 MAIN COOLANT PUMP DRIVEN BY: ○ ELEC. MOTOR ○ STEAM TURBINE ○ OTHER ____

6 AUX COOLANT PUMP DRIVEN BY: ○ ELEC. MOTOR ○ STEAM TURBINE ○ OTHER ____

7 ○ **SEP. CONSOLE FOR COOLANT SYSTEM.:** ○ ONE CONSOLE FOR EA. COMP. ○ ONE CONSOLE FOR ____ COMP'RS

8 NOTE: Instrumentation to be listed on ○ CONSOLE TO BE OF DECK PLATE TYPE CONSTRUCTION SUITABLE FOR

9 instrumentation data sheets. MULTI-POINT SUPPORT AND GROUTING WITH GROUT & VENT HOLES.

10 ○ ELECTRICAL CLASSIFICATION : CLASS ____ , GROUP ____ , DIV ____ ○ NON-HAZARDOUS

11 ▣ **BASIC SYS. REQ'MTS (NORM. COOLANT FLOW DATA)** ○ COOLANT TO BE ____ % ETHYLENE GLYCOL

		FORCED COOL'G	THERMO SYPHON	STAND PIPE	FLOW gpm	PRESSURE psig	INLET TEMP °F	OUTLET TEMP °F	SITE FLOW IND'TR
14	CYLINDER(S), ____ STAGE	○	○	○	____	____	____	____	○
15	CYLINDER(S), ____ STAGE	○	○	○	____	____	____	____	○
16	CYLINDER(S), ____ STAGE	○	○	○	____	____	____	____	○
17	CYLINDER(S), ____ STAGE	○	○	○	____	____	____	____	○
18	CYLINDER(S), ____ STAGE	○	○	○	____	____	____	____	○
19	CYLINDER(S), ____ STAGE	○	○	○	____	____	____	____	○
20	PISTON ROD PACK'G TOTAL	○			____	____	____	____	○
21	INTERCOOLER(S) TOTAL	○			____	____	____	____	○
22	AFTERCOOLER	○			____	____	____	____	○
23	OIL COOLER(S)	○			____	____	____	____	○
24	____	○			____	____	____	____	○
25	TOTAL FLOW				____				

26 ☐ **SYS. PRESSURES:** ☐ DESIGN, ____ psig ☐ HYDROTEST, ____ psig ▣ RELIEF VALVE(S), SETTING ____ psig

27 ▣ **COOLANT RESERVOIR:** ◇ SIZE, ____ FT IN DIA X ____ FT IN HT. ◇ CAPACITY ____ GALLONS

28 @ NORMAL OPERATING LEVEL

29 ◇ RESERVOIR MATERIAL ◇ INTERNAL COATING, TYPE ____

30 ○ LEVEL GAUGE ○ LEVEL SWITCH ○ DRAIN VALVE ○ INSPECTION & CLEAN-OUT OPENINGS

	☐ **PUMPS: (CENTRIFUGAL ONLY)**	◇ RAT'D FL'W gpm	◇ PRESS. psig	◇ REQ'D BHP	◇ DRIVER HP	◇ SPEED r/min	COUPLING REQ'D	MECH.SEAL REQ'D
33	MAIN	____	____	____	____	____	○	○
34	AUXILIARY	____	____	____	____	____	○	○

35 ☐ PUMP CASING MATERIAL (Ref 6.14.2.1.5): MAIN PUMP ____ AUX PUMP ____

36 ○ GUARD(S) REQ.'D FOR COUP'G(S) ○ MAIN PUMP ○ AUX PUMP ○ GUARD TYPE OR CODE ____

37 ○ AUX.PUMP CONTROL: ○ MANUAL ○ AUTO ○ ON-OFF-AUTO SEL. SWITCH: ○ BY PURCH. ○ BY MANUFACTURER

38 ○ WIRING TO TERMINAL BOX: ○ BY PURCH. ○ BY MANUFACTURER

39 ○ **COOLANT HEAT EXCHANGER:** ○ SHELL & TUBE ○ SINGLE ○ DUAL W/TRANSFER VALVE ○ TEMA C ○ TEMA R (API 660)

40 (DATA SHEETS ATTACHED)

41 ○ AIR COOLED EXCHANGER W/AUTO TEMP CONTROL (API 661 DATA SHEETS ATTACHED)

42 ○ W/BYPASS & TEM. CONTROL VALVE ○ MANUAL ○ AUTO ○ LOUVERS FOR AIR EXCH.

43 ○ SEE SEPARATE COOLER DATA SHEET FOR DETAILS; SPECIFY % GLYCOL ON BOTH SIDES

44 OF SHELL & TUBE

45	**SYS. COMPONENT SUPP.**	MANUFACTURER	MODEL		MANUFACTURER	MODEL
46	◇ MAIN PUMP	____	____	◇ TEMP CONTROL VALVE(S)	____	____
47	◇ AUXILIARY PUMP	____	____	◇ TRANSFER VALVE(S)	____	____
48	◇ MECHANICAL SEALS	____	____	◇ PUMP COUPLING(S)	____	____
49	◇ ELECTRIC MOTORS	____	____	◇ ____	____	____
50	◇ STEAM TURBINES	____	____	◇ ____	____	____
51	◇ ____	____	____	◇ ____	____	____
52	◇ ____	____	____	◇ ____	____	____

Figure A-1—Reciprocating Compressor Data Sheet (U.S. Customary Units) (continued)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
U.S. CUSTOMARY UNITS

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1	**PULSATION SUPPRESSION DEVICES FOR RECIPROCATING COMPRESSORS**		
2	THESE SHEETS TO BE FILLED OUT FOR EACH SERVICE AND/OR STAGE OF COMPRESSION		
3	APPLICABLE TO: ○ PROPOSALS ○ PURCHASE ○ AS BUILT		
4	FOR/USER		
5	SITE/LOCATION	AMBIENT TEMPERATURE MIN/MAX ____ / ____ °F	
6	COMPRESSOR SERVICE	NUMBER OF COMPRESSORS	
7	COMPRESSOR MFG.	MODEL/TYPE	
8	SUPPRESSOR MFG.		
9	NOTE: ○ Ind.Data Comp.'d Purch. ☐ By Compr/Supp.Mfg.w/Proposal ◇ By Mfg(s) after order ◙ By Mfg(s)/Purchaser as Applicable		
10	**GENERAL INFORMATION APPLICABLE TO ALL SUPPRESSORS**		
11	TOTAL NUMBER OF SERVICES AND/OR STAGES		
12	TOTAL NUMBER OF COMPRESSOR CYL. ____ TOTAL NUMBER OF CRANKTHROWS ____	STROKE ____ in. r/min ____	
13	○ ASME CODE STAMP ○ GOVERNMENTAL CODES OF ____	CODE REGULATIONS APPLY	
14	○ OTHER APPLICABLE PRESSURE VESSEL SPEC. OR CODE		
15	○ LUBE SERVICE ○ NON-LUBE SERV. ○ NO OIL ALLOWED INTERNALLY	DRY TYPE INTER.CORR.COATING ○ YES ○ NO	
16	RADIOGRAPHY (X-RAY OF WELDS): ○ NONE ○ SPOT ○ 100% ○ IMPACT TEST	○ SPECIAL WELDING REQUIREMENTS	
17	○ SHOP INSPECTION ○ WITNESS HYDROTEST ○ OUTDOOR STORAGE OVER 6 MONTHS	○ SPECIAL PAINT SPEC	
18	○ WITNESSED ○ OBSERVED		
19			
20	**CYLINDER, GAS, OPERATING, AND SUPPRESSOR DESIGN DATA**		
21		SERVICE ____	STAGE NO. ____
22	☐ COMPRESSOR MANUFACTURER'S RATED CAPACITY	LBS/HR ____ SCFM	____ MMSCFD ____
23	◙ LINE SIDE OPERATING PRESSURE	INLET, ____ psia	DISCHARGE, ____ psia
24	◙ OPERATING TEMP. WITHIN SUPPRESSORS	INLET, ____ °F	DISCHARGE, ____ °F
25	○ ALLOWABLE PRESSURE DROP THROUGH SUPPRESSORS	Δ P ____ psi / ____ %	ΔP ____ psi / ____ %
26		INLET SUPPRESSOR	DISCHARGE SUPPRESSOR
27	○ SUPRESSOR TAG NUMBER		
28	○ COMBINATION INLET SUPP SEPARATOR/INTERNALS	○ YES ○ NO / ○ YES ○ NO	/ ○ YES ○ NO
29	◙ NO. (QTY) OF INLET & DISCH. SUPP. PER STAGE		
30	○ ALLOWABLE PEAK-PEAK PULSE @ LINE SIDE NOZZLE	psi / %	psi / %
31	○ ALLOWABLE PEAK-PEAK PULSE @ CYL FLANGE NOZZLE	psi / %	psi / %
32			
33	○ DESIGN FOR FULL VACUUM CAPABILITY	○ YES ○ NO	○ YES ○ NO
34	○ MIN. REQ'D WORKING PRESSURE & TEMPERATURE		
35	NOTE: After design, the actual MAWP & temp are to be determined		
36	based on the weakest component and stamped on the	psig, ____ @ ____ °F	psig, ____ @ ____ °F
37	vessel. The actual MAWP is to be shown on pg.14 line 12		
38	and on the U1A Forms.		
39	○ INITIAL SIZING VOL. PER FORMULA OF 7.9.3.2		
40	NOTE: This is a Reference	____ FT³	____ FT³
41			
42	◇ AS BUILT VOLUME (FT³)	____ FT³	____ FT³
43			
44			
45			
46			
47			
48			
49			
50			
51			
52			

Figure A-1—Reciprocating Compressor Data Sheet (U.S. Customary Units) (continued)

	RECIPROCATING COMPRESSOR **API 618 5TH EDITION DATA SHEET** **U.S. CUSTOMARY UNITS**	JOB NO. ______ ITEM NO. ______ REVISION NO. ______ DATE ______ PAGE 14 OF 17 BY ______		Revision
1	**PULSATION SUPPRESSION DEVICES FOR RECIPROCATING COMPRESSORS (CONT'D)**		SERVICE ______	
2	THESE SHEETS TO BE FILLED OUT FOR EACH SERVICE AND/OR STAGE OF COMPRESSION		STAGE NO. ______	
3	**CONSTRUCTION REQUIREMENTS & DATA**	**INLET SUPPRESSOR**	**DISCHARGE SUPPRESSOR**	
4	○ SUPRESSOR TAG NUMBER			
5	○ BASIC MATERIAL REQUIRED, CS, SS, ETC.			
6	◇ ACTUAL MATERIAL DESIGNATION SHELL/HEAD	/	/	
7	○ SPECIAL HARDNESS LIMITATIONS, Rc ○ YES ○ NO	SHELL & HEADS WELDS	SHELL & HEADS WELDS	
8	◙ CORROSION ALLOWANCE., in. ○ REQUIRED	in.	in.	
9	◇ WALL THICKNESS, in. SHELL/HEAD	in./ in.	in./ in.	
10	☐ NOM. SHELL DIA X OVERALL LGTH. (in./vol. ft³)	x in./ ft³	x in./ ft³	
11	☐ PIPE OR ROLLED PLATE CONSTRUCTION	☐ PIPE ☐ ROLLED PLATE	☐ PIPE ☐ ROLLED PLATE	
12	◇ ACT. MAX ALLOW. WORKING PRESS. AND TEMPERATURE	PSI @ °F	PSI @ °F	
13	○ MINIMUM DESIGN METAL TEMP (6.15.8.1)	°F	°F	
14	○ INLET SUPRESS. TO BE SAME MAWP AS DISCH'RGE SUPPRESS.	○ YES ○ NO		
15	◇ MAX EXPECTED PRESSURE DROP(Δ P, PSI / %) LINE PRESS	Δ P psi/ %	Δ P psi/ %	
16	◇ WEIGHT (lb EACH)	lb	lb	
17	○ INSUL NUTS & ALLOW. FOR INSULATION REQUIRED (**X**)			
18	◇ EXPECTED P-P PULSE @ LINE SIDE/CYL FLG, % LINE PRESS	%/ %	%/ %	
19	BASED ON FINAL SUPPRESSOR DESIGN			
20	◙ SUPPORTS, TYPE/QUANTITY			
21	**CONNECTION REQUIREMENTS & DATA**			
22	○ LINE SIDE FLANGE. SIZE/RATING/FACING/TYPE			
23	○ COMP CYL FLANGE(S), QTY/SIZE/RATING/FACING/TYPE			
24	○ FLANGE FINISH, ○ PER 7.9.5.1.16 ○ SPECIAL (SPECIFY)			
25	>125 <250 ○ PER ANSI 16.5			
26	○ INSPECTION OPENINGS REQUIRED	○ YES ○ NO ○ BLINDED	○ YES ○ NO ○ BLINDED	
27	○ SPEC. QTY. SIZE, 6000 LB NPT CPLG./FLG TYPE & RATING			
28	◇ * QTY. SIZE, 6000 LB NPT CPLG./FLG TYPE & RATING			
29	○ VENT CONNECTIONS REQUIRED	○ YES ○ NO	○ YES ○ NO	
30	○ SPEC. QTY. SIZE, 6000 LB NPT CPLG./FLG TYPE & RATING			
31	◇ * QTY. SIZE, 6000 LB NPT CPLG./FLG TYPE & RATING			
32	○ DRAIN CONNECTIONS REQUIRED	○ YES ○ NO	○ YES ○ NO	
33	○ SPEC. QTY. SIZE, 6000 LB NPT CPLG./FLG TYPE & RATING			
34	◇ * QTY. SIZE, 6000 LB NPT CPLG./FLG TYPE & RATING			
35	○ PRESSURE CONNECTIONS REQUIRED	○ YES ○ NO	○ YES ○ NO	
36	○ SPEC. QTY. SIZE, 6000 LB NPT CPLG./FLG TYPE & RATING			
37	◇ * QTY. SIZE, 6000 LB NPT CPLG./FLG TYPE & RATING			
38	○ TEMPERATURE CONNECTIONS REQUIRED	○ YES ○ NO	○ YES ○ NO	
39	○ SPEC. QTY. SIZE, 6000 LB NPT CPLG./FLG TYPE & RATING			
40	○ CYL NOZZLE ○ MAIN BODY			
41	◇ * QTY. SIZE, 6000 LB NPT CPLG./FLG TYPE & RATING			
42				
43				
44				
45				
46	**OTHER DATA AND NOTES**			
47	◇ COMPRESSOR MFG'S SUPP. OUTLINE OR DRAWING NO.			
48	◇ SUPP. MFG'S OUTLINE OR DRAWING NO.			
49	NOTES * = AS BUILT			
50				
51				

Figure A-1—Reciprocating Compressor Data Sheet (U.S. Customary Units) (continued)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
U.S. CUSTOMARY UNITS

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1 ⧇ **INSTRUMENTATION**

2 PURCHASER TO FILL IN (☐ ○ ⬡) AFTER COMMODITY TO INDICATE: ☐ BY COMP. MFR. ○ BY PURCH. ⬡ BY OTHERS

3 INSTRUMENT & CONTROL ○ ONE FOR EA. UNIT ○ ONE COMMON TO ALL UNITS

4 PANEL (☐ ○ ⬡): ○ MACHINE MT'ED ○ FREE STANDING (OFF UNIT) ○ LOCAL ○ REMOTE ○ OUTDOORS

5 ○ PNEUMATIC ○ ELEC. ○ ELECTRONIC ○ HYDRAULIC ○ PROGRAMMABLE CONTL'R

6 ○ NEMA 7, CLASS ______ , GROUP ______ , DIVISION ______ ○ INTRINSICALLY SAFE

7 ○ I/S BARRIERS (☐ ○ ⬡)

8 ○ NEMA 4, WATERTIGHT & DUSTTIGHT ○ PURGED TO NFPA 496 TYPE ○ X ○ Y ○ Z

9 ○ OTHER NEMA ______ LOW PURGE PRESS. ○ ALARM ○ SHUTDOWN

10 ○ VIB, ISOLATORS ○ STRIP HEATERS ○ PURGE CONN. ○ EXTRA CUTOUTS

11 ○ ANNUNCIATOR W/FIRST-OUT INDICATION LOCATED ON CONTROL PANEL

12 ○ PURCHASER'S CONN. BROUGHT OUT TO TERMINAL BOX BY VENDOR

13 BUFFER GAS CONTROL ○ ONE FOR EA. UNIT ○ ONE COMMON TO ALL UNITS

14 PANEL (☐ ○ ⬡): ○ MACHINE MT'ED ○ FREE STANDING (OFF UNIT) ○ WITH STAND ○ OUTDOORS

15 ○ CLASS ______ , GROUP ______ , DIVISION ______

16 ○ CONSTANT PRESSURE DISPOSAL SYSTEM ○ VARIABLE PRESSURE DISPOSAL SYSTEM

17 **ADDITIONAL PANEL REMARKS:**

18 ______

19

20 ○ INSTRUMENTATION SUITABLE FOR: ○ INDOORS ○ OUTDOORS ○ OTHER ______

21 ○ PREFERRED INSTRUMENT SUPPLIERS, (TO BE COMPLETED BY PURCHASER), OTHERWISE MFR'S STANDARD APPLIES

22	PRESSURE GAUGES	MFR		SIZE & TYPE		MTL	
23	TEMPERATURE GAUGES	MFR		SIZE & TYPE		MTL	
24	LIQUID LEVEL GAUGES	MFR		TYPE		MTL	
25	DIFF. PRESSURE GAUGES	MFR		SIZE & TYPE		MTL	
26	PRESS. TRANSMITTERS	MFR		TYPE		MTL	
27	LIQUID LEV. TRANSMITTER	MFR		TYPE		MTL	
28	PRESSURE SWITCHES	MFR		TYPE		MTL	
29	TEMPERATURE SWITCHES	MFR		TYPE		MTL	
30	LIQUID LEVEL SWITCHES	MFR		TYPE		MTL	
31	DIFF. PRESSURE SWITCHES	MFR		TYPE		MTL	
32	CONTROL VALVES	MFR		TYPE		MTL	
33	PRESSURE SAFETY VALVES	MFR		TYPE		MTL	
34	SIGHT FLOW INDICATORS	MFR		TYPE		MTL	
35	VIBRATION MONITORS & EQUIP.	MFR		TYPE		MTL	
36	THERMOCOUPLES	MFR		TYPE		MTL	
37	RTD'S	MFR		TYPE		MTL	
38	SOLENOID VALVES	MFR		TYPE		MTL	
39	ANNUNCIATOR	MFR		MODEL & (QTY SPARE POINTS)		( )	
40	PROGRAMMABLE CONTROLLER	MFR		TYPE		MTL	
41		MFR		TYPE		MTL	

42 ○ PRESSURE GAUGE REQUIREMENTS ○ LIQUID-FILLED PRESSURE GAUGES: ○ YES ○ NO

43		LOCALLY	PANEL		LOCALLY	PANEL
44	FUNCTION	MOUNTED	MOUNTED		MOUNTED	MOUNTED
45	LUBE OIL MAIN PUMP DISCHAR.	(☐ ○ ⬡)	(☐ ○ ⬡)	PROCESS GAS: INLET PRESS.	(☐ ○ ⬡)	(☐ ○ ⬡)
46	LUBE OIL AUX. PUMP DISCHARG.	(☐ ○ ⬡)	(☐ ○ ⬡)	@ EA. STAGE	(☐ ○ ⬡)	(☐ ○ ⬡)
47	LUBE OIL PRESS. AT FRAME HEADER	(☐ ○ ⬡)	(☐ ○ ⬡)	DISCH. PRESS.	(☐ ○ ⬡)	(☐ ○ ⬡)
48	LUBE OIL FILTER ΔP	(☐ ○ ⬡)	(☐ ○ ⬡)	@ EA. STAGE	(☐ ○ ⬡)	(☐ ○ ⬡)
49	COOLING H_2O INLET HEADER	(☐ ○ ⬡)	(☐ ○ ⬡)		(☐ ○ ⬡)	(☐ ○ ⬡)
50		(☐ ○ ⬡)	(☐ ○ ⬡)		(☐ ○ ⬡)	(☐ ○ ⬡)

51 **REMARKS:** ______

52 ______

Figure A-1—Reciprocating Compressor Data Sheet (U.S. Customary Units) (continued)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
U.S. CUSTOMARY UNITS

JOB NO. ____________ ITEM NO. ____________
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1	**INSTRUCTIONS (CONT'D)**						
2	**TEMPERATURE MEASUREMENT REQUIREMENTS**	LOCALLY	PANEL	GAUGE W/	THERMO	RTD	I/S
3	**FUNCTION**	MOUNTED	MOUNTED	CAPILLARY	CPL SYS	SYS	SYS
4	LUBE OIL ○ INLET TO ○ OUT OF FRAME	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
5	LUBE OIL ○ INLET TO ○ OUT OF COOLER	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
6	MAIN JRNL BEARINGS (THERMOCOUPLES OR RTD'S ONLY)	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
7	MOTOR BEARING(S) (THERMOCOUPLES OR RTD'S ONLY)	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
8	CYL. COOLANT MANIFOLD: ○ INLET ○ OUTLET	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
9	CYL. JKT. COOLANT: ○ INLET ○ OUTLET ○ EA. CYL	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
10	PROCESS GAS: ○ INLET ○ DISCH. ○ EACH CYL	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
11	INTERCOOLER(S) ○ INLET ○ GAS ○ COOLANT	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
12	○ OUTLET ○ GAS ○ COOLANT	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
13	AFTERCOOLER: ○ INLET ○ GAS ○ COOLANT	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
14	○ OUTLET ○ GAS ○ COOLANT	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
15	PKG COOLANT ○ INLET ○ OUTLET	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
16	PRESS. PGK CASE, CYL PIST ROD (THRM'CPLS OR RTD'S ONLY)	(☐ ○ ⬡)	(☐ ○ ⬡)		○	○	○
17	COMPRESSOR VALVES ○ SUCT. ○ DISCH. TC'S OR RTD'S ONLY	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
18	____________	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
19	____________	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○

20 **ALARM & SHUTDOWN SYSTEM REQ'MTS** NOTE: ALARM & SHUTDOWN DEVICES SHALL BE INDIVIDUALLY SEPARATE

21 ANNUNCIATION POINTS

22 ALARM DEVICES: ○ TRANSMITTER ○ SWITCH

23 SHUTDOWN DEVICES ○ TRANSMITTER ○ SWITCH

				ALARM		SHUTDOWN		
23–26	**FUNCTION**	ALARM	SHUT DOWN	IN PNL BY MFR	IN CTL ROOM PANEL OTH'RS	IN PNL BY MFR	IN CTL ROOM PANEL OTH'RS	TOTAL NO. OF POINTS
27	LOW LUBE OIL PRESS. @ BEARING HEADER	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
28	HIGH LUBE OIL ΔP ΔP ACROSS FILTER	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
29	LOW LUBE OIL LEVEL, FRAME	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
30	AUX LUBE OIL PUMP, FAIL TO START	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
31	CYL LUBE SYSTEM PROTECTION	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
32	COMPR. VIBRATION, SHUTDOWN ONLY		(☐ ○ ⬡)	○	○	○	○	______
33	VIBRATION, W/ CONTINUOUS MONITORING	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
34	ROD DROP DETECTOR, CONTACT TYPE(1/CYL)	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
35	ROD DROP PROXIMITY PROBE (1/CYL)	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
36	OIL TEMP OUT OF FRAME	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
37	HIGH GAS DISCH. TEMP EACH CYLINDER	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
38	HIGH JACKET COOLANT TEMP., EA. CYL	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
39	LOW SUCTION PRESS., FIRST STG INLET	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
40	HI DISCH. PRESS. ○ FINAL ○ EA STG	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
41	HI CYL. GAS ΔP, EACH STAGE	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
42	HI LIQ. LEV., EA. MOISTURE SEPARATOR	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
43	LOW PURGE GAS PRESS, DISTANCE PIECE(S)	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
44	HI X-HD PIN TEMP	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
45	PRESS PKG CASE (PISTON ROD TEMP)	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
46	____________	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______

47 TOTAL NUMBER OF ANNUNCIATION POINTS

48 SWITCH CONTACT OPERATION NOTE: EACH SWITCH SHALL BE MINIMUM SPDT ARRANGEMENT

49 ALARM CONTACTS SHALL: ○ OPEN (DE-ENER.) TO SOUND ALARM & BE ENERGIZED WHEN COMPR. IS IN OPERATION

50 ○ CLOSE (ENERGIZE) TO SOUND ALARM & BE DE-ENERGIZED WHEN COMPR. IS IN OPERATION

51 SHUTDOWN CONTACTS SHALL: ○ OPEN (DE-ENERGIZED) TO SHUTDOWN & BE ENERGIZE WHEN COMPR. IS IN OPERATION

52 ○ CLOSE (ENERGIZE) TO SHUTDOWN & BE DE-ENERGIZE WHEN COMPR. IS IN OPERATION

53 REF: 7.6.6.2 FOR MINIMUM RECOMMENDED PROTECTION REQUIREMENTS

Figure A-1—Reciprocating Compressor Data Sheet (U.S. Customary Units) (continued)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
U.S. CUSTOMARY UNITS

JOB NO. ______ ITEM NO. ______
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1 **INSTRUMENTATION (CONT'D)**

2 ○ MISCELLANEOUS INSTRUMENTATION
3 SIGHT FLOW IND. (COOLANT ONLY) (☐ ○ ⬡) FOR: ○ INTERCOOLER(S) ○ AFTER CLR ○ OIL COOLER
4 ○ CYL JACKET COOLANT ○ ROD PRESS. PKG COOLANT
5 PNEUMATIC PRESSURE TRANSMITTERS (☐ ○ ⬡) FOR: ______
6 PRESSURE TRANSMITTERS (ELEC. OUTP.) (☐ ○ ⬡) FOR: ______
7 PNEUMATIC LEVEL TRANSMITTERS (☐ ○ ⬡) ______
8 ALARM HORN & ACKN'LMT TEST BUTTON (☐ ○ ⬡) ______
9 CONDUIT & WIRING W/JUNCT. BOXES (CON-SOLES) (☐ ○ ⬡) ______
10 TEST VALVES (☐ ○ ⬡) FOR: ______
11 DRAIN VALVES (☐ ○ ⬡) FOR: ______
12 GAUGE GLASS(ES) (☐ ○ ⬡) FOR: ______
13 TACHOMETER (☐ ○ ⬡) ______ SPEED RANGE ______ TO ______ r/min
14 CRANKSHAFT KEY PHASER (☐ ○ ⬡) FOR: ______
15 AND TRANSDUCER ______
16 ______ (☐ ○ ⬡) ______

17 ○ SEPARATE LUBE OIL CONSOLE INSTRUMENTATION: PURCH. TO LIST REQ'MTS IN ADDITION TO ANY ABOVE REQ'MTS
18 ______ (☐ ○ ⬡) ______
19 ______ (☐ ○ ⬡) ______
20 ______ (☐ ○ ⬡) ______
21 ______ (☐ ○ ⬡) ______
22 ______ (☐ ○ ⬡) ______
23 ______ (☐ ○ ⬡) ______

24 ○ SEPARATE COOLING WATER CONSOLE INSTRUMENT: PURCH. TO LIST REQ'MTS IN ADDITION TO ANY ABOVE REQ'MTS
25 ______ (☐ ○ ⬡) ______
26 ______ (☐ ○ ⬡) ______
27 ______ (☐ ○ ⬡) ______
28 ______ (☐ ○ ⬡) ______
29 ______ (☐ ○ ⬡) ______
30 ______ (☐ ○ ⬡) ______

31 RELIEF VALVES

	LOCATION	BY	MANUFACTURER	TYPE	◇ SIZE	◇ SETTING
32						
33		(☐ ○ ⬡)				
34		(☐ ○ ⬡)				
35		(☐ ○ ⬡)				
36		(☐ ○ ⬡)				
37		(☐ ○ ⬡)				
38		(☐ ○ ⬡)				
39		(☐ ○ ⬡)				
40		(☐ ○ ⬡)				
41		(☐ ○ ⬡)				
42		(☐ ○ ⬡)				

43 **NOTES:** SEE MOTOR DATA SHEET FOR ADDITIONAL MOTOR INSTRUMENTATION REQUIREMENTS
44 FOR TURBINE DRIVERS USE APPLICABLE API DATA SHEETS
45 FOR GEAR REDUCERS USE APPLICABLE API DATA SHEETS
46 ELECTRICAL & INSTRUMENTATION CONNECTIONS SHALL BE MADE DIRECTLY BY THE PURCHASER TO INDIVIDUAL
47 INSTRUMENTS ON THE COMPRESSOR

48 **ADDITIONAL INSTRUMENTATION REMARKS/SPECIAL REQUIREMENTS:** ______
49 ______
50 ______
51 ______

Figure A-1—Reciprocating Compressor Data Sheet (U.S. Customary Units) (continued)

JOB NO. ____ ITEM NO. ____
PURCHASE ORDER NO. ____
SPECIFICATION NO. ____
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RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
SI UNITS

1 APPLICABLE TO: ○ PROPOSALS ○ PURCHASE ○ AS BUILT
2 FOR/USER ____ SITE/LOCATION ____ SERVICE ____ NO. REQ'D ____
3 NOTE: ○ INDICATES INFO. TO BE ☐ BY MANUFACTURER ◇ BY MANUFACTURER ◎ BY MANUFACTURER OR
4 COMPLETED BY PURCH. WITH PROPOSAL AFTER ORDER PURCHASER AS APPLICABLE
5 COMPR. MFGR ____ TYPE MODEL NO(S) ____ SERIAL NO(S) ____
6 COMPR.THROWS: TOTAL NO. ____ NO. WITH CYLS. ____ NOMINAL FRAME RATING ____ BkW @ RATED R/MIN OF ____
7 ☐ MAX/MIN ALLOWABLE SPEED ____ / ____ r/min
8 DRIVER MFGR. ____ DRIVER NAMEPLATE HP/OPERATING r/min ____ / ____
9 DRIVE SYSTEM: ○ DIRECT COUPLED ○ GEARED & COUPLED ○ V-BELT
10 TYPE OF DRIVER: ○ IND. MOTOR ○ SYN. MOTOR ○ STEAM TURBINE ○ GAS TURBINE ○ ENGINE ○ OTHER ____
11 CYLINDERS CONSTRUCTION: ○ LUBE ○ NON-LUBE
12
13 ○ MAX ACCEPTABLE AVG PISTON SPEED ____ m/s

14 **OPERATING CONDITIONS (EACH MACHINE)**

15 ○ SERVICE OR ITEM NO.						
16 ○ STAGE						
17 ○ NORM. OR ALT. CONDITION						
18 ○ CERTIFIED PT. (X) MARK ONE						
19 ○ MOLECULAR WEIGHT						
20 ○ C_P/C_V (K) @ 65°C OR ____ °C						

21 **INLET CONDITIONS:** AT INLET TO: ○ PULSE DEVICES ○ COMPRESSOR CYLINDER FLANGES
22 NOTE: ○ SIDE STREAM TO ____ STAGE(S), THESE INLET PRESS. ARE FIXED

23 ○ PRESSURE (bar) @ PUL. SUPP. INLET						
24 ◎ PRESSURE (bar) @ CYL. FLANGE						
25 ○ TEMPERATURE (°C)						
26 ○ REC: SIDE STREAM TEMPS (°C)						
27 ☐ COMPRESSIBILITY (Z_s)						

28 **INTERSTAGE:** INTERSTAGE Δ P INCL: ○ PULSE DEVICES ○ PIPING ○ COOLERS ○ SEPARATORS ○ OTHER ____
29 ◎ ΔP BETWEEN STAGES, %/bar | / | / | / | / | / | / |
30 **DISCHARGE CONDITIONS:** AT OUTLET FROM: ○ PULSE DEVICE ○ COMP. CYL. FLANGES ○ OTHER ____

31 ◎ PRESSURE (bar) @ CYL. FLANGE						
32 ○ PRESS. (bar) @ PUL. SUPP. OUTLET						
33 ☐ TEMP., ADIABATIC, °C						
34 ☐ TEMP., PREDICTED, °C						
35 ☐ COMPRESSIBILITY (Z_2) OR (Z_{AVG})						

36 *** CAPACITY AT INLET TO COMPRESSOR, NO NEGATIVE TOLERANCE (-0%)**

37 ○ kg/h CAPACITY SPECIFIED						
38 IS ○ WET ○ DRY						
39 ○ m^3/h (1 bar & 60°C)						

40 *** MFGR.'S RATED CAPACITY (AT INLET TO COMPRESSSOR & kW @ CERTIFIED TOLERANCE OF ±3% FOR CAP. & ±3% FOR kW)**

41 ☐ kg/h CAPACITY SPECIFIED						
42 IS ○ WET ○ DRY						
43 ☐ INLET VOLUME FLOW (m^3/h)						
44 ☐ MMSCCD/SCCM (14.7 PSIA & 60°C)						
45 ☐ BkW/STAGE						
46 ☐ TOTAL BkW @ COMPRESSOR SHAFT						
47 ☐ TOTAL kW INCLUDING						
48 V-BELT & GEAR LOSSES						

49 *** CAPACITY FOR NNT** **REMARKS:** ____
50 MANUFACTURER'S = REQUIRED ÷ 0.97 ____
51 THEREFORE REQUIRED = MFR'S x 0.97 ____

Figure A-2—Reciprocating Compressor Data Sheet (SI Units)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
SI UNITS

JOB NO. ____ ITEM NO. ____
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1	**GAS ANALYSIS AT OPERATING CONDITIONS**							
2	**MOLE % (BY VOLUME) ONLY**							
3	○ SERVICE/ITEM NO.							
4	○ STAGE							
5	○ NORMAL OR ALT							
6			M.W.					
7	AIR		28.966					
8	OXYGEN	O_2	32.000					
9	NITROGEN	N_2	28.016					
10	WATER VAPOR	H_2O	18.016					
11	CARBON MONOX.	CO	28.010					
12	CARBON DIOX.	CO_2	44.010					
13	HYDRO. SULFIDE	H_2S	34.076					
14	HYDROGEN	H_2	2.016					
15	METHANE	CH_4	16.042					
16	ETHYLENE	C_2H_4	28.052					
17	ETHANE	C_2H_6	30.068					
18	PROPYLENE	C_3H_6	42.078					
19	PROPANE	C_3H_8	44.094					
20	I-BUTANE	C_4H_{10}	58.120					
21	n-BUTANE	C_4H_{10}	58.120					
22	I-PENTANE	C_5H_{12}	72.146					
23	n-PENTANE	C_5H_{12}	72.146					
24	HEXANE PLUS							
25	AMMONIA	NH_3	17.031					
26	HYDRO. CHLOR.	HCl	36.461					
27	CHLORINE	Cl_2	70.914					
28	CHLORIDES - TRACES							
29								
30								
31								
32	☐ CALCULATED MOL WT.							
33	☐ C_p/C_v (K) @ 65° OR ______ °C							

34 NOTE: IF WATER VAPOR AND/OR CHLORIDES ARE PRESENT, EVEN MINUTE
35 TRACES, IN THE GAS BEING COMPRESSED, IT MUST BE INCLUDED ABOVE.

REMARKS

APPLICABLE SPECIFICATIONS

○ API 618, RECIPROCATING COMPRESSORS FOR PETROLEUM, CHEMICAL AND GAS INDUSTRY SERVICES
NACE MR-O175 (6.15.1.11)
○ ______
○ ______
○ ______
○ ______
○ ______
○ ______
○ ______
○ ______

36 ○ SITE/LOCATION CONDITIONS
37 ELEVATION ______ m ______ bar AMBIENT TEMPS: MAX ______ °C MIN ______ °C
38 ○ MIN DESIGN METAL TEMP ______ °C (6.15.8.1) RELATIVE HUMIDITY: MAX ______ % MIN ______ %
39 COMPRESSOR LOCATION: ○ INDOOR ○ HEATED ○ UNHEATED ○ AT GRADE LEVEL ○ ELEVATED: ______ m
40 ○ OUTDOOR ○ NO ROOF ○ UNDER ROOF ○ PARTIAL SIDES ○ PLATFORM: ○ ON-SHORE
41 ○ OFF-SHORE ○ WEATHER PROTECTION REQ. ○ TROPICALIZATION REQ.
42 ○ WINTERIZATION REQUIRED
43 UNUSUAL CONDITIONS: ○ CORROSIVES ○ DUST ○ FUMES ○ OTHER ______
44 ______
45 ELECTRICAL CLASSIFICATIONS

46		HAZARDOUS					NON-HAZARDOUS
47	MAIN UNIT	○ CLASS	______	GROUP ______	DIVISION	______	○
48	L.O. CONSOLE	○ CLASS	______	GROUP ______	DIVISION	______	○
49	CW CONSOLE	○ CLASS	______	GROUP ______	DIVISION	______	○
50							
51							

Figure A-2—Reciprocating Compressor Data Sheet (SI Units) (continued)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
SI UNITS

JOB NO. ______ ITEM NO. ______
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1 **PART LOAD OPERATING CONDITIONS**

2 CAPACITY CONTROL BY: ○ MFG'S CAP. CONTROL ○ PURCHASERS BY-PASS ○ BOTH ○ OTHER ______

3 FOR: ○ PART LOAD COND. ○ START-UP ONLY ○ BOTH

4 WITH: ○ AUTO LOADING DELAY INTERLOCK (7.6.2.4) ○ AUTO IMMEDIATE UNLOADING

5 USING: ○ FIXED VOLUME POCK. ○ SUCTION VALVE UNLOADERS: ○ FINGER ○ PLUG ○ OTHER

6 ACTION: ○ DIRECT (AIR-TO-UNLOAD) ○ REVERSE (AIR-TO-LOAD/FAIL SAFE)

7 NUMBER OF STEPS: ○ ONE ○ THREE ○ FIVE ○ OTHER ______

8 ○ RAIN COVER REQUIRED OVER UNLOADERS

9 **ALL UNLOADING STEPS BASIS MANUFACTURERS CAPACITY SHOWN ON PAGE 1.**

10 **INLET AND DISCHARGE PRESSURE ARE** ○ **AT CYLINDER FLANGES** ○ **PULSATION SUPPRESSOR FLANGES**

11	○ SERVICE OR ITEM NO.						
12	◙ STAGE						
13	◙ NORMAL OR ALTERNATE CONDITION						
14	○ PERCENT CAPACITY						
15	○ WEIGHT FLOW, kg/h						
16	◙ MMSCFD/SCFM (14.7 bar & 60°C)						
17	☐ POCKETS/VALVES OPERATION *						
18	☐ POCKET CLEARANCE ADDED %						
19	☐ TYPE UNLOADERS, PLUG/FINGER						
20	◙ INLET TEMPERATURE, °C						
21	◙ INLET PRESSURE, bar						
22	◙ DISCHARGE PRESSURE, bar						
23	☐ DISCHARGE TEMP., ADIABATIC °C						
24	☐ DISCHARGE TEMP., PREDICTED °C						
25	☐ VOLUMETRIC EFF.,%HE/%CE	/	/	/	/	/	/
26	☐ CALC. GAS ROD LOAD, kN, C **						
27	☐ CALC. GAS ROD LOAD, kN, T **						
28	◇ COMB. ROD LOAD, LB C (GAS & INERTIA)						
29	◇ COMB. ROD LOAD, LB T (GAS & INERTIA)						
30	◇ ROD REV., DEGREES MIN @ X-HD PIN ***						
31	☐ kW/STAGE						
32	☐ TOTAL kW @ COMPRESSOR SHAFT						
33	☐ TOTAL kW INCL. V-BELT & GEAR LOSSES						
34							

35 * SHOW OPERATION WITH THE FOLLOWING SYMBOLS:

36 SUCTION VALVE(S) UNLOADED = S
37 HEAD END = HE OR
38 OR PLUS FIXED POCKET OPEN = F
39 CRANK END = CE OR
40 VARIABLE POCKET OPEN = V

41

42 EXAMPLE: HE-F/CE-S = HEAD END FIXED POCKET OPEN / CRANK END SUCTION VALVE(S) UNLOADED.

43 * * C = COMPRESSION T = TENSION *** X - HD = CROSSHEAD

44 ☐ MINIMUM PRESSURE REQUIRED TO OPERATE CYLINDER UNLOADING DEVICES, ______ barg

45 CYLINDER UNLOADING MEDIUM: ○ AIR ○ NITROGEN ○ OTHER ______

46 ○ PRESSURE AVAILABLE FOR CYLINDER UNLOADING DEVICES, MAX/MIN ______ / ______ barg

47 **REMARKS, SPECIAL REQUIREMENTS, AND/OR SKETCH**

48

49

50

51

Figure A-2—Reciprocating Compressor Data Sheet (SI Units) (continued)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
SI UNITS

JOB NO. _____ ITEM NO. _____
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1 ○ **SCOPE OF BASIC SUPPLY**

2 PURCHASER TO FILL IN (☐ ○ ⬡) AFTER COMMODITY TO INDICATE: ☐ BY COMPR. MFR. ○ BY PURCH. ⬡ BY OTHERS

3 ○ DRIVER (☐ ○ ⬡): ○ VARIABLE SPEED SPEED RANGE _____ r/min TO _____ r/min

4 ○ INDUCTION MOTOR ○ SYNCHRONOUS MOTOR ○ STEAM TURBINE ○ ENGINE ○ OTHER _____

5 ○ API 541 ○ API 546 ○ API 611 ○ API 612

6 ○ OUTBOARD BEARING ○ PROVISION FOR DRY AIR PURGE FOR OUTBOARD BEARING.

7 ○ SLIDE BASE FOR DRIVER (☐ ○ ⬡) SOLE PLATE FOR DRIVER (☐ ○ ⬡)

8 ○ MOTOR STARTING EQUIPMENT (☐ ○ ⬡); DEFINE _____

9 ○ GEAR (☐ ○ ⬡): ○ BASEPLATE FOR GEAR ○ API 613 ○ API 677

10 ○ COUPLING(S) (☐ ○ ⬡): ○ LOW SPD. ○ HI-SPD. ○ QUILL SHAFT ○ KEY-LESS DRV. ○ KEY'D DRV. ○ OTHER _____

11 ○ API 671

12 ○ V-BELT DRIVE (☐ ○ ⬡): ○ SHEAVES & V-BELTS (☐ ○ ⬡) ○ STATIC CONDUCTING V-BELTS ○ BANDED V-BELTS

13 ○ DRIVE GUARD(S) (☐ ○ ⬡): ○ MANUFACTURER'S STD. ○ NON-SPARKING ○ CALIF CODE ○ API 671, ANNEX G

14 ○ OTHER

15 ○ PULSATION SUPPRESSORS (☐ ○ ⬡): ○ INITIAL INLET & FINAL DISCHARGE ○ SUPPORTS (☐ ○ ⬡)

16 ○ INTERSTAGE ○ SUPPORTS (☐ ○ ⬡)

17 ○ SUPPRESSOR(S) TO HAVE MOISTURE REMOVAL SECTION: ○ INITIAL INLET ○ ALL INTERSTAGE INLET

18 ○ ACOUSTICAL SIMUL. STUDY (☐ ○ ⬡): DESIGN ○ 1, EMPIRICAL PULSATION SUPRESSION DEVICE SIZING

19 APPROACH ○ 2, ACOUSTIC SIMULATION AND PIPING RESTRAINT ANALYSIS

20 CHECK ONLY ONE, SEE 7.9.4.1.1, TABLE 6) ○ 3, ACOUSTIC SIMULATION AND PIPING RESTRAINT ANALYSIS

21 STUDY TO CONSIDER: PLUS MECHANICAL ANALYSIS

22 ALL SPECIFIED LOAD COND., INCL. ○ SINGLE ACT., PLUS ○ COMP.OPER.IN PARALLEL ○ ALTERNATE GASES

23 ○ CRITICAL FLOW MEASUREMENT (7.9.4.2.5.3.3) ○ WITH EXISTING COMP. AND PIPING SYSTEMS

24 ○ PULSATION SUPRESS'N DEVICE LOW CYCLE FATIGUE ANALYSIS ○ PIPING SYSTEM FLEXIBILITY

25 ○ VENDOR REVIEW OF PURCHASER'S PIPING ARRANGEMENT

26 NOTE: SEE APPENDIX N FOR INFORMATION REQUIRED FOR STUDY

27 PACKAGED: ○ NO ○ YES (☐ ○ ⬡) DEFINE BASIC SCOPE OF PACKAGING IN REMARKS SECTION, PAGE 5

28 ○ DIRECT GROUTED ○ CEMENTED/MORTAR GROUT ○ EPOXY GROUT; MFG/TYPE _____ / _____

29 ○ RAILS ○ CHOCK BLOCKS ○ SHIMS ○ BASEPLT. ○ SKID ○ SOLEPLT. ○ BOLTS OR STUDS FOR SOLEPLT. TO FRAME

30 ○ SUITABLE FOR COLUMN MOUNTING (UNDER SKID AND/OR BASEPLATE)

31 ○ LEVELING SCREWS ○ NON-SKID DECKING ○ SUB SOLEPLATES

32 ○ INTERCLR(S) (☐ ○ ⬡) ○ OFF MOUNTED ○ MACHINE MTD. ○ AFTERCLR(S) (☐ ○ ⬡)

33 ○ SEPARATOR(S) (☐ ○ ⬡) ○ CONDENSATE SEPARATION & COLLECTION FACILITY SYSTEM (7.8.2.1)

34 ○ INTERSTAGE PIP. (☐ ○ ⬡): ○ FINAL DISC. PIP. (☐ ○ ⬡): ○ PARTIAL PRE FAB, FIELD FIT ○ SHOP FITTED

35 FLANGE FINISH ○ API 618 FLANGE FINISH > 125 < 250 (7.9.5.1.16) ○ FLANGE FINISH PER ANSI 16.5 ○ SPECIAL FINISH

36 ○ SPECIAL PIPING REQUIREMENTS (7.7.1.13). (DEFINE IN REMARKS SECTION NEXT PAGE)

37 ○ INITIAL INLET, ○ INTERSTAGE SUCTION PIPING ARR'D FOR: ○ INSULATION (☐ ○ ⬡) ○ HEAT TRACING (☐ ○ ⬡

38 ○ INLET STRAINER(S) (☐ ○ ⬡): ○ INITIAL INLET ○ SIDESTREAM INLET ○ SPOOL PIECE FOR INLET STRAINERS

39 ○ MANIFOLD PIPING; ○ DRAINS ○ VENTS ○ RELIEF VALVES ○ AIR/GAS SUPPLY

40 ○ RELIEF VALVE(S) (☐ ○ ⬡): ○ INITIAL INLET ○ INTERSTAGE ○ FINAL DISCHARGE

41 ○ RUPTURE DISC(S) (☐ ○ ⬡) ○ THRU STUDS IN PIPING FLANGES

42 ○ FOR ATMOSPHERIC INLET AIR COMPR. ONLY: ○ INLET AIR FILTER (☐ ○ ⬡) ○ INLET FILTER -SILENCER (☐ ○ ⬡)

43 ○ PREFERRED TYPE OF CYLINDER COOLING (☐ ○ ⬡): ○ FORCED ○ THERMOSYPHON _____ STAGE CYL'(S)

44 NOTE: MANUFACTURER SHALL RECOMMEND ○ STATIC (STAND-PIPE) _____ STAGE CYL'(S)

45 BEST TYPE OF COOLING AFTER ○ CYL. COOLANT PIPING BY (☐ ○ ⬡) ○ MATCH M'RKED

46 FINAL ENGINEERING REVIEW OF ALL ○ SINGLE INLET/OUTLET MANIFOLD & VALVES ○ SIGHT GL'SS(ES)

47 OPERATING CONDITIONS ○ INDIVIDUAL INLET/ OUTLET PER CYL. ○ VALVE(S)

48 ○ CLOSED SYSTEM WITH PUMP, COOLER, SURGE TANK, & PIPING

49

50

51

Figure A-2—Reciprocating Compressor Data Sheet (SI Units) (continued)

RECIPROCATING COMPRESSOR
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○ **SCOPE OF BASIC SUPPLY (Con't)**

○ SEPARATE COOLING CONSOLE (☐ ○ ⬡): ○ ONE FOR EA. UNIT ○ ONE CMMN TO ALL UNITS ○ DUAL PUMPS (AUX .& MAIN)
○ ARRANGED FOR HEATING JACKET WATER AS WELL AS COOLING ○ SHOP RUN
○ ROD PRESS. PACKING COOLING SYSTEM (☐ ○ ⬡): ○ SEPARATE CONSOLE ○ COMBINE WITH JKT SYSTEM ○ FILTERS
○ FRAME LUBE OIL SYSTEM (☐ ○ ⬡): ○ AUX. PUMP ○ DUAL FILTERS WITH TRANSFER VALVE ○ SHOP RUN
○ CONTINUOUS FLOW IN SENSING LINE TO PRESSURE SWITCHES
○ SEPARATE LUBE OIL CONSOLE (☐ ○ ⬡): ○ EXTENDED TO MOTOR OUTBOARD BEARING ○ SHOP RUN
NOTE: PIPING BETWEEN ALL CONSOLES AND COMPRESSOR UNIT BY PURCHASER

○ CAPACITY CONTROL (☐ ○ ⬡): ○ SEE DATA SHEET PAGE 3 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)
SEE INSTRUMENTATION DATA SHEETS FOR DETAILS OF PANEL, ADDITIONAL REMARKS, AND INSTRUMENTATION.
NOTE: ALL TUBING, WIRING, & CONNECTIONS BETWEEN OFF-UNIT FREE STANDING PANELS AND COMPRESSOR UNIT BY PURCHASER.

○ HEATERS (☐ ○ ⬡): ○ FRAME LUBE OIL ○ CYL. LUBRICATORS ○ COOLING WATER ○ DRIVER(S) ○ GEAR OIL
○ ELECTRIC ○ STEAM

○ BARRING DEVICE (☐ ○ ⬡): ○ MANUAL ○ PNEUMATIC ○ ELECTRIC ○ FLYWHEEL LOCKING DEVICE (☐ ○ ⬡)
○ CRANKCASE RAPID PRESSURE RELIEF DEVICE(S) (☐ ○ ⬡)
○ SPECIAL CORROSION PROTECTION: ○ NO ○ YES ○ MFR'S STANDARD ○ OTHER ______
○ HYDRAULIC TENSIONING TOOLS ○ NO ○ YES
○ MECHANICAL RUN TEST: ○ NO ○ YES ○ MFG'S STANDARD ○ OTHER ______
○ COMPLETE SHOP RUN TEST OF ALL MACHINE MOUNTED EQUIPMENT, PIPING & APPURT.'(S)

PAINTING: ○ MANUFACTURER'S STANDARD ○ SPECIAL ______
NAMEPLATES: ○ U.S. CUSTOMARY UNITS ○ SI UNITS
SHIPMENT: ○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQUIRED (☐ ○ ⬡)
○ STANDARD 6 MONTH STORAGE PREPARATION (☐ ○ ⬡), PER SPEC ______
○ OUTDOOR STORAGE FOR OVER 6 MONTHS (☐ ○ ⬡), PER SPEC ______
○ INITIAL INSTALLATION AND OPERATING TEMP ALIGNMENT CHECK AT JOBSITE BY VENDOR REPRESENTATIVE
○ COMPRESSOR MANUFACTURER'S USER'S LIST FOR SIMILAR SERVICE
○ COMPRESSOR VALVE DYNAMIC RESPONSE
○ PERFORMANCE DATA REQUIRED (9.3.3): ○ BHP VS. SUCTION PRESSURE CURVES
○ ROD LOAD/GAS LOAD CHARTS
○ VALVE FAILURE DATA CHARTED
○ SPEED/TORQUE CURVE DATA
○ BkW VS. CAPACITY PERFORMANCE CURVES OR TABLES REQUIRED FOR UNLOADING STEPS AND/OR VARIABLE SUCTION/DISCHARGE PRESSURES

REMARKS: ______

Figure A-2—Reciprocating Compressor Data Sheet (SI Units) (continued)

RECIPROCATING COMPRESSOR
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SI UNITS

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UTILITY CONDITIONS

ELECTRICAL POWER:	AC VOLTS /	PHASE /	HERTZ	DC VOLTS		AC VOLTS /	PHASE /	HERTZ /	DC VOLTS
○ MAIN DRIVER	/	/			INSTRUMENT	/	/	/	
○ AUXILIARY MOTORS	/	/			ALARM & SHTDWN	/	/	/	
○ HEATERS	/	/				/	/	/	

INSTRUMENT AIR: NORMAL PRESSURE barg MAX/MIN / barg
NITROGEN: NORMAL PRESSURE barg MAX/MIN / barg

STEAM FOR: **DRIVERS** / **HEATERS**

INLET: PRESS	barg	MAX/MIN	/	barg	INLET: PRESS	barg	MAX/MIN	/	barg
(NORM.) TEMP	°C	MAX/MIN	/	°C	(NORM.) TEMP	°C	MAX/MIN	/	°C
EXH'ST: PRESS	barg	MAX/MIN	/	barg	EXH'ST:PRESS	barg	MAX/MIN	/	barg
(NORM.) TEMP	°C	MAX/MIN	/	°C	(NORM.) TEMP	°C	MAX/MIN	/	°C

COOLING WATER FOR: **COMPRESSOR CYLINDERS** / **COOLERS**

TYPE WATER / TYPE WATER

SUPP.: PRESS	barg	MAX/MIN	/	barg	SUPP.: PRESS	barg	MAX/MIN	/	barg
(NORM.) TEMP	°C	MAX/MIN	/	°C	(NORM.) TEMP	°C	MAX/MIN	/	°C
R'T'RN: PRESS	barg	MAX/MIN	/	barg	R'T'RN: PRESS	barg	MAX/MIN	/	barg
(NORM.) TEMP	°C	MAX/MIN	/	°C	(NORM.) TEMP	°C	MAX/MIN	/	°C

COOLING FOR ROD PACKING:
TYPE FLUID SUPPLY PRESSURE barg @ °C RETURN barg @ °C

FUEL GAS: NORMAL PRESSURE barg MAX/MIN / barg LHV MJ/m^3
COMPOSITION

REMARKS/SPECIAL REQUIREMENTS:

Figure A-2—Reciprocating Compressor Data Sheet (SI Units) (continued)

RECIPROCATING COMPRESSOR
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1	○ **CYLINDER DATA AT FULL LOAD CONDITION**						
2	SERVICE/ITEM NO.						
3	STAGE						
4	INLET PRESSURE, barg } @ CYLINDER						
5	DISCHARGE PRESSURE, barg } FLANGES						
6	CYLINDERS PER STAGE						
7	SINGLE OR DOUBLE ACTING (SA OR DA)						
8	BORE, mm						
9	STROKE, mm						
10	RPM: RATED / MAX ALLOW	/					
11	PISTON SPEED, m/s: RATED / MAX ALLOW	/					
12	CYLINDER LINER, YES/NO						
13	LINER NOMINAL THICKNESS, mm						
14	PISTON DISPLACEMENT, m^3/h						
15	CYLINDER DESIGN CLEARANCE, % AVERAGE						
16	VOLUMETRIC EFFICIENCY, % AVERAGE						
17	VALVES, INLET/DISCHARGE, QTY PER CYL.	/	/	/	/	/	/
18	TYPE OF VALVES						
19	VALVE LIFT, INLET/DISCHARGE, mm	/	/	/	/	/	/
20	VALVE VELOCITY, m/s						
21	SUCTION VALVE(S)						
22	DISCHARGE VALVE(S)						
23	ROD DIAMETER, mm						
24	MAX ALLOW. COMBINED ROD LOADING, kN, C *						
25	MAX ALLOW. COMBINED ROD LOADING, kN, T *						
26	CALCULATED GAS ROD LOAD, kN, C *						
27	CALCULATED GAS ROD LOAD, kN, T *						
28	COMBINED ROD LOAD (GAS + INERTIA), kN, C *						
29	COMBINED ROD LOAD (GAS + INERTIA), kN, T *						
30	ROD REV., DEGREES MIN @ X-HD PIN**						
31	RECIP WT. (PISTON, ROD, X-HD & NUTS), kg**						
32	MAX ALLOW. WORKING PRESSURE, barg						
33	MAX ALLOW. WORKING TEMPERATURE, °C						
34	HYDROSTATIC TEST PRESSURE, barg						
35	GAS LEAKAGE TEST PRESSURE, barg						
36	INLET FLANGE SIZE/RATING	/	/	/	/	/	/
37	FACING						
38	DISCHARGE FLANGE SIZE/RATING	/	/	/	/	/	/
39	FACING						
40	DISCHARGE RELIEF VALVE SETTING DATA AT INLET PRESSURES GIVEN ABOVE:						
41	RECOMMENDED SETTING, barg						
42	GAS ROD LOAD, kN, C *						
43	GAS ROD LOAD, kN, T *						
44	COMBINED ROD LOAD, kN, C *						
45	COMBINED ROD LOAD, kN, T *						
46	ROD REVERSAL, °MIN @ X-HD PIN**						
47	NOTE: CALCULATED AT INLET PRESSURES						
48	GIVEN ABOVE & RECOMMENDED SETTING.						
49	○ SETTLE-OUT GAS PRESSURE						
50	(DATA REQUIRED FOR STARTING)	* C = COMPRESSION		* T = TENSION		**X-HD = CROSSHEAD	
51	**NOTES/REMARKS:**						

Figure A-2—Reciprocating Compressor Data Sheet (SI Units) (continued)

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SI UNITS

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1	☐ **CONSTRUCTION FEATURES**						
2	SERVICE ITEM NO.						
3	STAGE						
4	CYLINDER SIZE (BORE DIA), mm						
5	ROD RUN-OUT: NORMAL COLD VERTICAL						
6	(per Annex C)						
7	CYLINDER INDICATOR VALVES REQUIRED	○	○	○	○	○	○
8	INDICATOR CONNECTIONS ABOVE 345 bar	○	○	○	○	○	○
9	FLUOROCARBON SPRAYED CYLINDER	○	○	○	○	○	○
	MATERIALS OF CONSTRUCTION						
10	CYLINDER(S)						
11	CYLINDER LINER(S)						
12	PISTON(S)						
13	PISTON RINGS						
14	WEAR BANDS ○ REQUIRED						
15	PISTON ROD(S): MATERIAL/YIELD, N/mm^2	/	/	/	/	/	/
16	THREAD ROOT STRESS @ MACRL * @ X-HD END						
17	PISTON ROD HARDNESS, BASE MATERIAL, Rc						
18	PISTON ROD COATING ○ REQUIRED						
19	COATING HARDNESS, Rc						
20	VALVE SEATS / SEAT PLATE						
21	VALVE SEAT MIN HARDNESS, Rc						
22	VALVE GUARDS (STOPS)						
23	VALVE DISCS						
24	VALVE SPRINGS						
25	ROD PRESSURE PACKING RINGS						
26	ROD PRESSURE PACKING CASE						
27	ROD PRESSURE PACKING SPRINGS						
28	SEAL / BUFFER PACKING, DISTANCE PIECE						
29	SEAL / BUFFER PACKING, INTERMEDIATE						
30	WIPER PACKING RINGS						
31	MAIN JOURNAL BEARINGS, CRANKSHAFT						
32	CONNECTING ROD BEARING, CRANKPIN						
33	CONNECTING ROD BUSHING, X-HD END						
34	CROSSHEAD (X-HD) PIN BUSHING						
35	CROSSHEAD PIN						
36	CROSSHEAD						
37	CROSSHEAD SHOES						
38	INSTRUMENTATION IN COLD SIDE						
39	CONTACT W/PROCESS GAS HOT SIDE						
40	* MACRL = MAXIMUM ALLOWABLE COMBINED ROD LOAD						

41	☐ COMPRESSOR CYLINDER ROD PACKING	DISTANCE PIECE(S): ○ TYPE A ○ TYPE B ○ TYPE C ○ TYPE D
42	○ FULL FLOATING PACKING	REF. FIGURE G-3
43	○ VENTED TO: ○ FLARE @ ____ barg ○ ATMOS.	COVERS: ○ SOLID METAL ○ SCREEN ○ LOUVERED
44	○ SUCTION PRESSURE @ ____ barg	CYLINDER COMPARTMENT: ○ VENTED TO ____ barg
45	○ FORCED LUBRICATED ○ NON-LUBE	(Outboard Distance Piece) ○ PURGED AT ____ barg
46	☐ WATER COOLED, ____ STAGE(S), ____ GPM REQ'D	○ PRESSURIZED TO ____ barg
47	☐ OIL COOLED, ____ STAGE(S), ____ GPM REQ'D	○ WITH RELIEF VALVE
48	○ WATER FILTER ○ PROV.FUTURE WATER/OIL COOLING	FRAME COMPARTMENT: ○ VENTED TO ____ barg
49	○ VENT/BUFFER GAS SEAL PACKING ARR. (REF. FIG I-1)	(Inboard Distance Piece) ○ PURGED AT ____ barg
50	○ CONSTANT OR ○ VARIABLE DISPOSAL SYSTEM	○ PRESSURIZED TO ____ barg
51	○ BUFFER GAS PRESSURE, ____ barg	○ WITH RELIEF VALVE
52	○ SPLASH GUARDS FOR WIPER PACKING	☐ DISTANCE PIECE MAWP ____ barg

Figure A-2—Reciprocating Compressor Data Sheet (SI Units) (continued)

RECIPROCATING COMPRESSOR (API 618-5TH) DATA SHEET SI UNITS

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◎ CONSTRUCTION FEATURES (CONTINUED)

○ FABRICATED CYLINDER, HEADS, & CONNECTION SKETCHES FOR DESIGN REVIEW BY PURCHASER. (6.15.5.13)

◎ COUPLING(S)

	○ LOW-SPEED	○ HI-SPEED
	Between Compressor & Driver or Gear	Between Driver & Gear
◇ BY MANUFACTURER		
◇ MODEL		
◇ TYPE		

API-671 APPLIES ○ YES ○ NO

○ INSPECTION AND SHOP TESTS (REF. 8.1.5)

	REQ'D	WITN.	OBSER.
*SHOP INSPECTION	○	○	○
ACTUAL RUNNING CLEARANCES AND RECORDS	○	○	○
MFG STANDARD SHOP TESTS	○	○	○
CYLINDER HYDROSTATIC TEST	○	○	○
CYLINDER PNEUMATIC TEST	○	○	○
CYLINDER HELIUM LEAK TEST	○	○	○
CYL. JACKET WATER HYDRO TEST	○	○	○
*MECHANICAL RUN TEST (4 HOUR)	○	○	○
BAR-OVER TO CHECK ROD RUNOUT	○	○	○
*LUBE OIL CONSOLE RUN/TEST (4 HOUR)	○	○	○
*COOLING H_2O CONSOLE RUN/TEST	○	○	○
RADIOGRAPHY BUTT WELDS ○ GAS ○ OIL ○ FAB CYLS.	○	○	○
MAG PARTICLE/LIQUID PENETRANT OF WELDS SPECIFY ADDITIONAL REQUIREMENTS (8.2.1.3)	○	○	○
________	○	○	○
SHOP FIT-UP OF PULSATION SUPPL. DEVICES & ALL ASSOCIATED GAS PIPING	○	○	○
*CLEANLINESS OF EQUIP., PIPING, & APPURTENANCES	○	○	○
*HARDNESS OF PARTS, WELDS & HEAT AFFECTED ZONES	○	○	○
*NOTIFICATION TO PURCHASER OF ANY REPAIRS TO MAJOR COMPONENTS	○		
________	○	○	○
________	○	○	○

*SPECIFIC REQUIREMENTS TO BE DEFINED, FOR EXAMPLE, DISMANTLING, AUX EQUIPMENT OPERATIONAL & RUN TESTS.

ANNEX K COMPLIANCE: ○ VENDOR
○ PURCHASER

○ BUFFER GAS PACKING ARR. REF: ANNEX I FIGURES I-1, I-2 & I-3
○ OIL WIPER PACKING PURGE
○ INTERMEDIATE PARTITION PURGE
INERT BUFFER GAS PURGE GAS: ○ N_2 ○ OTHER ________
○ VENT, DRAIN, PURGE PIPING BY MFG'R ○ NO ○ YES

☐ V-BELT DRIVE

	DRIVEN SHEAVE (COMPRESSOR SHAFT)	DRIVE SHEAVE (DRIVER SHAFT)
RPM (EXPECTED)		
PITCH DIA. (IN.)		
◇ QTY & GROOVE X-SEC.		
POWER TRANSMITT'D		Incl. Belt Losses

DRIVER NAMEPLATE HP RATING ________
◇ CENTER DISTANCE (IN.) ________
◇ QTY, TYPE, ________
X-SEC., & LENGTH BELTS ________
◇ BELT SERVICE FACTOR (RELATIVE TO DRIVER NAMEPLATE HP RATING) ________

◎ CYLINDER LUBRICATION

○ NON-LUBE ________ STAGE(S)/SERVICE
○ LUBRICATED ________ STAGE(S)/SERVICE
TYPE OF LUBE OIL: ○ SYNTHETIC ________
○ HYDROCARBON ________
LUBRICATOR DRIVE BY: ☐ COMP. CRANKSHAFT, DIRECT
☐ CHAIN, FROM CRANKSHAFT
◎ ELECTRIC MOTOR
◎ OTHER ________
◇ LUBRICATOR MFR ________
◇ MODEL ________
TYPE LUBRICATOR: (6.14.3) ○ SINGLE PLUNGER PER POINT
○ DIVIDER BLOCKS ________
◇ COMPARTM'T, TOTAL QTY. ________
◇ PLUNGERS (PUMPS), TOTAL QTY. ________
◇ SPARE PLUNGERS, QTY. ________
◇ SPARE COMPARTM'T W/OUT PLUNGERS ________
○ HEATERS: ○ ELECTRIC W/THERM.(S) ○ STEAM

☐ ESTIMATED WEIGHTS AND NOMINAL DIMENSIONS

☐ TOTAL COMPR. WT, LESS DRIVER & GEAR ________ kg
◇ WT, OF COMPLETE UNIT, (LESS CONSOLES) ________ kg
◇ MAXIMUM ERECTION WEIGHT ________ kg
◇ MAXIMUM MAINTENENCE WEIGHT ________ kg
◇ DRIVER WEIGHT/GEAR WEIGHT ________ / ________ kg
◇ LUBE OIL/COOLANT CONSOLE ________ / ________ kg
◇ FREE STANDING PANEL ________

SPACE REQUIREMENTS, m:	LENGTH	WIDTH	HEIGHT
◇ COMPLETE UNIT			
◇ LUBE OIL CONSOLE			
◇ CYLINDER COOLANT CONSOLE			
◇ FREE STANDING PANEL			
☐ PISTON ROD REMOVAL DIST.			

OTHER EQUIPMENT SHIPPED LOOSE (DEFINE)
◇ PULSATION SUPP., WEIGHT ________ kg
◇ PIPING ________ kg
◇ INTERSTAGE EQUIPMENT ________ kg

Figure A-2—Reciprocating Compressor Data Sheet (SI Units) (continued)

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☐ **UTILITY CONSUMPTION**

ELECTRIC MOTORS

FOR INDUCTION MOTORS SEE NOTE OF 7.1.2.6 AND MOTOR DATA SHEET	NAMEPLATE kW	LOCKED ROTOR AMPS	FULL LOAD STEADY STATE AMPS	MAIN DRIVER NON-STEADY STATE AMPS AT COMPRESSOR RATED HORSEPOWER (INDUCTION MOTORS ONLY)
◇ MAIN DRIVER				____ AMPS
◇ MAIN LUBE OIL PUMP				@ COMPRESSOR RATED
◇ AUX LUBE OIL PUMP				kW OF ____
◇ MAIN CYLINDER COOLANT PUMP				@ CURRENT PULSATIONS
◇ AUX CYLINDER COOLANT PUMP				OF ____ %
◇ MAIN ROD PKG COOLANT PUMP				
◇ AUX ROD PKG COOLANT PUMP				
◇ CYLINDER LUBRICATOR				

ELECTRIC HEATERS

	WATTS	VOLTS	HERTZ
◇ FRAME OIL HEATER(S)			
◇ CYLINDER COOLANT HEATER(S)			
◇ CYL. LUBRICATOR HEATER(S)			
◇ MAIN DRIVER SPACE HEATER(S)			

STEAM

	FLOW		PRESSURE		TEMPERATURE		BACK PRESSURE	
◇ MAIN DRIVER		kg/h @		barg		°CTT TO		barg
◇ FRAME OIL HEATER(S)		kg/h @		barg		°CTT TO		barg
◇ CYL. LUB. HEATER(S)		kg/h @		barg		°CTT TO		barg
		kg/h @		barg		°CTT TO		barg
		kg/h @		barg		°CTT TO		barg

COOLING WATER REQUIREMENTS

	FLOW m^3/h	INLET TEMP °C	OUTLET TEMP °C	INLET PRESS barg	OUTLET PRESS barg	MAX PRESS barg
☐ CYLINDER JACKETS						
◇ CYLINDER COOLANT CONSOLE						
◇ FRAME LUBE OIL COOLER						
◇ ROD PRESSURE PACKING*						
◇ PACKING COOLANT CONSOLE						
◇ INTERCOOLER(S)						
◇ AFTERCOOLER						
◇ TOTAL QUANTITY, m^3/h						

REMARKS/SPECIAL REQUIREMENTS: ____

*ROD PACKING COOLANT MAY BE OTHER THAN WATER ____

____

Figure A-2—Reciprocating Compressor Data Sheet (SI Units) (continued)

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1 ⧇ **FRAME LUBE OIL SYSTEM**

2 ⧇ **BASIC LUBE OIL SYSTEM FOR FRAME:** ⧇ SPLASH ⧇ PRESSURE (FORCED) ○ HEATERS REQUIRED:
3 ☐ REF: TYPE MAIN BEARINGS: ⧇ TAP'RD ROLL'R ⧇ PRECISION SL'VE ○ ELEC. W/THERMOSTAT(S) ○ STEAM
4 ⧇ **PRESSURE SYSTEM:** ○ MAIN OIL PUMP DRIVEN BY: ○ COMP. CRANKSHAFT ○ ELEC. MOTOR ○ OTHER ____
5 ☐ PSV FOR MAIN PUMP EXTERNAL TO CRANKCASE ○ CHECK VALVE ON MAIN PUMP (FIG G-5)
6 ○ AUX OIL PUMP DRIVEN BY: ○ ELEC. MOTOR ○ OTHER ____
7 ☐ HAND OPERATED PRE-LUBE PUMP FOR STARTING ○ OPERATIONAL TEST & 4 HOUR MECH RUN TEST
8 ○ CONTINUOUS OIL FLOW THROUGH SWITCH SENSING LINE (7.7.2.5)
9 ○ **SEP. CONSOLE FOR PRESS. LUBE SYS:** ○ ONE CONSOLE FOR EA. COMP. ○ ONE CONSOLE FOR ____ COMPRESSORS
10 Note: Instrumentation to be listed on ○ CONSOLE TO BE OF DECK PLATE TYPE CONSTRUCTION SUITABLE FOR
11 Instrumentation Data Sheets. MULTI-POINT SUPPORT AND GROUTING WITH GROUT & VENT HOLES.
12 ○ ELECTRICAL CLASSIFICATION : CLASS ____ , GROUP ____ , DIV ____ ○ NON-HAZARDOUS

13 ☐ **BASIC SYS. REQ'MTS (NORM. OIL FLOWS & VOLUMES)**

14	☐ LUBE OIL	FLOW	PRESSURE	VISCOSITY		SUMP VOLUME
15		m^3/h	barg	SSU @ 40°C	SSU @ 100°C	m^3
16	☐ COMPRESSOR FRAME					
17	◇ DRIVER					
18	◇ GEAR					

19 ☐ SYSTEM PRESSURES: ☐ DESIGN ____ barg ☐ HYDROTEST ____ barg
20 ☐ PRESSURE CONTROL VALVE SETTING ____ barg ☐ PUMP REL'F VALVE(S) SET ____ barg

21 22	○ **PIPING MATERIALS:**	CARBON STEEL	STAINLESS STEEL WITH SS FLANGES	STAINLESS STEEL WITH CARBON STEEL FLANGES
23	○ UPSTREAM OF PUMPS & FILTERS	○	○	○
24	○ DOWNSTREAM OF FILTERS	○	○	○
25	○ ____	○	○	○
26	○ ____	○	○	○

27 28	☐ **PUMPS** (Gear or Screw Type Only)	◇ RAT'D FL'W m^3	◇ PRESSURE barg	◇ COLD START REQ'D kW	◇ DRIVER kW	◇ SPEED R/MIN	COUPLING REQ'D	MECH. SEAL REQ'D
29	MAIN						○	○
30	AUXILIARY						○	○

31 ☐ PUMP CASING MATERIAL (Ref. 6.14.2.1.5): MAIN PUMP ____ AUX PUMP ____
32 ○ GUARD(S) REQ. FOR COUPLING(S): ○ MAIN PUMP ○ AUX PUMP ○ GUARD TYPE OR CODE ____
33 ○ AUXILIARY PUMP CONTROL: ○ MANUAL ○ AUTOMATIC ○ ON-OFF-AUTO SEL. SWITCH: ○ BY PURCH. ○ BY MFR.
34 ○ WIRING TO TERMINAL BOX: ○ BY PURCH. ○ BY MFR.
35 ○ SWITCHES ○ RTD'S/THERMOCOUPLES

36 ○ **COOLERS:** ○ SHELL & TUBE ○ SINGLE ○ DUAL W/TRANSFER VALVE ○ MFG'S STD. ○ TEMA C ○ TEMA R (API 660)
37 ○ REMOVABLE BUNDLE ○ WATER COOLED ○ AIR COOLED W/AUTO TEMP CONTROL (API-661) Data Shts - Attached
38 ○ W/BYPASS & TEMP CONTROL VALVE: ○ MANUAL ○ AUTO
39 ○ SEE SEPARATE HEAT EXCHANGER DATA SHEETS FOR DETAILS, SPECIFY % GLYCOL ON COOLING WATER SIDE

40 ⧇ **FILTER(S)** ○ SINGLE ○ DUAL W/TRANSFER VALVE ○ ASME CODE DESIGN ○ ASME CODE STAMPED
41 ☐ DESIGN PRESSURE, ____ barg ☐ ∆ P CLEAN, ____ barg ☐ ∆ P COLLAPSE, ____ barg
42 ☐ MICRON RATING, ____ ☐ CARTRIDGE MATERIAL, ____ ◇ CARTRIDGE P/N ____
43 ☐ BONNET MATERIAL, ____ ☐ CASING MATERIAL, ____ ○ FURN.SPARE CARTR.,QTY ____

44	☐ **SYS. COMPONENT SUPP.**	MANUFACTURER	MODEL		MANUFACTURER	MODEL
45	◇ MAIN PUMP			◇ OIL COOLER(S)		
46	◇ AUXILIARY PUMP			◇ TRANSFER VALVE(S)		
47	◇ MECHANICAL SEALS			◇ PUMP COUPLING(S)		
48	◇ ELECTRIC MOTORS			◇ SUCTION STRAINER(S)		
49	◇ STEAM TURBINES			◇ CHECK VALVE(S)		
50	◇ OIL FILTER(S)			◇ ____		
51						

Figure A-2—Reciprocating Compressor Data Sheet (SI Units) (continued)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
SI UNITS

JOB NO. ____ ITEM NO. ____
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1 ◙ **COOLANT SYSTEM**

2 ○ **BASIC COOLING SYS. FOR:** ○ COMPRESSOR CYL.(S) ○ ROD PACKING(S) ○ PROCESS COOLER(S) ○ OIL COOLER(S)
3 ○ HEATERS REQ.'D FOR PRE-HEATING: ○ ELEC.,W/ THERMOSTAT(S) ○ STEAM
4 ○ **PRESSURE FORCED CIRCULATING SYS:** ○ OPEN, PIPING BY: ○ PURCH. ○ MFR ○ CLOSED, PIPING BY MFR.
5 MAIN COOLANT PUMP DRIVEN BY: ○ ELEC. MOTOR ○ STEAM TURBINE ○ OTHER ____
6 AUX COOLANT PUMP DRIVEN BY: ○ ELEC. MOTOR ○ STEAM TURBINE ○ OTHER ____
7 ○ **SEP. CONSOLE FOR COOLANT SYSTEM.:** ○ ONE CONSOLE FOR EA. COMP. ○ ONE CONSOLE FOR ____ COMP'RS
8 NOTE: Instrumentation to be listed on ○ CONSOLE TO BE OF DECK PLATE TYPE CONSTRUCTION SUITABLE FOR
9 instrumentation data sheets. MULTI-POINT SUPPORT AND GROUTING WITH GROUT & VENT HOLES.
10 ○ ELECTRICAL CLASSIFICATION : CLASS ____ , GROUP ____ , DIV ____ ○ NON-HAZARDOUS

11 ◙ **BASIC SYS. REQ'MTS (NORM. COOLANT FLOW DATA)** ○ COOLANT TO BE ____ % ETHYLENE GLYCOL

		FORCED COOL'G	THERMO SYPHON	STAND PIPE	FLOW m^3/h	PRESSURE barg	INLET TEMP °C	OUTLET TEMP °C	SITE FLOW IND'TR
14	CYLINDER(S), ____ STAGE	○	○	○	____	____	____	____	○
15	CYLINDER(S), ____ STAGE	○	○	○	____	____	____	____	○
16	CYLINDER(S), ____ STAGE	○	○	○	____	____	____	____	○
17	CYLINDER(S), ____ STAGE	○	○	○	____	____	____	____	○
18	CYLINDER(S), ____ STAGE	○	○	○	____	____	____	____	○
19	CYLINDER(S), ____ STAGE	○	○	○	____	____	____	____	○
20	PISTON ROD PACK'G TOTAL	○			____	____	____	____	○
21	INTERCOOLER(S) TOTAL	○			____	____	____	____	○
22	AFTERCOOLER	○			____	____	____	____	○
23	OIL COOLER(S)	○			____	____	____	____	○
24	____	○			____	____	____	____	○
25	TOTAL FLOW				____				

26 ☐ **SYS. PRESSURES:** ☐ DESIGN, ____ barg ☐ HYDROTEST, ____ barg ◙ RELIEF VALVE(S), SETTING ____ barg
27 ◙ **COOLANT RESERVOIR:** ◇ SIZE, ____ mm IN DIA X ____ mm IN HT. ◇ CAPACITY ____ m^3
28 @ NORMAL OPERATING LEVEL
29 ◇ RESERVOIR MATERIAL ◇ INTERNAL COATING, TYPE ____
30 ○ LEVEL GAUGE ○ LEVEL SWITCH ○ DRAIN VALVE ○ INSPECTION & CLEAN-OUT OPENINGS

31 ☐ **PUMPS: (CENTRIFUGAL ONLY)**

		◇ RAT'D FL'W m^3/h	◇ PRESS. barg	◇ REQ'D kW	◇ DRIVER kW	◇ SPEED r/min	COUPLING REQ'D	MECH.SEAL REQ'D
33	MAIN	____	____	____	____	____	○	○
34	AUXILIARY	____	____	____	____	____	○	○

35 ☐ PUMP CASING MATERIAL (Ref 6.14.2.1.5): MAIN PUMP ____ AUX PUMP ____
36 ○ GUARD(S) REQ.'D FOR COUP'G(S) ○ MAIN PUMP ○ AUX PUMP ○ GUARD TYPE OR CODE ____
37 ○ AUX.PUMP CONTROL: ○ MANUAL ○ AUTO ○ ON-OFF-AUTO SEL. SWITCH: ○ BY PURCH. ○ BY MANUFACTURER
38 ○ WIRING TO TERMINAL BOX: ○ BY PURCH. ○ BY MANUFACTURER

39 ○ **COOLANT HEAT EXCHANGER:** ○ SHELL & TUBE ○ SINGLE ○ DUAL W/TRANSFER VALVE ○ TEMA C ○ TEMA R (API 660)
40 (DATA SHEETS ATTACHED)
41 ○ AIR COOLED EXCHANGER W/AUTO TEMP CONTROL (API 661 DATA SHEETS ATTACHED)
42 ○ W/BYPASS & TEM. CONTROL VALVE ○ MANUAL ○ AUTO ○ LOUVERS FOR AIR EXCH.
43 ○ SEE SEPARATE COOLER DATA SHEET FOR DETAILS; SPECIFY % GLYCOL ON BOTH SIDES
44 OF SHELL & TUBE

45	**SYS. COMPONENT SUPP.**	MANUFACTURER	MODEL		MANUFACTURER	MODEL
46	◇ MAIN PUMP			◇ TEMP CONTROL VALVE(S)	____	____
47	◇ AUXILIARY PUMP	____	____	◇ TRANSFER VALVE(S)	____	____
48	◇ MECHANICAL SEALS	____	____	◇ PUMP COUPLING(S)	____	____
49	◇ ELECTRIC MOTORS	____	____	◇ ____	____	____
50	◇ STEAM TURBINES	____	____	◇ ____	____	____
51	◇ ____	____	____	◇ ____	____	____
52	◇ ____	____	____	◇ ____	____	____

Figure A-2—Reciprocating Compressor Data Sheet (SI Units) (continued)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
SI UNITS

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Revision

1 **PULSATION SUPPRESSION DEVICES FOR RECIPROCATING COMPRESSORS**
2 THESE SHEETS TO BE FILLED OUT FOR EACH SERVICE AND/OR STAGE OF COMPRESSION
3 APPLICABLE TO: ○ PROPOSALS ○ PURCHASE ○ AS BUILT
4 FOR/USER ____
5 SITE/LOCATION ____ AMBIENT TEMPERATURE MIN/MAX ____ / ____ °C
6 COMPRESSOR SERVICE ____ NUMBER OF COMPRESSORS ____
7 COMPRESSOR MFG. ____ MODEL/TYPE ____
8 SUPPRESSOR MFG. ____
9 NOTE: ○ Ind.Data Comp.'d Purch. ☐ By Compr/Supp.Mfg.w/Proposal ◇ By Mfg(s) after order ⧇ By Mfg(s)/Purchaser as Applicable
10 **GENERAL INFORMATION APPLICABLE TO ALL SUPPRESSORS**
11 TOTAL NUMBER OF SERVICES AND/OR STAGES ____
12 TOTAL NUMBER OF COMPRESSOR CYL. ____ TOTAL NUMBER OF CRANKTHROWS ____ STROKE ____ mm r/min ____
13 ○ ASME CODE STAMP ○ GOVERNMENTAL CODES OF ____ CODE REGULATIONS APPLY
14 ○ OTHER APPLICABLE PRESSURE VESSEL SPEC. OR CODE ____
15 ○ LUBE SERVICE ○ NON-LUBE SERV. ○ NO OIL ALLOWED INTERNALLY DRY TYPE INTER.CORR.COATING ○ YES ○ NO
16 RADIOGRAPHY (X-RAY OF WELDS): ○ NONE ○ SPOT ○ 100% ○ IMPACT TEST ○ SPECIAL WELDING REQUIREMENTS
17 ○ SHOP INSPECTION ○ WITNESS HYDROTEST ○ OUTDOOR STORAGE OVER 6 MONTHS ○ SPECIAL PAINT SPEC ____
18 ○ WITNESSED ○ OBSERVED
19
20 **CYLINDER, GAS, OPERATING, AND SUPPRESSOR DESIGN DATA**
21 SERVICE ____ STAGE NO. ____
22 ☐ COMPRESSOR MANUFACTURER'S RATED CAPACITY LBS/HR ____ SCFM ____ MMSCFD ____

23	⧇ LINE SIDE OPERATING PRESSURE	INLET, ____ bar	DISCHARGE, ____ bar
24	⧇ OPERATING TEMP. WITHIN SUPPRESSORS	INLET, ____ °C	DISCHARGE, ____ °C
25	○ ALLOWABLE PRESSURE DROP THROUGH SUPPRESSORS	Δ P ____ bar / ____ %	Δ P ____ bar / ____ %
26		INLET SUPPRESSOR	DISCHARGE SUPPRESSOR
27	○ SUPRESSOR TAG NUMBER		
28	○ COMBINATION INLET SUPP SEPARATOR/INTERNALS	○ YES ○ NO / ○ YES ○ NO	/ ○ YES ○ NO
29	⧇ NO. (QTY) OF INLET & DISCH. SUPP. PER STAGE		
30	○ ALLOWABLE PEAK-PEAK PULSE @ LINE SIDE NOZZLE	bar / %	bar / %
31	○ ALLOWABLE PEAK-PEAK PULSE @ CYL FLANGE NOZZLE	bar / %	bar / %
32			
33	○ DESIGN FOR FULL VACUUM CAPABILITY	○ YES ○ NO	○ YES ○ NO
34	○ MIN. REQ'D WORKING PRESSURE & TEMPERATURE		
35	NOTE: After design, the actual MAWP & temp are to be determined		
36	based on the weakest component and stamped on the	barg, ____ @ ____ °C	barg, ____ @ ____ °C
37	vessel. The actual MAWP is to be shown on pg.14 line 12		
38	and on the U1A Forms.		
39	○ INITIAL SIZING VOL. PER FORMULA OF 7.9.3.2		
40	NOTE: This is a Reference	____ m^3	____ m^3
41			
42	◇ AS BUILT VOLUME (m³)	____ m^3	____ m^3

43
44
45
46
47
48
49
50
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52

Figure A-2—Reciprocating Compressor Data Sheet (SI Units) (continued)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
SI UNITS

JOB NO. ______ ITEM NO. ______
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Revision

1	**PULSATION SUPPRESSION DEVICES FOR RECIPROCATING COMPRESSORS (CONT'D)**	SERVICE	
2	THESE SHEETS TO BE FILLED OUT FOR EACH SERVICE AND/OR STAGE OF COMPRESSION	STAGE NO.	
3	**CONSTRUCTION REQUIREMENTS & DATA**	**INLET SUPPRESSOR**	**DISCHARGE SUPPRESSOR**
4	○ SUPRESSOR TAG NUMBER		
5	○ BASIC MATERIAL REQUIRED, CS, SS, ETC.		
6	◇ ACTUAL MATERIAL DESIGNATION SHELL/HEAD	/	/
7	○ SPECIAL HARDNESS LIMITATIONS, Rc ○ YES ○ NO	SHELL & HEADS WELDS	SHELL & HEADS WELDS
8	▣ CORROSION ALLOWANCE., mm ○ REQUIRED	mm	mm
9	◇ WALL THICKNESS, mm SHELL/HEAD	mm/ mm	mm/ mm
10	☐ NOM. SHELL DIA X OVERALL LGTH. (INCH/VOL.mm³)	x mm/ mm^3	x mm/ mm^3
11	☐ PIPE OR ROLLED PLATE CONSTRUCTION	☐ PIPE ☐ ROLLED PLATE	☐ PIPE ☐ ROLLED PLATE
12	◇ ACT. MAX ALLOW. WORKING PRESS. AND TEMPERATURE	bar @ °C	bar @ °C
13	○ MINIMUM DESIGN METAL TEMP (6.15.8.1)	°C	°C
14	○ INLET SUPRESS. TO BE SAME MAWP AS DISCH'RGE SUPPRESS.	○ YES ○ NO	
15	◇ MAX EXPECTED PRESSURE DROP(Δ P, %) LINE PRESS	Δ P bar/ %	Δ P bar/ %
16	◇ WEIGHT (kg EACH)	kg	kg
17	○ INSUL NUTS & ALLOW. FOR INSULATION REQUIRED (**X**)		
18	◇ EXPECTED P-P PULSE @ LINE SIDE/CYL FLG, % LINE PRESS	%/ %	%/ %
19	BASED ON FINAL SUPPRESSOR DESIGN		
20	▣ SUPPORTS, TYPE/QUANTITY		
21	**CONNECTION REQUIREMENTS & DATA**		
22	○ LINE SIDE FLANGE. SIZE/RATING/FACING/TYPE		
23	○ COMP CYL FLANGE(S), QTY/SIZE/RATING/FACING/TYPE		
24	○ FLANGE FINISH, ○ PER 7.9.5.1.16 ○ SPECIAL (SPECIFY)		
25	>125 <250 ○ PER ANSI 16.5		
26	○ INSPECTION OPENINGS REQUIRED	○ YES ○ NO ○ BLINDED	○ YES ○ NO ○ BLINDED
27	○ SPEC. QTY. SIZE, /FLG TYPE & RATING		
28	◇ * QTY. SIZE, /FLG TYPE & RATING		
29	○ VENT CONNECTIONS REQUIRED	○ YES ○ NO	○ YES ○ NO
30	○ SPEC. QTY. SIZE, /FLG TYPE & RATING		
31	◇ * QTY. SIZE, /FLG TYPE & RATING		
32	○ DRAIN CONNECTIONS REQUIRED	○ YES ○ NO	○ YES ○ NO
33	○ SPEC. QTY. SIZE, /FLG TYPE & RATING		
34	◇ * QTY. SIZE, /FLG TYPE & RATING		
35	○ PRESSURE CONNECTIONS REQUIRED	○ YES ○ NO	○ YES ○ NO
36	○ SPEC. QTY. SIZE, /FLG TYPE & RATING		
37	◇ * QTY. SIZE, /FLG TYPE & RATING		
38	○ TEMPERATURE CONNECTIONS REQUIRED	○ YES ○ NO	○ YES ○ NO
39	○ SPEC. QTY. SIZE, /FLG TYPE & RATING		
40	○ CYL NOZZLE ○ MAIN BODY		
41	◇ * QTY. SIZE, /FLG TYPE & RATING		
42			
43			
44			
45			
46	**OTHER DATA AND NOTES**		
47	◇ COMPRESSOR MFG'S SUPP. OUTLINE OR DRAWING NO.		
48	◇ SUPP. MFG'S OUTLINE OR DRAWING NO.		
49	NOTES * = AS BUILT		
50			
51			

Figure A-2—Reciprocating Compressor Data Sheet (SI Units) (continued)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
SI UNITS

JOB NO. ______ ITEM NO. ______
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Revision

1 ⊡ **INSTRUMENTATION**

2 PURCHASER TO FILL IN (☐ ○ ⬡) AFTER COMMODITY TO INDICATE: ☐ BY COMP. MFR. ○ BY PURCH. ⬡ BY OTHERS

3 INSTRUMENT & CONTROL ○ ONE FOR EA. UNIT ○ ONE COMMON TO ALL UNITS

4 PANEL (☐ ○ ⬡): ○ MACHINE MT'ED ○ FREE STANDING (OFF UNIT) ○ LOCAL ○ REMOTE ○ OUTDOORS

5 ○ PNEUMATIC ○ ELEC. ○ ELECTRONIC ○ HYDRAULIC ○ PROGRAMMABLE CONTL'R

6 ○ NEMA 7, CLASS ______, GROUP ______, DIVISION ______ ○ INTRINSICALLY SAFE

7 ○ I/S BARRIERS (☐ ○ ⬡)

8 ○ NEMA 4, WATERTIGHT & DUSTTIGHT ○ PURGED TO NFPA 496 TYPE ○ X ○ Y ○ Z

9 ○ OTHER NEMA ______ LOW PURGE PRESS. ○ ALARM ○ SHUTDOWN

10 ○ VIB, ISOLATORS ○ STRIP HEATERS ○ PURGE CONN. ○ EXTRA CUTOUTS

11 ○ ANNUNCIATOR W/FIRST-OUT INDICATION LOCATED ON CONTROL PANEL

12 ○ PURCHASER'S CONN. BROUGHT OUT TO TERMINAL BOX BY VENDOR

13 BUFFER GAS CONTROL ○ ONE FOR EA. UNIT ○ ONE COMMON TO ALL UNITS

14 PANEL (☐ ○ ⬡): ○ MACHINE MT'ED ○ FREE STANDING (OFF UNIT) ○ WITH STAND ○ OUTDOORS

15 ○ CLASS ______, GROUP ______, DIVISION ______

16 ○ CONSTANT PRESSURE DISPOSAL SYSTEM ○ VARIABLE PRESSURE DISPOSAL SYSTEM

17 **ADDITIONAL PANEL REMARKS:**

18 ______

19 ______

20 ○ INSTRUMENTATION SUITABLE FOR: ○ INDOORS ○ OUTDOORS ○ OTHER ______

21 ○ PREFERRED INSTRUMENT SUPPLIERS, (TO BE COMPLETED BY PURCHASER), OTHERWISE MFR'S STANDARD APPLIES

22	PRESSURE GAUGES	MFR		SIZE & TYPE		MTL	
23	TEMPERATURE GAUGES	MFR		SIZE & TYPE		MTL	
24	LIQUID LEVEL GAUGES	MFR		TYPE		MTL	
25	DIFF. PRESSURE GAUGES	MFR		SIZE & TYPE		MTL	
26	PRESS. TRANSMITTERS	MFR		TYPE		MTL	
27	LIQUID LEV. TRANSMITTER	MFR		TYPE		MTL	
28	PRESSURE SWITCHES	MFR		TYPE		MTL	
29	TEMPERATURE SWITCHES	MFR		TYPE		MTL	
30	LIQUID LEVEL SWITCHES	MFR		TYPE		MTL	
31	DIFF. PRESSURE SWITCHES	MFR		TYPE		MTL	
32	CONTROL VALVES	MFR		TYPE		MTL	
33	PRESSURE SAFETY VALVES	MFR		TYPE		MTL	
34	SIGHT FLOW INDICATORS	MFR		TYPE		MTL	
35	VIBRATION MONITORS & EQUIP.	MFR		TYPE		MTL	
36	THERMOCOUPLES	MFR		TYPE		MTL	
37	RTD'S	MFR		TYPE		MTL	
38	SOLENOID VALVES	MFR		TYPE		MTL	
39	ANNUNCIATOR	MFR		MODEL & (QTY SPARE POINTS)			( )
40	PROGRAMMABLE CONTROLLER	MFR		TYPE		MTL	
41		MFR		TYPE		MTL	

42 ○ PRESSURE GAUGE REQUIREMENTS ○ LIQUID-FILLED PRESSURE GAUGES: ○ YES ○ NO

43		LOCALLY	PANEL		LOCALLY	PANEL
44	FUNCTION	MOUNTED	MOUNTED		MOUNTED	MOUNTED
45	LUBE OIL MAIN PUMP DISCHAR.	(☐ ○ ⬡)	(☐ ○ ⬡)	PROCESS GAS: INLET PRESS.	(☐ ○ ⬡)	(☐ ○ ⬡)
46	LUBE OIL AUX. PUMP DISCHARG.	(☐ ○ ⬡)	(☐ ○ ⬡)	@ EA. STAGE	(☐ ○ ⬡)	(☐ ○ ⬡)
47	LUBE OIL PRESS. AT FRAME HEADER	(☐ ○ ⬡)	(☐ ○ ⬡)	DISCH. PRESS.	(☐ ○ ⬡)	(☐ ○ ⬡)
48	LUBE OIL FILTER Δ P	(☐ ○ ⬡)	(☐ ○ ⬡)	@ EA. STAGE	(☐ ○ ⬡)	(☐ ○ ⬡)
49	COOLING H_2O INLET HEADER	(☐ ○ ⬡)	(☐ ○ ⬡)		(☐ ○ ⬡)	(☐ ○ ⬡)
50		(☐ ○ ⬡)	(☐ ○ ⬡)		(☐ ○ ⬡)	(☐ ○ ⬡)

51 **REMARKS:** ______

52 ______

Figure A-2—Reciprocating Compressor Data Sheet (SI Units) (continued)

RECIPROCATING COMPRESSOR **API 618 5TH EDITION DATA SHEET** **SI UNITS**	JOB NO. ______ ITEM NO. ______ REVISION NO. ______ DATE ______ PAGE 16 OF 17 BY ______	Revision

1	**INSTRUMENTATION (CONT'D)**						
2	**TEMPERATURE MEASUREMENT REQUIREMENTS**	LOCALLY	PANEL	GAUGE W/	THERMO	RTD	I/S
3	**FUNCTION**	MOUNTED	MOUNTED	CAPILLARY	CPL SYS	SYS	SYS
4	LUBE OIL ○ INLET TO ○ OUT OF FRAME	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
5	LUBE OIL ○ INLET TO ○ OUT OF COOLER	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
6	MAIN JRNL BEARINGS (THERMOCOUPLES OR RTD'S ONLY)	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
7	MOTOR BEARING(S) (THERMOCOUPLES OR RTD'S ONLY)	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
8	CYL. COOLANT MANIFOLD: ○ INLET ○ OUTLET	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
9	CYL. JKT. COOLANT: ○ INLET ○ OUTLET ○ EA. CYL	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
10	PROCESS GAS: ○ INLET ○ DISCH. ○ EACH CYL	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
11	INTERCOOLER(S) ○ INLET ○ GAS ○ COOLANT	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
12	○ OUTLET ○ GAS ○ COOLANT	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
13	AFTERCOOLER: ○ INLET ○ GAS ○ COOLANT	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
14	○ OUTLET ○ GAS ○ COOLANT	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
15	PKG COOLANT ○ INLET ○ OUTLET	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
16	PRESS. PGK CASE, CYL PIST ROD (THRM'CPLS OR RTD'S ONLY)	(☐ ○ ⬡)	(☐ ○ ⬡)		○	○	○
17	COMPRESSOR VALVES ○ SUCT. ○ DISCH. TC'S OR RTD'S ONLY	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
18	______	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○
19	______	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○

20	**ALARM & SHUTDOWN SYSTEM REQ'MTS**	NOTE: ALARM & SHUTDOWN DEVICES SHALL BE INDIVIDUALLY SEPARATE						
21				ANNUNCIATION POINTS				
22	ALARM DEVICES: ○ TRANSMITTER ○ SWITCH			ALARM		SHUTDOWN		
23	SHUTDOWN DEVICES ○ TRANSMITTER ○ SWITCH			IN	IN CTL	IN	IN CTL	TOTAL
24				PNL	ROOM	PNL	ROOM	NO.
25			SHUT	BY	PANEL	BY	PANEL	OF
26	**FUNCTION**	ALARM	DOWN	MFR	OTH'RS	MFR	OTH'RS	POINTS
27	LOW LUBE OIL PRESS. @ BEARING HEADER	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
28	HIGH LUBE OIL Δ P / P ACROSS FILTER	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
29	LOW LUBE OIL LEVEL, FRAME	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
30	AUX LUBE OIL PUMP, FAIL TO START	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
31	CYL LUBE SYSTEM PROTECTION	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
32	COMPR. VIBRATION, SHUTDOWN ONLY		(☐ ○ ⬡)	○	○	○	○	______
33	VIBRATION, W/ CONTINUOUS MONITORING	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
34	ROD DROP DETECTOR, CONTACT TYPE(1/CYL)	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
35	ROD DROP PROXIMITY PROBE (1/CYL)	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
36	OIL TEMP OUT OF FRAME	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
37	HIGH GAS DISCH. TEMP EACH CYLINDER	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
38	HIGH JACKET COOLANT TEMP., EA. CYL	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
39	LOW SUCTION PRESS., FIRST STG INLET	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
40	HI DISCH. PRESS. ○ FINAL ○ EA STG	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
41	HI CYL. GAS Δ P, EACH STAGE	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
42	HI LIQ. LEV., EA. MOISTURE SEPARATOR	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
43	LOW PURGE GAS PRESS, DISTANCE PIECE(S)	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
44	HI X-HD PIN TEMP	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
45	PRESS PKG CASE (PISTON ROD TEMP)	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
46	______	(☐ ○ ⬡)	(☐ ○ ⬡)	○	○	○	○	______
47			TOTAL NUMBER OF ANNUNCIATION POINTS					

48 SWITCH CONTACT OPERATION NOTE: EACH SWITCH SHALL BE MINIMUM SPDT ARRANGEMENT

49 ALARM CONTACTS SHALL: ○ OPEN (DE-ENER.) TO SOUND ALARM & BE ENERGIZED WHEN COMPR. IS IN OPERATION

50 ○ CLOSE (ENERGIZE) TO SOUND ALARM & BE DE-ENERGIZED WHEN COMPR. IS IN OPERATION

51 SHUTDOWN CONTACTS SHALL: ○ OPEN (DE-ENERGIZED) TO SHUTDOWN & BE ENERGIZE WHEN COMPR. IS IN OPERATION

52 ○ CLOSE (ENERGIZE) TO SHUTDOWN & BE DE-ENERGIZE WHEN COMPR. IS IN OPERATION

53 REF: 7.6.6.2 FOR MINIMUM RECOMMENDED PROTECTION REQUIREMENTS

Figure A-2—Reciprocating Compressor Data Sheet (SI Units) (continued)

RECIPROCATING COMPRESSOR
API 618 5TH EDITION DATA SHEET
SI UNITS

JOB NO. ______ ITEM NO. ______

REVISION NO. ______ DATE ______

PAGE 17 OF 17 BY ______

Revision

○ INSTRUMENTATION (CONT'D)

○ MISCELLANEOUS INSTRUMENTATION

SIGHT FLOW IND. (COOLANT ONLY) (☐ ○ ⬡) FOR: ○ INTERCOOLER(S) ○ AFTER CLR ○ OIL COOLER

○ CYL JACKET COOLANT ○ ROD PRESS. PKG COOLANT

PNEUMATIC PRESSURE TRANSMITTERS (☐ ○ ⬡) FOR: ______

PRESSURE TRANSMITTERS (ELEC. OUTP.) (☐ ○ ⬡) FOR: ______

PNEUMATIC LEVEL TRANSMITTERS (☐ ○ ⬡) ______

ALARM HORN & ACKN'LMT TEST BUTTON (☐ ○ ⬡) ______

CONDUIT & WIRING W/JUNCT. BOXES (CON-SOLES) (☐ ○ ⬡) ______

TEST VALVES (☐ ○ ⬡) FOR: ______

DRAIN VALVES (☐ ○ ⬡) FOR: ______

GAUGE GLASS(ES) (☐ ○ ⬡) FOR: ______

TACHOMETER (☐ ○ ⬡) ______ SPEED RANGE ______ TO ______ r/min

CRANKSHAFT KEY PHASER (☐ ○ ⬡) FOR: ______

AND TRANSDUCER ______

______ (☐ ○ ⬡) ______

○ SEPARATE LUBE OIL CONSOLE INSTRUMENTATION: PURCH. TO LIST REQ'MTS IN ADDITION TO ANY ABOVE REQ'MTS

______ (☐ ○ ⬡) ______

______ (☐ ○ ⬡) ______

______ (☐ ○ ⬡) ______

______ (☐ ○ ⬡) ______

______ (☐ ○ ⬡) ______

______ (☐ ○ ⬡) ______

○ SEPARATE COOLING WATER CONSOLE INSTRUMENT: PURCH. TO LIST REQ'MTS IN ADDITION TO ANY ABOVE REQ'MTS

______ (☐ ○ ⬡) ______

______ (☐ ○ ⬡) ______

______ (☐ ○ ⬡) ______

______ (☐ ○ ⬡) ______

______ (☐ ○ ⬡) ______

______ (☐ ○ ⬡) ______

○ RELIEF VALVES

LOCATION	BY	MANUFACTURER	TYPE	◇ SIZE	◇ SETTING
	(☐ ○ ⬡)				
	(☐ ○ ⬡)				
	(☐ ○ ⬡)				
	(☐ ○ ⬡)				
	(☐ ○ ⬡)				
	(☐ ○ ⬡)				
	(☐ ○ ⬡)				
	(☐ ○ ⬡)				
	(☐ ○ ⬡)				
	(☐ ○ ⬡)				

NOTES: 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

ADDITIONAL INSTRUMENTATION REMARKS/SPECIAL REQUIREMENTS: ______

______

______

______

Figure A-2—Reciprocating Compressor Data Sheet (SI Units) (continued)

Annex B
(informative)

Capacity Rating and Tolerance

The content of this informative annex refers to 3.18, 3.30, 3.48, 6.13, and 6.1.18.

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 no negative tolerance permitted (this is typically the process flow sheet material balance capacity). The purchaser must complete the data sheets with a capacity, and identify the operating conditions as “normal” or “alternate.” The purchaser must also provide information on the data sheets about any proposed alternate operating conditions. The sizing of the compressor must take 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. While 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 3.40.

C.3 Maximum Allowable Runout

C.3.1 Acceptable limits of rod runout and shop test requirements and records are discussed in 6.1.28.

C.3.2 The maximum allowable horizontal runout at any side position of the dial indicators shall be zero, plus or minus 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 must 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 While 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 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 must include the effect of rod sag when type 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 Figures C-1 and C-2 can be used to compute expected vertical rod runout for perfect alignment.

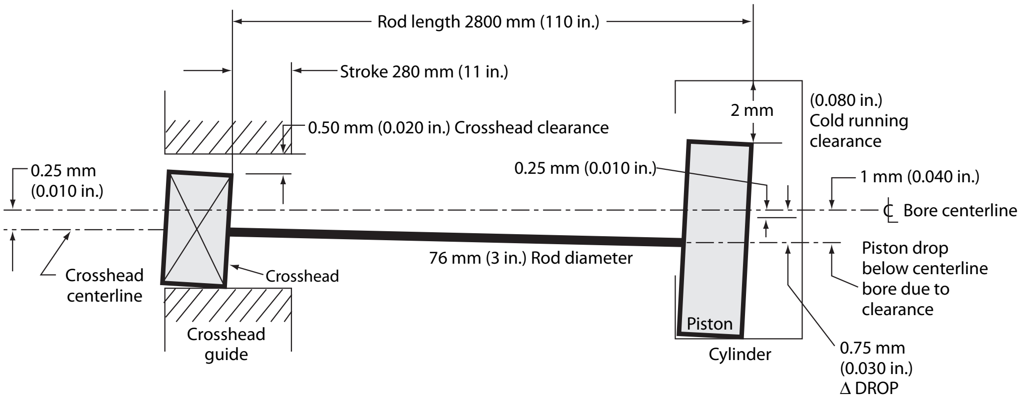
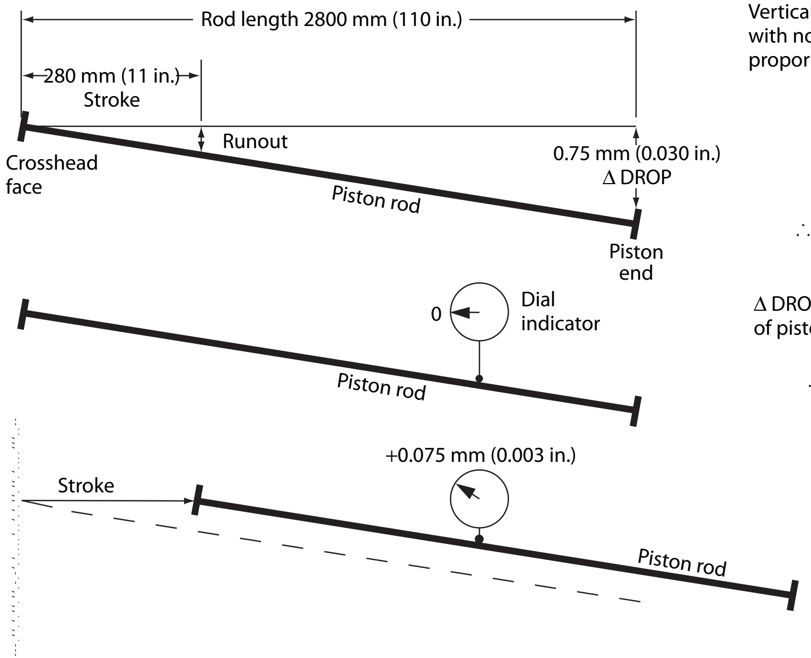


Figure C-1—Basic Geometry with Cold Vertical Runout



Vertical rod runout at perfect alignment conditions, with no rod sag, closely approximates a proportional right triangle relationship where

$$\frac{\text{Stroke}}{\text{Rod Length}} = \frac{\text{Runout}}{\Delta\ \text{DROP}}$$

$$\therefore\ \text{Runout} = \frac{\text{Stroke}}{\text{Rod Length}} \times \Delta\ \text{DROP}$$

Δ DROP = 1/2 difference in running clearance of piston and crosshead

$$\therefore\ \text{Runout} = \frac{11}{110} \times 0.030$$

$$= 0.003 \text{ in. for this example}$$

$$\text{Or} = \frac{280}{2800} \times 0.75$$

$$= 0.075 \text{ mm for this example}$$

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 rod pressure packing case as shown in Figure C-6A. 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.

ROD RUNOUT TABLE

Contractor/User ____________________ Job No. ____________ Item No. ____________

Purchase Order No. ____________ Site/Location ____________ Date ____________

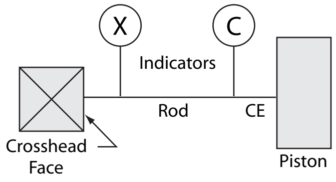
Compressor Mfgr. ____________ Type/Model ____________ Ser. No. ____________

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 ________

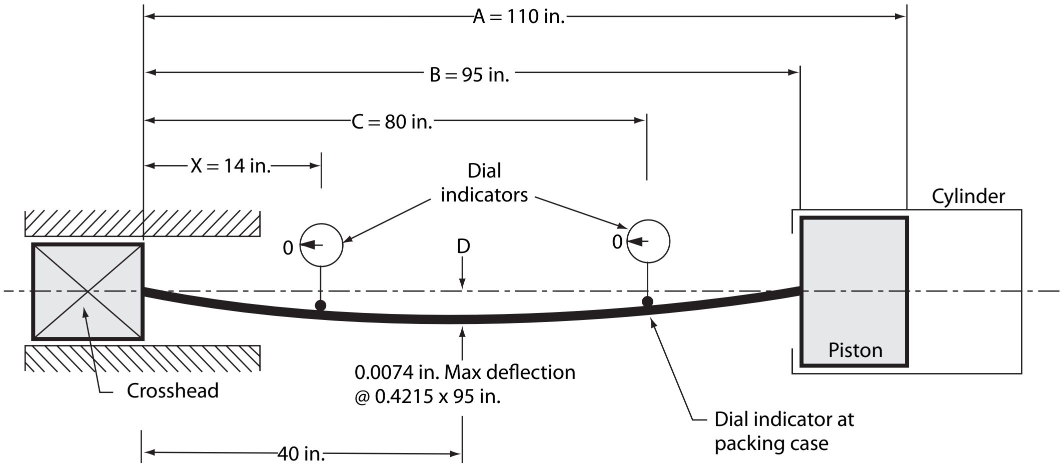
Indicator Positions (Piston at CE) From Crosshead Face To: X ________ C ________



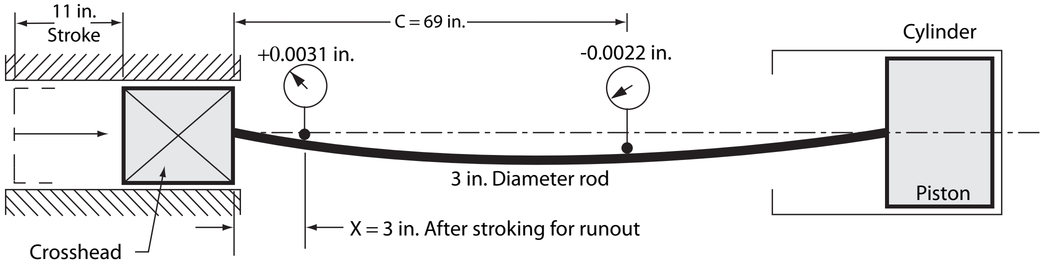
	EXPECTED / ACTUAL ROD RUNOUT				
	Allowable Limits @ X Expected	Measured Values @ X Actual	Allowable Limits @ C Expected	Measured Values @ C Actual	Inspector & Date
Cold (Before Run)					
Vertical (Top, Nut Loose)					
Horizontal (Drive Side, Nut Loose)					
Vertical (Top, Nut Tight)					
Horizontal (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

C.5.3 Dial indicators for vertical runout should be placed on top of the rod at the twelve o’clock position as shown in Figure C-4, Figure C-5, and Figure C-6A. 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 three o’clock or nine o’clock position depending on which throw is being measured. For accurate readings, dial indicators must be perpendicular to the rod at these positions.



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 x rod length 95 in.

Rod diameter = 3 in.	
Density = 0.283 lb/in^3 (steel)	Total weight = 190 lb
Modulus of elasticity, E = 30 x 10^6 psi	Moment of inertia, I = 3.9761 in.^{4}
Rod length B = 95 in.	Rod length C at cylinder indicator position = 80 in.

$$\text{Max D} = \frac{1}{184.65}\left(\frac{WB^3}{EI}\right) = \frac{1}{184.65}\left(\frac{190 \text{ X } 95^3}{30 \text{ X } 10^6 \text{ X } 3.9761}\right) = 0.0074 \text{ in. at } 40.04 \text{ in. from free end}$$

Deflection at any point C on the rod $= \frac{1}{48} \times \frac{W}{EIB} \quad (3BC^3 - 2C^4 - B^3C)$

$\therefore$ Deflection at indicator location C = 80 in. $= \frac{1}{48} \times \frac{190}{EI \times 95} \quad (3 \times 95 \times 80^3 - 2 \times 80^4 - 95^3 \times 80)$

$= 0.02083 \times 1.6767 \times 10^{-8} (-4{,}590{,}000) = -0.0016$ in.

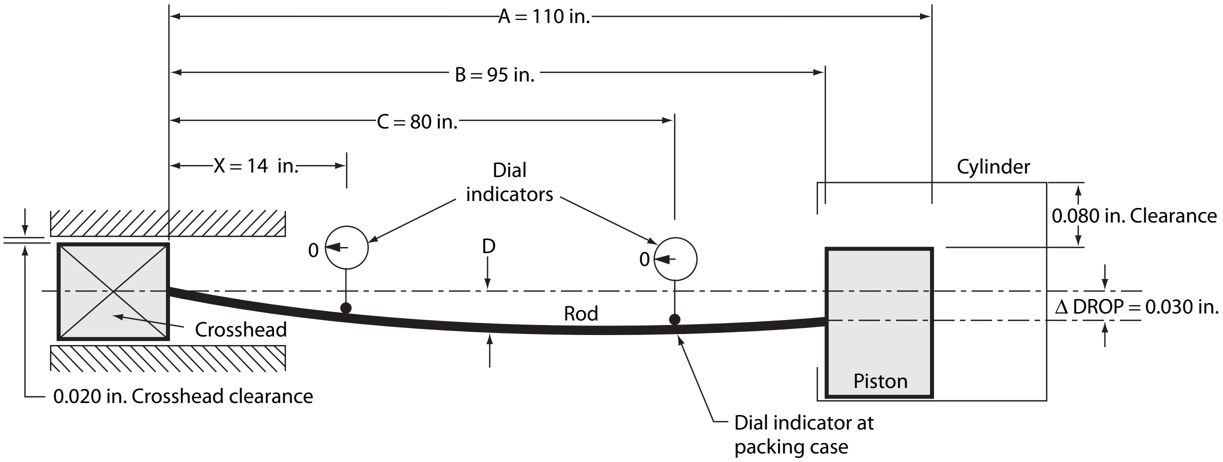
Deflection at C = 69 in. (80 in. minus stroke) $= 0.02083 \times 1.6767 \times 10^{-8} (3 \text{ X } 95 \text{ X } 69^3 - 2 \times 69^4 - 95^3 \times 69)$

$= 0.02083 \times 1.6767 \times 10^{-8} (-10{,}868{,}052) = -0.0038$ in.

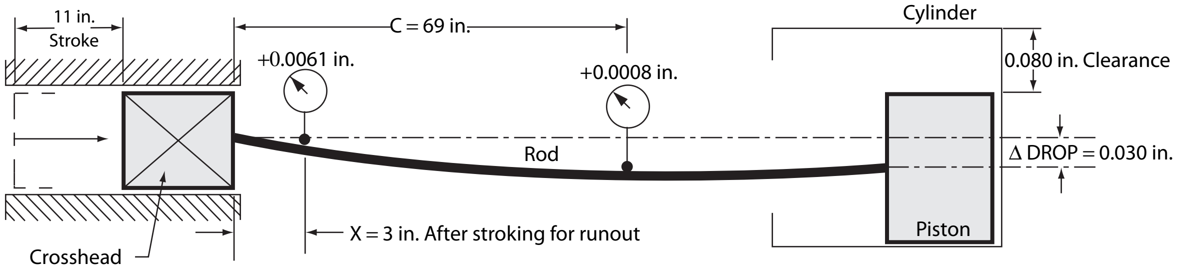
$\therefore$ Rod runout at packing case = 0.0016 in. - 0.0038 in. = -0.0022 in.

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 △ DROP = 0



Crosshead clearance = 0.020 in., cylinder clearance = 0.080 in., Δ DROP = 0.030 in.

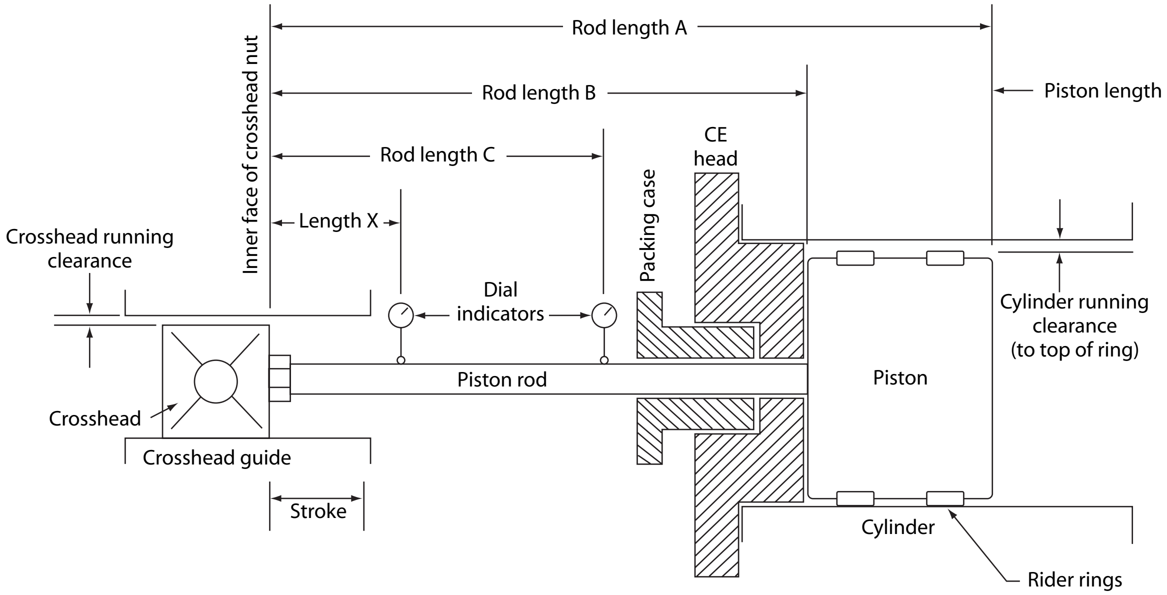


Note: This example is based
on US customary units.
D = Maximum sag

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-6C using the calculation data shown on Figure C-6B. 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 Figures C-7 through C-11.

As shown on the computer printout sheet Figure C-6C and the curve of Figure C-7, 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 on Figure C-6C and the curves of Figure C-8 through C-11. As mentioned in C.9, 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 △ 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) ____________________

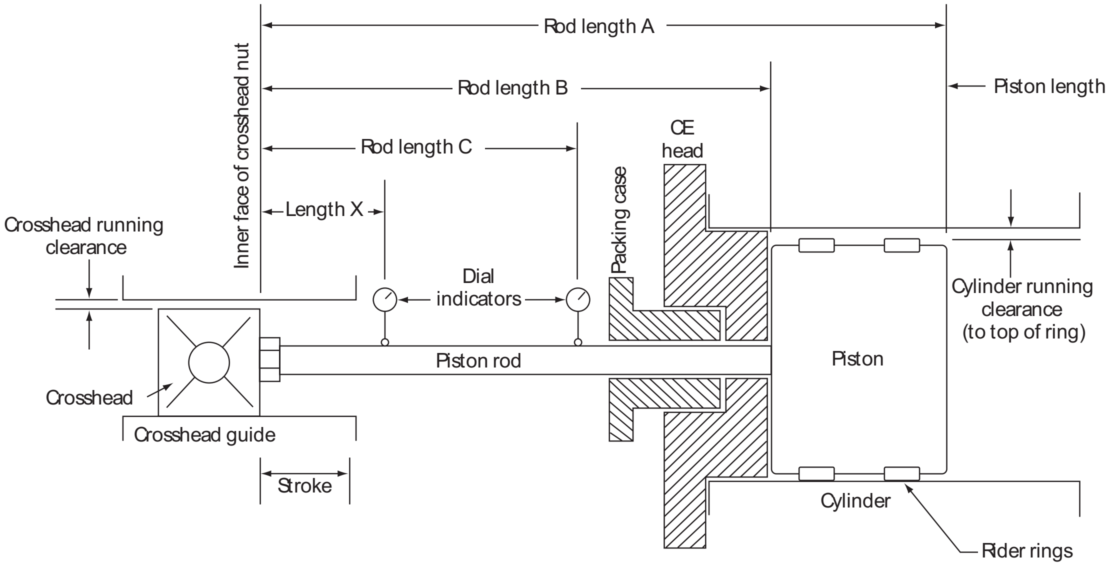
☐ Reference data

● 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-6A—Data for Rod Runout Calculation

Note: The cylinder running clearance is the bore ID minus the OD across the rider rings. Use actual values for final calculations.



☐ Throw number	1
☐ Stage	1
☐ Cylinder bore diameter	20 in.
● Cylinder running clearance	0.080 in., 0.060 in., 0.040 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

Notes: 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-6B—Rod Runout Calculation Example

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-6A 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 (that is, 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-6B 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 an 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

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 pressure packing case at the locations noted in C.5.2, and shown in Figure C-6A. 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. See 6.1.28 for allowable limit.

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-6A.

C.7.2 BASIC GEOMETRY

The basic geometry is illustrated in Figures C-1 and 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 (△ 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 △ 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 △ DROP at any point on the rod, which is necessary to calculate vertical rod runout at specific dial indicator locations when combining △ DROP with rod sag as shown in Figures C-4 and 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-6A. Note that the data includes both dial indicator positions along the top of the rod. The combined △ DROP and deflection must be calculated at these dial indicator positions as shown in Figures C-4 and C-5.

As can be seen from Figures C-4 and 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 (△ 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 (△ 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 Figures C-4 and C-5), the dial indicator at the crosshead should normally read positive.

C.8 Hot Runout

For large cylinders with aluminum pistons and Fluorocarbon wear 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 wear bands, 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 △ 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-5C and the five curves illustrated by Figures C-7 through C-11. 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.

ROD RUNOUT

EXAMPLE OF COMPUTERIZED PRINTOUT USING THE CYLINDER DATA OF FIGURE C-5B

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	

		Limits	
Standard calculated rod runout per Figure C-2			
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 Figures C-6 through C-10

Figure C-6C—Sample Printout for Rod Runout

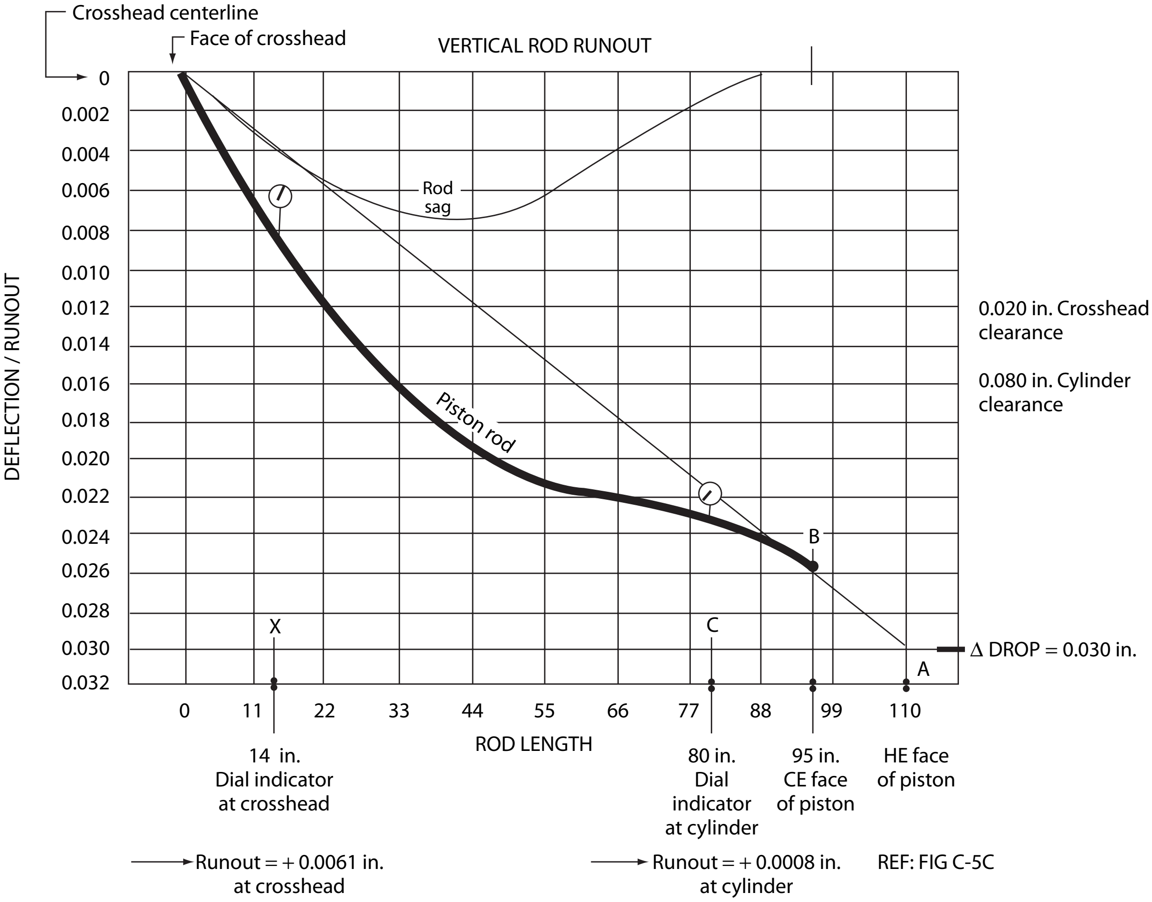


Figure C-7—Graphical Illustration of Rod Runout at 0.080 in. Cylinder Running Clearance

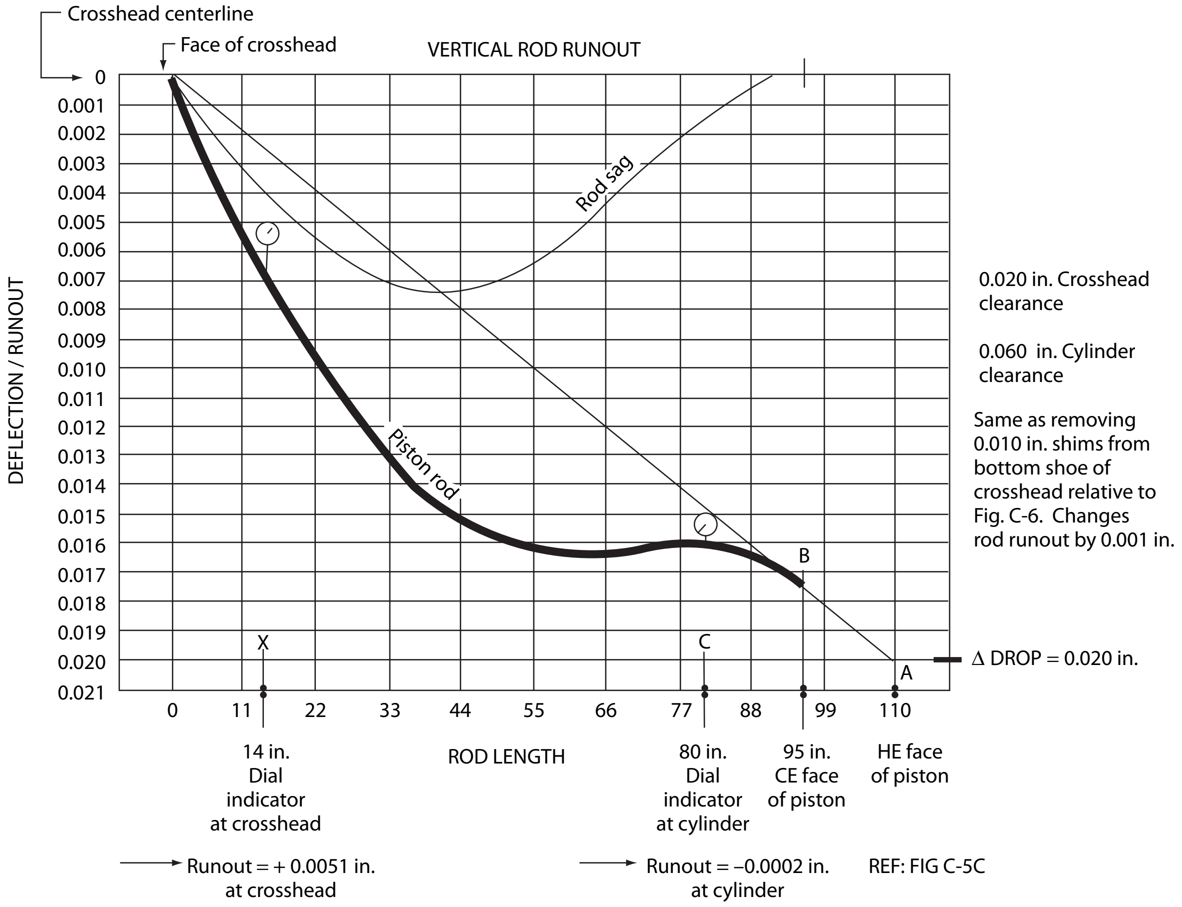


Figure C-8—Graphical Illustration of Rod Runout at 0.060 in. Cylinder Running Clearance

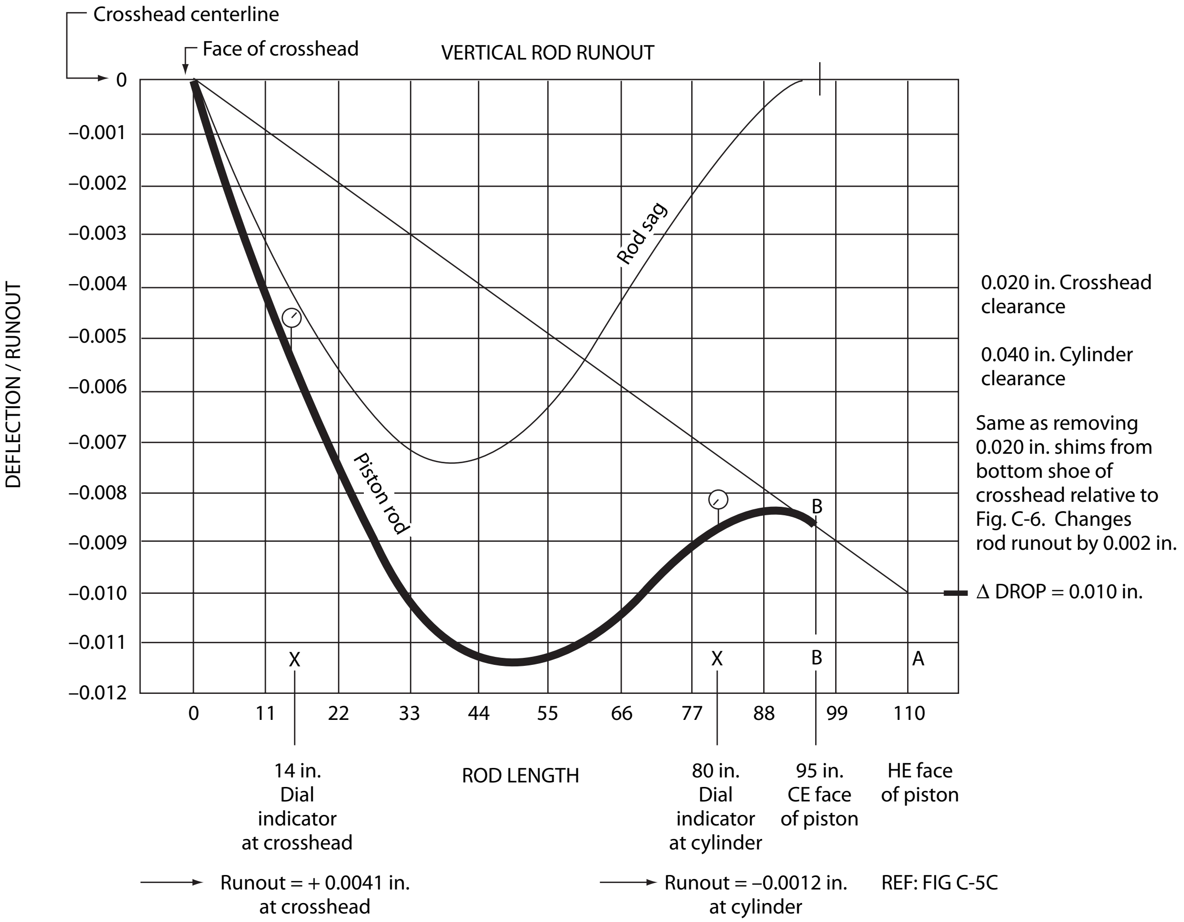


Figure C-9—Graphical Illustration of Rod Runout at 0.040 in. Cylinder Running Clearance

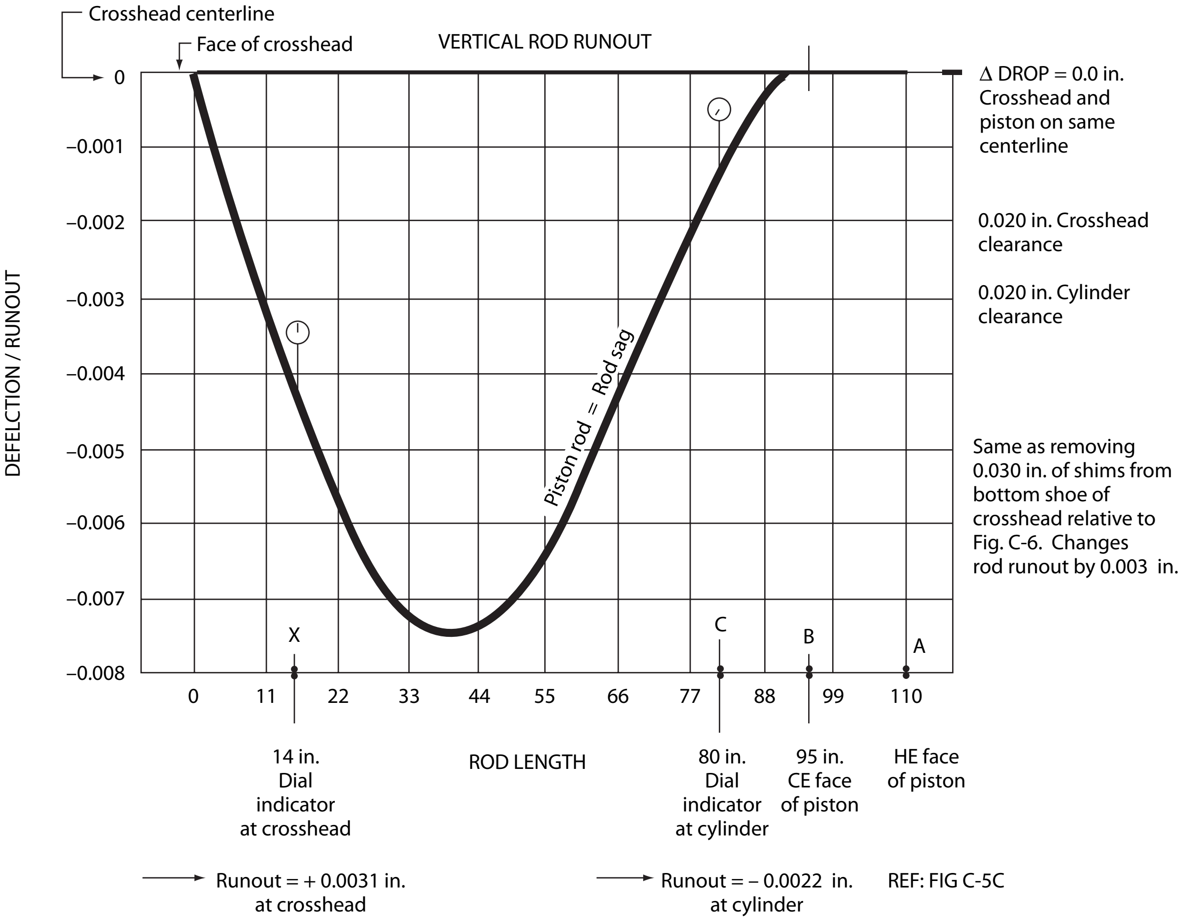


Figure C-10—Graphical Illustration of Rod Runout at 0.020 in. Cylinder Running Clearance

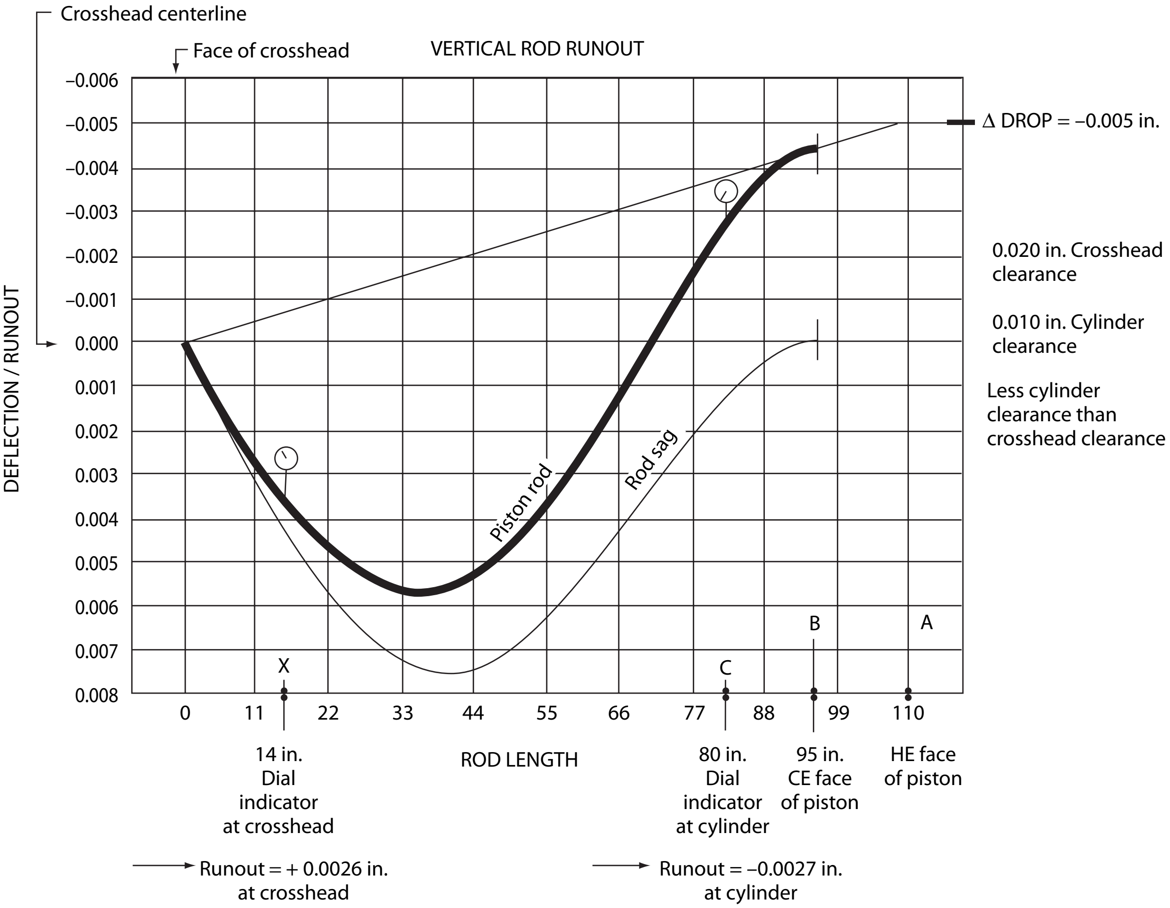


Figure C-11—Graphical Illustration of Rod Runout at 0.010 in. Cylinder Running Clearance

C.9 Vertical Runout Adjustment

C.9.1 If it is believed that some adjustment is necessary to the vertical runout readings, it must first be assured 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 △ 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 on Figure C-5C and in the series of five runout curves of Figures C-6 through C-10.

With reference to Figures C-6 and C-9, note that a 0.76 mm (0.030 in.) change of shims, that would put the crosshead and piston on the same centerline such that △ 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 must 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 △ 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 Figures C-1 and 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 △ DROP.

To see the effect of rider ring wear on vertical rod runout, use Figure C-10 as the initial reference and compare it to Figure C-9, which has a △ 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 in order 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.

Annex D
(informative)

Repairs to Gray or Nodular Iron Castings

D.1 Scope

This annex covers repair procedures that have been successfully applied to gray and nodular iron castings for compressor cylinders and related parts in various services. These procedures are only briefly described for the purpose of reference by the purchaser and the vendor; detailed descriptions of the procedures are beyond the scope of this standard. Limitations on the use of the procedures are included. These procedures should be applied only after careful evaluation of the situation by the purchaser and the vendor. When the service conditions of the casting involve toxic or hazardous gases, an even more exhaustive evaluation should be made.

D.2 Repair methods and limitations

In cylinders designed to handle gases having a mean molar mass (molecular weight) below 12, no repairs of any type shall be made to defects that result in leakage between the cylinder bore and the water jacket during hydrostatic testing. With the purchaser's written approval, the repair methods specified in D.2.1 through D.2.3 may be used for compressor cylinders designed to compress gases with a mean molar mass of 12 or greater.

D.2.1 Areas in which hydrostatic testing shows leaks between the water jacket and the atmosphere or between the gas passage and the atmosphere or between the water jacket and the gas passage may be repaired by plugging per 6.13.6.5.2, or by approved procedures for vacuum-plus-pressure impregnating. Impregnating may be considered only for limited porosity-type leakage and only after hydrostatic testing of both the water jacket and the gas passage has proved the mechanical integrity of the casting.

D.2.2 Defects that show up on machined surfaces or in other areas where no leak is involved, may be repaired by iron plating. Such defects could include porosity in valve seats or head and cylinder end faces or out-of-tolerance of cylinder bores requiring a liner. Plating repairs are not acceptable in critical areas such as o-ring seating areas or surfaces swept by the compressor piston, where sharp edges could damage o-rings, piston rings, and so forth. If repair plating is used in other locations, no sharp corners shall be formed or left which could damage o-rings, etc. (see 6.13.6.5).

D.2.3 Damaged threaded holes in castings may be mechanically repaired by use of thread inserts or bushings.

D.3 Tests

After any part is repaired in accordance with D.2.1, D.2.2, or D.2.3, the part shall be subjected to both a hydrostatic test and a gas test (see 8.3.2).

Annex E
(informative)

Purchaser's Checklist

This checklist 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 E-1—Purchaser's Checklist

Clause	Question	Answer
2.3	Applicable standards:____	
5.1	Have units of measurement been specified?	Yes No
6.1.3	Has equipment's normal operating point been specified?	Yes No
6.1.5	Has the pressure design code been specified?	Yes No
6.1.6	Requirements and maximum allowable sound pressure level? Requirement:____ Maximum allowable sound pressure level: _______________dB (A)	
6.1.12	Area classification for electrical components? Applicable standards:____ Are local codes and regulations applicable?	Yes No
6.1.17	Which details of an initial installation check shall be agreed by vendor and purchaser?____ Operating temperature alignment check?	Yes No
6.1.20	Location and environmental conditions (see data sheet, page 2).	
6.1.21	Have utility streams been identified?	Yes No
6.1.22	Equipment's normal operating point specified in the data sheet, page 1?	Yes No
6.4	Values specified by the purchaser, based on his experience? for: maximum average piston speed: _____________________ m/s for: maximum speed: __________________________________ rpm	
6.5.2	Is 100% unloading necessary?	Yes No
6.8.2.4	Is coating of the running bore of the cylinder required?	Yes No
6.8.3.5.2	Self-contained, forced circulation, closed jacket cooling system to be furnished by the vendor:	Yes No
6.8.4.1.16	DN 12 indicator tap at each end of each cylinder?	Yes No
6.8.4.1.17	Have indicator valves been specified?	Yes No
6.12.1.1	Type of distance piece, specified in data sheet, page 8?	Yes No
6.9.1.9	Shall the vendor submit a written valve dynamics report?	Yes No
6.9.2.1	Is unloading to be specified (data sheet, page 3)?	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 (data sheet, page 8)?	Yes No
6.12.1.4/5	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
6.12.2.4c	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
6.13.2.7	Closed liquid cooling system for packing to be supplied?	Yes No
6.13.1.6	Venting and buffer gas cups for cylinder pressure packing required?	Yes No
6.14.2.1.3	Is special purpose oil system specified?	Yes No
6.14.2.2	Has the type of driver for auxiliary lube oil pump been specified on the data sheet, page 11?	Yes No
6.14.2.5	Has the heating device for oil reservoir been specified on the data sheet, page 5?	Yes No
6.14.2.6	Shall the relief valve for crankcase driven pump be mounted outside the crankcase?	Yes No
6.14.2.1.10	Shall oil system be run in vendors shop?	Yes No

Table E-1—Purchaser's Checklist (Continued)

Clause	Question	Answer
6.14.3.1.1	Has the type of lubricator for compressor cylinders and for the pressure packing lubrication been specified on the data sheet, page 9?	Yes No
6.14.3.1.2	How shall lubricator to be driven?	From crankshaft / Independently
6.14.3.1.4	Is a heating device with thermostatic control for the lubricator reservoir required?	Yes No
6.14.3.1.6	Which alarm functions for cylinder and pressure packing lubrication are required? for cylinder:____ for pressure packing:____ (See data sheet, page 16)	
6.14.3.1.9	Are synthetic lubricants of compressor cylinder lubrication required and specified in data sheet, page 9?	Yes No
6.14.3.2.2	Is an agreement for additional or alternative protection device for divider block lubrication required?	Yes No
6.15.1.5	Are additional material tests specified?	Yes No
6.15.1.8	Has the presence and maximum amounts of corrosive, reactive or hazardous agents or components in the process fluid been specified on the data sheet, page 2?	Yes No
6.15.1.11	Has the amount of hydrogen sulfide been specified on the data sheet, page 2?	Yes No
6.15.5.12	Is additional inspection required for specific welds?	Yes No
6.15.5.13	Shall the proposed welding designs of fabricated cylinders be available for purchaser's review?	Yes No
6.15.6.5	Shall purchaser be given notice of repairs to major components?	Yes No
6.15.7.5	Is 100 % radiography of butt welds or magnetic particle inspection or liquid inspection of welds required?	Yes No
6.15.7.6	Shall proposed connection sketches be submitted to the purchaser before fabrication?	Yes No
6.15.8.1	Has the minimum design metal temperature related to the expected operating conditions been specified?	Yes No
6.16.7	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 on the data sheet, page 1?	Yes No
7.1.1.5	Are there process-variations or start-up conditions that affect driver selection?	Yes No
7.1.1.6	Are the driver starting conditions specified on the data sheet?	Yes No
7.1.2.1	Have the type of motor, its characteristics and accessories been specified on the data sheets?	Yes No
7.1.2.3	Shall single bearing motors be provided with a temporary inboard support device?	Yes No
7.1.2.4	Has the reduced voltage for starting-torque requirements been specified?	Yes No
7.1.2.15	Shall hydrodynamic motor bearings be supplied with oil from compressor frame lubrication system (data sheet, page 5)?	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 ISO 10 438 (or API Std 614) required?	Yes No
7.2.1.3	Are couplings required to comply with API Std 671 (data sheet, page 4)?	Yes No
7.2.1.7	Are couplings for auxiliary drives required to comply with API Std 671 (data sheet, page 4)?	Yes No
7.2.2.1	Has the standard for guards been specified on data sheet, page 4?	Yes No
7.3.1	Has the standard for gear units been specified on data sheet, page 4?	Yes No
7.5.1.1	Has the type of mounting plates been specified on the data sheet, page 4?	Yes No
7.5.3.5	Have chock blocks been specified on the data sheet, page 4?	Yes No
7.5.3.9	Have leveling plates been specified on data sheet, page 4?	Yes No
7.5.4.1	Has the major equipment to be mounted on a baseplate been indicated on the data sheet, page 4?	Yes No
7.5.4.8	Has a baseplate suitable for column mounting been specified on the data sheet, page 4?	Yes No
7.5.4.9	Shall the baseplate be designed to facilitate optical, laser, or other accurate leveling in the field?	Yes No
7.5.4.14	Shall a dynamic response analysis of the skid be performed?	Yes No
7.5.4.15	Shall sub-soleplates be provided with the baseplate?	Yes No
7.5.5.1	Have soleplates or rails been specified on the data sheet, page 4?	Yes No
7.5.5.4	Shall sub-soleplates be supplied for soleplates?	Yes No
7.6.1.2	Are all auxiliary system instrumentation be provided by the vendor specified?	Yes No
7.6.2.1	Which sensing lines handling hazardous fluids require transduced signals?____ Source of the control signal and its sensitivity and range?____________________________	
7.6.2.2	Has the configuration of the control system been specified?	Yes No

Table E-1—Purchaser's Checklist (Continued)

Clause	Question	Answer
7.6.2.4	Is an automatic loading-delay interlock required?	Yes No
7.6.4.1	Have instruments for local, gauge board, or instrument panel been specified?	Yes No
7.6.4.2	Has a tachometer to indicate compressor speed been specified on the data sheet, page 17?	Yes No
7.6.4.3.3	Have temperature detectors for packing been specified on the data sheet, page 16?	Yes No
7.6.4.3.4	Have temperature detectors for main bearings and valves been specified on data sheet, page 16?	Yes No
7.6.6.4	Has the extent of the alarm/shutdown system to be supplied by the vendor been specified on data sheet, page 16?	Yes No
7.6.6.6	Has the design of alarm and shutdown circuits been specified?	Yes No
7.6.6.7	Have high temperature alarms for crosshead pins been specified on data sheet, page 16?	Yes No
7.6.7.1	Shall the vendor furnish and mount vibration detection and transducing devices?	Yes No
7.6.7.2	Shall a non-contacting proximity device to measure vertical movement of each piston rod be installed?	Yes No
7.6.7.3	Shall a one-event-per-revolution mark be provided on the crankshaft?	Yes No
7.6.7.4	Shall the vendor provide piston rod drop detectors?	Yes No
7.6.8	Shall the vendor supply a temperature monitoring system in accordance with API Std 670?	Yes No
7.7.1.2	Has the extent of piping system to be supplied by the vendor been specified on data sheet, page 4?	Yes No
7.7.1.4	Shall piping, pulsation suppression devices and knockout vessels be arranged for heat tracing and insulation (see 7.9.5.1.17)?	Yes No
7.7.1.6	Shall the vendor review the drawings of all upstream and downstream piping, appurtenances, vessels and supports?	Yes No
7.7.1.13	Special requirements for piping, flanges, valves and other appurtenances for hydrogen, hydrogen sulphide or toxic services?________________________________	
7.7.2.5	Is a continuous through flow for instrument sensing lines to safety switches required?	Yes No
7.7.4.3	Shall coolant piping on the compressor be furnished by the vendor?	Yes No
7.7.6.1	Extent of process piping to be furnished by the vendor?________________________________	
7.7.6.3	Have design, location, and orientation of start-up screens been agreed?	Yes No
7.7.6.4	Shall a removable spool piece for start-up screens be supplied?	Yes No
7.8.1.1	Has the type of intercoolers to be furnished by the vendor been specified?	Yes No
7.8.1.2	Has the type of aftercoolers to be furnished by the vendor been specified?	Yes No
7.8.2.1	Shall liquid separation and collection facilities be provided?	Yes No
7.8.2.7	Shall an automatic drainage system be provided?	Yes No
7.8.2.8	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 on data sheet, page 4?	Yes No Yes No
7.9.2	Have alternate gases, conditions of service, or start-up been specified?	Yes No
7.9.3.1	Will compressor be operated in conjunction with other compressor units (data sheet, page 4)?	Yes No
7.9.3.2	Has Design Approach 1 been specified (data sheet, page 4)?	Yes No
7.9.4.1.2	Shall the analysis be performed by the vendor or a third party?	Vendor / Third party
7.9.4.2.5.2.2.4	Has criteria for flow pulsations in systems with sensitive elements been agreed upon?	Yes No
7.9.4.2.5.2.5.2	Shall a piping system flexibility analysis be performed?	Yes No
7.9.5.11	Shall the pulsation suppressors be stamped with the symbol of the specified pressure vessel code?	Yes No
7.9.5.1.4	Shall butt welds of pulsation suppression devices be 100% radiographed?	Yes No
7.9.5.1.7	Shall a final moisture removal section be included in the suction suppression device?	Yes No
7.9.5.1.10	Has purchaser approved use of circular notched baffles?	Yes No
7.9.5.1.11	Shall a thermowell connection for the cylinder nozzle of each suction pulsation suppressor be provided?	Yes No
7.9.5.1.17	Has provision for insulation at pulsation suppression devices been specified on the data sheet, page 14?	Yes No
7.9.5.1.20	Shall internals of carbon steel suppressors be coated with phenolic or vinyl resin?	Yes No
7.9.5.1.22	Shall dynamic and static stresses from pulsation-induced forces be analyzed?	Yes No
7.9.6	Shall the vendor supply supports for the pulsation suppression devices and for vendor supplied piping?	Yes No
7.10.1	Has purchaser specified special design details for air intake filters?	Yes No
7.11.2	Shall hydraulic tensioning tools be included in special tools?	Yes No

Table E-1—Purchaser's Checklist (Continued)

Clause	Question	Answer	
7.11.5	Shall the compressor be fitted with a device to lock the shaft in position during maintenance?	Yes	No
8.1.2	Is purchaser's inspector to submit completed inspection checklist before shipment?	Yes	No
8.1.6	Has the extent of purchaser's participation in the inspection and testing and amount of advance notification been specified on the data sheet, page 9?	Yes	No
8.2.1.1 f	Shall the vendor keep available for at least 20 years final-assembly, maintenance and running clearances?	Yes	No
8.2.1.3	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 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 on the data sheet, page 9?	Yes	No
8.2.3.4	Shall the hardness of parts, welds and heat-affected zones be tested?	Yes	No
8.3.3.2	Has a 4-hour running test of the compressor been specified on the data sheet, page 9?	Yes	No
8.3.3.3	Is a 4-hour mechanical running test prior to shipment required for packaged units, including auxiliary system packages?	Yes	No
8.3.3.6	Is an operational test and a 4-hour mechanical running test prior to shipment for auxiliary system consoles required?	Yes	No
8.3.3.7	Is dismantling for inspection 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	
9.2.3m	Special requirements for long term storage of spare parts?____________________		
9.2.3s	Is a list of similarly installed machines to be attached to the proposal required?	Yes	No
9.3.1.3	Has time allowed for the purchaser to review vendor's data been specified and agreed? (see VDDR form in Annex F)	Yes	No
9.3.3.1	Shall the vendor submit performance curves or tables etc.?	Yes	No
9.3.3.3	Shall the vendor furnish data required for independent rod-load, gas-load and rod-load reversal calculations?	Yes	No
9.3.3.4	Shall the effect of valve failure on rod loads and reversals be calculated and furnished?	Yes	No

Annex F
(normative)

Vendor Drawing and Data Requirements

F.1 General

This annex consists of a sample vendor drawing and data requirement form (VDDR), 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.

09 Insert VDDR form here (see Errata 1 at end of document).

F.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. Pressure packing drawing(s).
9. Gas load, rod load, and crosshead 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. Non-destructive 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.

F.3 Description of VDDR Items

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. See 6.8.2.4.1.

    b. The mass (weight) of each assembly, of the heaviest piece of equipment which must be handled for erection and of significant Items to be handled for maintenance.

    c. All principal dimensions, including 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:
    - a. Dimensions of mounting plates for the complete train and auxiliary systems complete with diameter, number and location of bolt holes and thickness of metal through which bolts must 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 (see 6.6.5). 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:
    - 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 must 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 9.3.3.1).
8. Pressure packing drawing(s). (One for each packing type.)
9. Gas load, rod load and crosshead load reversal and duration charts (see 9.3.3.2).
10. Starting torque versus speed curves. (For driver and compressor—on the same chart.) Acceleration time (see 9.3.3.5).
11. Motor driver performance characteristics and performance data including:
    - a. For induction motors 150 kW (200 hp) and smaller:
        1. Efficiency and power factors at one-half, three-quarter and full load.
        2. Speed-torque curves.
    - b. For induction motors larger than 150 kW (200 hp), certified test reports for all tests run and performance curves as follows:
        1. Time-current heating curve.
        2. Speed-torque curves at 70%, 80%, 90% and 100% of rated voltage.
        3. Efficiency and power factor curves from 0 to rated service factor.
        4. Current versus load curves from 0% – rated service factor.
        5. Current versus speed curves from 0% – 100% of rated speed.
        6. Permissible safe stall time and repeated start capability (hot and cold).
    - c. For synchronous motors.
        1. Speed-torque, current-speed and power factor-speed curves at 70%, 80%, 90% and 100% of rated voltage.
        2. Pull-in and pull-out torque.
        3. Permissible safe stall time and repeated start capability (hot and cold).
        4. Efficiency and power factor curves from 0 to rated service factor.

    5. 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 6.1.10).
14. Gear Data.

    a. Certified dimensional outline drawings and list of connections including:
        1. The size, rating, location and identification of all customer connections including vents, drains, lube oil, conduit boxes, junction boxes and instruments.
        2. All principal dimensions, including those required for the purchaser's foundation, piping design, maintenance clearances and dismantling clearances.
        3. Overall and handling masses.
        4. Shaft center line heights.
        5. Shaft end dimensions and tolerances for the couplings.
        6. Direction of rotation.
        7. Location of the center of mass of the gear unit.
        8. The size and location of anchor bolt holes and thickness of sections through which bolts must pass.
        9. 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:
        1. Data for torsional analysis.
        2. Lateral critical speed reports when specified.
        3. 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 gear manufacturer.
    f. Spare parts recommendations.

15. Other driver data, including:

    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:

    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 7.9.3.3).
18. Intercooler and aftercooler data, including, but not limited to:

    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 6.15.1.2.
20. "Start-up" spares list (see 9.2.3i).
21. Recommended normal maintenance spare parts (see 9.3.6).

22. Process schematic:

Schematic diagram of the process fluids flowing through the machine, including:

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:

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:

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:

   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 7.11.1). List of special tools furnished for maintenance.
38. Fabrication, testing and delivery schedule (see Item 42). 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 (see 6.1.16 and 7.7.1.6).
42. Progress reports (see 9.3.5). See Item 38, including:

   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 7.1.2.6) 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 7.9 and Annex M) including but not limited to:

   a. Design approach (see 7.9.4.2.1) 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.
   d. Other information as required by Annex M.

46. Data required for third-party acoustic and mechanical analysis. Information described in Annex M.

Note: It is the purchaser's responsibility to provide some of the information described.

47. Engineering analysis for fabricated cylinders (see 6.15.5.1).
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 6.9.1.9).
50. Data for an independent valve dynamic analysis.
51. Connection sketches (see 6.15.7.6).

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 15ºC (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:
    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. Non-destructive 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 8.3.4.1).
60. Certified mill test reports of Items as agreed in the pre-commitment or pre-inspection meeting(s). Physical and chemical data.
61. Crankshaft ultrasonic test certificate (see 8.2.2.3.3).
62. Valve leak test certificate.
63. As-built data sheets for compressor, gear, driver and auxiliary equipment, including gas data (see 6.1.23).
64. Installation manual (see 9.3.7.2) 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
        1. Items 1, 2, 3, 40, 52.
        2. Grouting (see 7.5.3.8).
        3. Setting equipment, rigging procedures, component masses and lifting diagram.
        4. Dismantling clearances.
        5. Preservation and storage requirements (see 8.4.2).
        6. Field assembly procedures, including frame and cylinder alignment requirements.
    b. Section 2—Driver
        1. Storage and preservation.
        2. Setting gear, rigging procedures, component masses and lifting diagram.
        3. Piping recommendations.
        4. Composite outline drawing for driver including anchor bolt hole locations.
        5. Dismantling clearances.
        6. Thermal and mechanical movements of frame and shaft.
        7. Motor air gap data (see 7.1.2.13).
    c. Section 3—Gear
        1. Storage and preservation.
        2. Setting gear, rigging procedures, component masses and lifting diagram.
        3. Piping recommendations.
        4. Composite outline drawing for gear including anchor bolt hole locations.
        5. Dismantling clearances.
        6. Thermal and mechanical movements of casing and shaft.
    d. Section 4—Auxiliary equipment
        1. Storage and preservation.
        2. Setting equipment, rigging procedures, component masses and lifting diagram.
        3. Piping recommendation.

65. Operation and maintenance manual, (see 9.3.7.3) 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
  1. Initial commissioning and start-up, including final tests and checks.
  2. Normal start-up.
  3. Normal shutdown.
  4. Emergency shutdown.
  5. Operating limits, including Item 13 above.
  6. Lube-oil recommendations, including injection rates and specifications.
  7. Routine operational procedures.
  8. 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:
  1. Valve overhaul data.
  2. Cylinder overhaul data.
  3. 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 non-lubricated condition.
  4. Fits and clearances for wearing parts, recommended, maximum and minimum.
  5. Items 4, 8, 19, 21, 37, 48, 52, 53 and 63.
  6. Routine maintenance requirements.
  7. 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
  1. Drawings in the manual shall be for the specific equipment supplied. Typical drawings are unacceptable.
  2. 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 9.3.7.4.

Technical and quality control data for technical support personnel for the complete train and auxiliary equipment, including but not limited to:

Items 1 – 16, 18 – 20, 23, 26, 29 – 31, 33 – 37, 39 – 40, 43, 45 – 49, 52 – 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 (see 7.6.2.3).

Annex G
(normative)

Figures and Schematics

G.1 General

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 vendor.

Instrument piping and valving details are not shown on typical schematics. Such requirements, including on-line testing requirements, shall be agreed upon by the purchaser and 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 I.

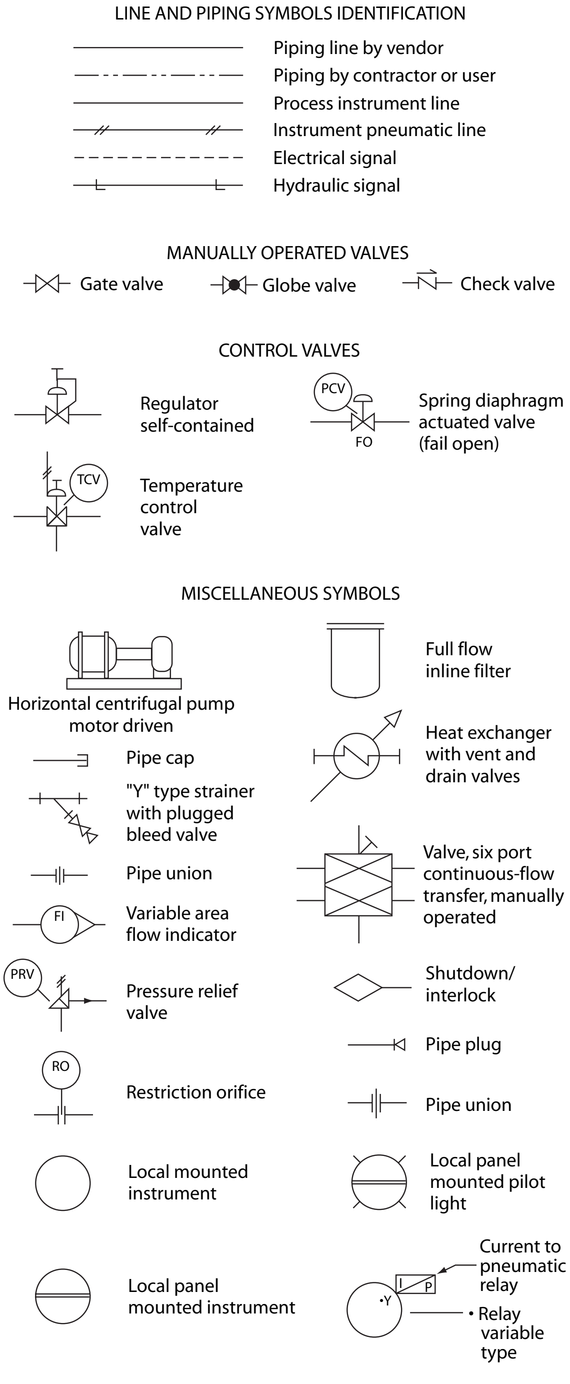
G.2 Legend for Schematics

The abbreviations and symbols used in the schematics in this annex are defined below.

G.2.1 FLOW DIAGRAM IDENTIFICATIONS LETTERS

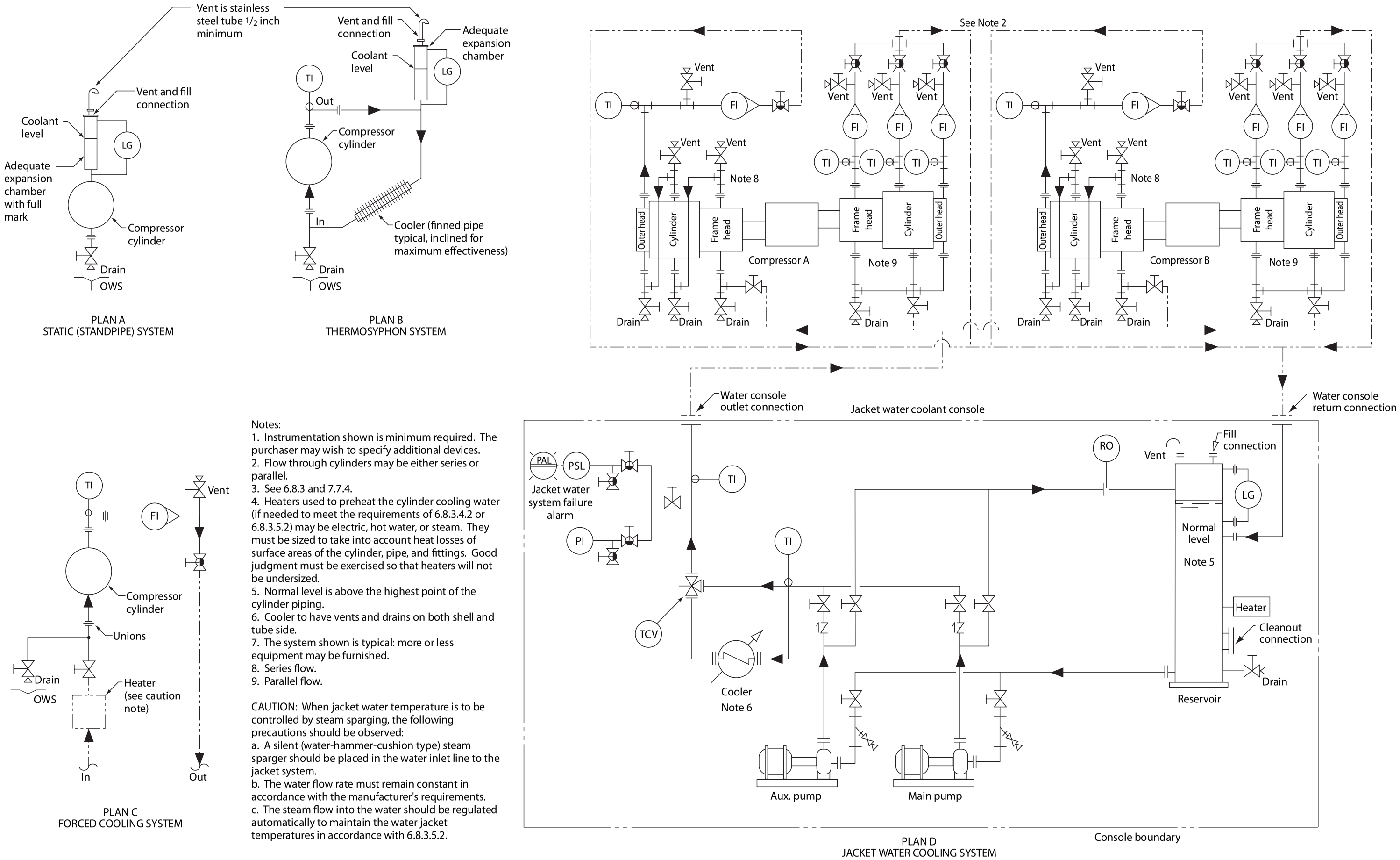
Letter	First Letter	Subsequent Letters
A	Analysis	Alarm
C	Conductivity (Electrical)	Controller
D	Density (Sp. Gr.)	Differential
E	Voltage (EMF/Electrical)	Element (Primary)
F	Flow	Ratio (Fraction)
G	Gauging (Dimensional)	Glass/Gauge
H	Hand Actuated (Manual)	High
I	Current (Amps)	Indicator
L	Level	Light/Low
O	(Unclassified)	Orifice (Restriction)
P	Pressure/Vacuum	Point
S	Speed/Frequency	Safety/Switch
T	Temperature	Transmitter
V	Vibration/Viscosity	Valve
Y	(Unclassified)	Relay

G.2.2 SYMBOLS



ABBREVIATIONS

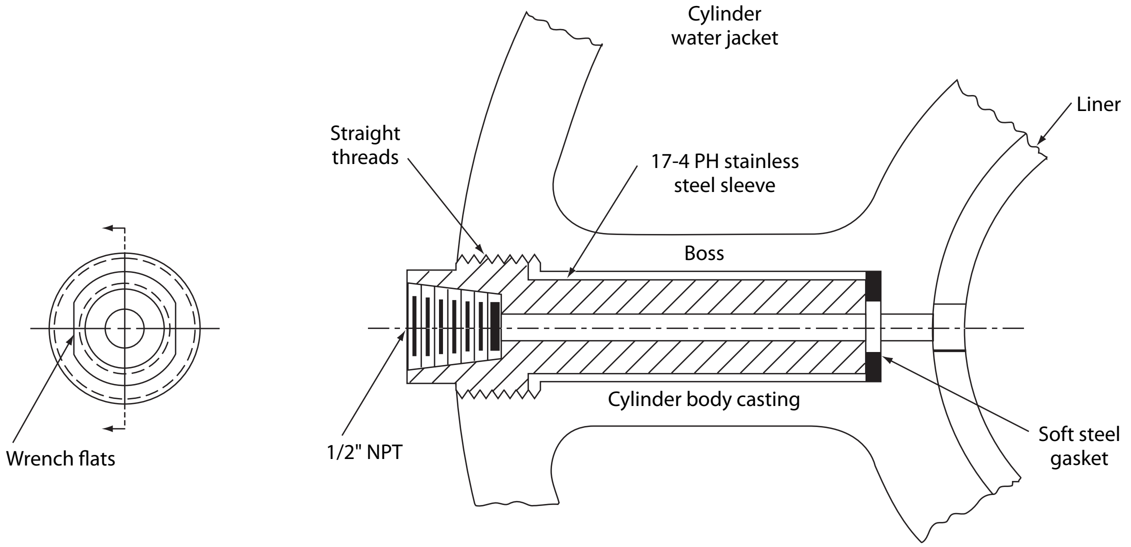
CSO – Car Seal Open	OWS – Oily Water Sewer
FO – Fail Open	FC – Fail Closed
NO – Normally Open	NC – Normally Closed



Notes:
1. Instrumentation shown is minimum required. The purchaser may wish to specify additional devices.
2. Flow through cylinders may be either series or parallel.
3. See 6.8.3 and 7.7.4.
4. Heaters used to preheat the cylinder cooling water (if needed to meet the requirements of 6.8.3.4.2 or 6.8.3.5.2) may be electric, hot water, or steam. They must be sized to take into account heat losses of surface areas of the cylinder, pipe, and fittings. Good judgment must be exercised so that heaters will not be undersized.
5. Normal level is above the highest point of the cylinder piping.
6. Cooler to have vents and drains on both shell and tube side.
7. The system shown is typical: more or less equipment may be furnished.
8. Series flow.
9. Parallel flow.

CAUTION: When jacket water temperature is to be controlled by steam sparging, the following precautions should be observed:
a. A silent (water-hammer-cushion type) steam sparger should be placed in the water inlet line to the jacket system.
b. The water flow rate must remain constant in accordance with the manufacturer's requirements.
c. The steam flow into the water should be regulated automatically to maintain the water jacket temperatures in accordance with 6.8.3.5.2.

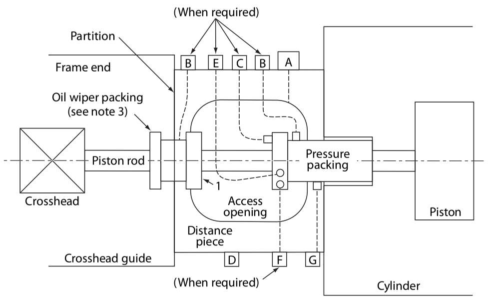
Figure G-1—Cylinder Cooling System



Note 1: See 6.8.4.1.16

Note 2: This typical arrangement utilizes a 17-4 stainless steel sleeve as a standard compressor cylinder design. The sleeve is installed during manufacture of the cylinder, providing a high-strength, corrosion resistant passage through a minor boss area. The design installation arrangement of the 17-4 stainless steel sleeve may vary among manufacturers.

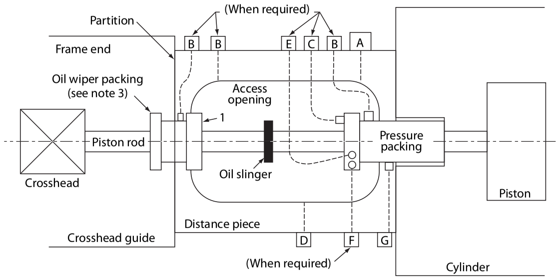
Figure G-2—Typical Cylinder Indicator Tap Connection



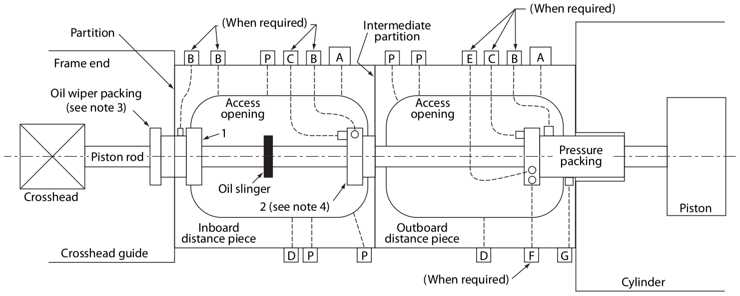
TYPE A
SHORT SINGLE-COMPARTMENT DISTANCE PIECE
(MAY BE INTEGRAL WITH CROSSHEAD GUIDE OR CRANK END HEAD)

Legend:
1. Seal or buffer packing, distance piece
2. Intermediate seal or buffer packing, distance piece (solid access covers required)

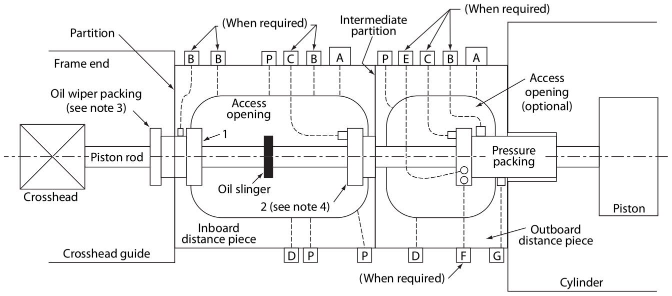
Connections (see 6.12.2 for sizes):
A Vent, distance piece
B Purge, buffer, or pressure, packing or distance piece
C Lube, pressure packing
D Drain, distance piece
E Coolant out, pressure packing
F Coolant in, pressure packing
G Common vent and drain, pressure packing
P Plugged connection



TYPE B
LONG SINGLE-COMPARTMENT DISTANCE PIECE
(SUFFICIENT LENGTH FOR OIL SLINGER TRAVEL)



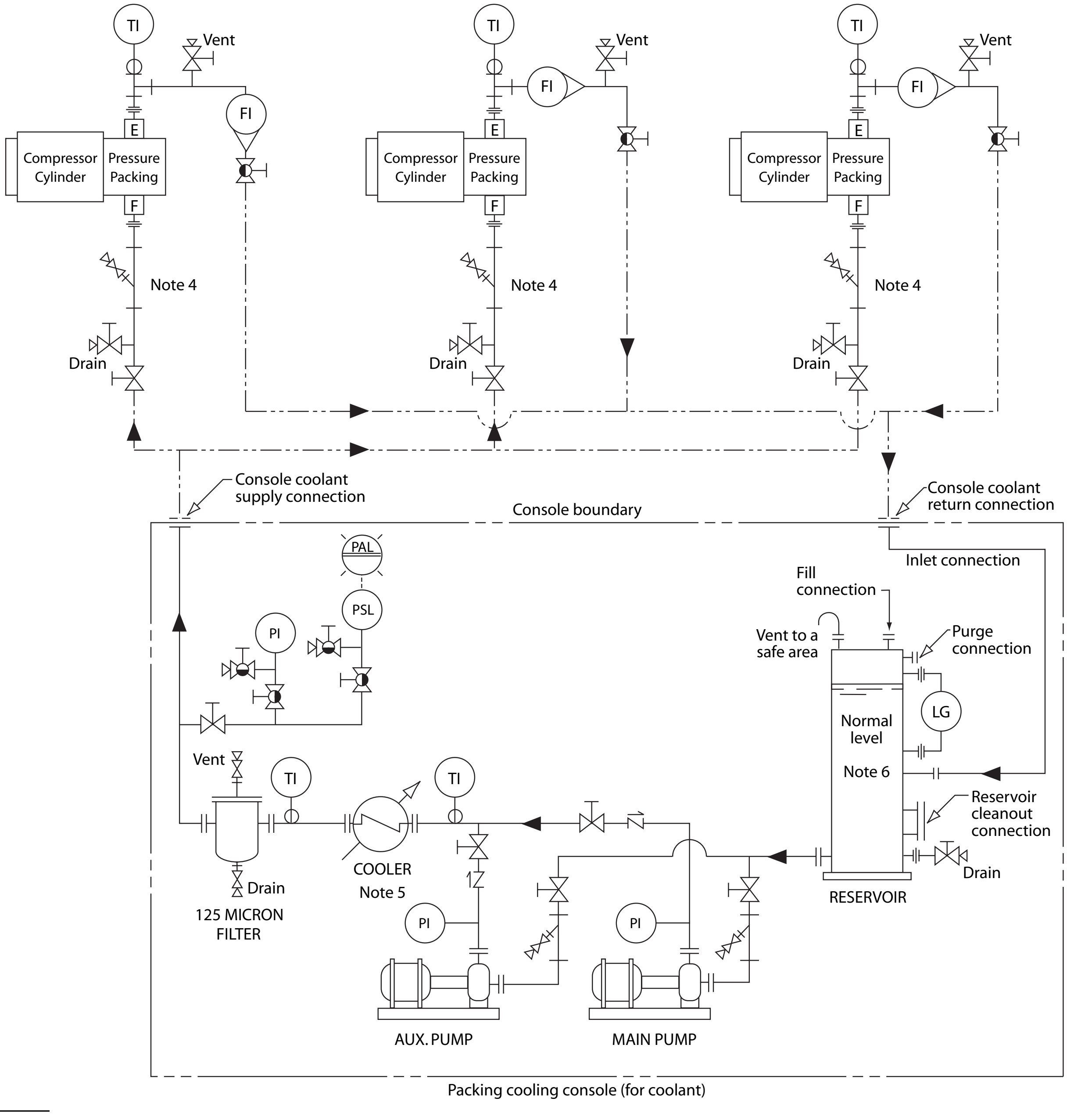
TYPE C
LONG TWO-COMPARTMENT OR DOUBLE DISTANCE PIECE ARRANGEMENT
(INBOARD AND OUTBOARD DISTANCE PIECES EACH OF SUFFICIENT
LENGTH FOR OIL SLINGER TRAVEL)



TYPE D
SHORT TWO-COMPARTMENT OR DOUBLE DISTANCE PIECE ARRANGEMENT
(INBOARD DISTANCE PIECE OF SUFFICIENT LENGTH FOR OIL SLINGER TRAVEL)

Notes:
1. See 6.10 and 6.13.1.3.
2. The orientation of distance-piece and packing-flange/case connections may vary depending on the individual distance piece and the type of packing case used.
3. The oil wiper packing may be located in the distance piece on the other side of the partition from that shown, and would be an integral assembly with the seal or buffer packing (1).
4. The intermediate seal or buffer packing (2) may be located in the outboard distance piece on the other side of the partition from that shown.

Figure G-3—Distance Piece and Packing Arrangements



Note 1: The instrumentation shown is the minimum required. The purchaser may wish to specify additional devices.

Note 2: For cooling medium other than water system design shall be mutually agreed upon between purchaser and the vendor.

Note 3: See 6.13.

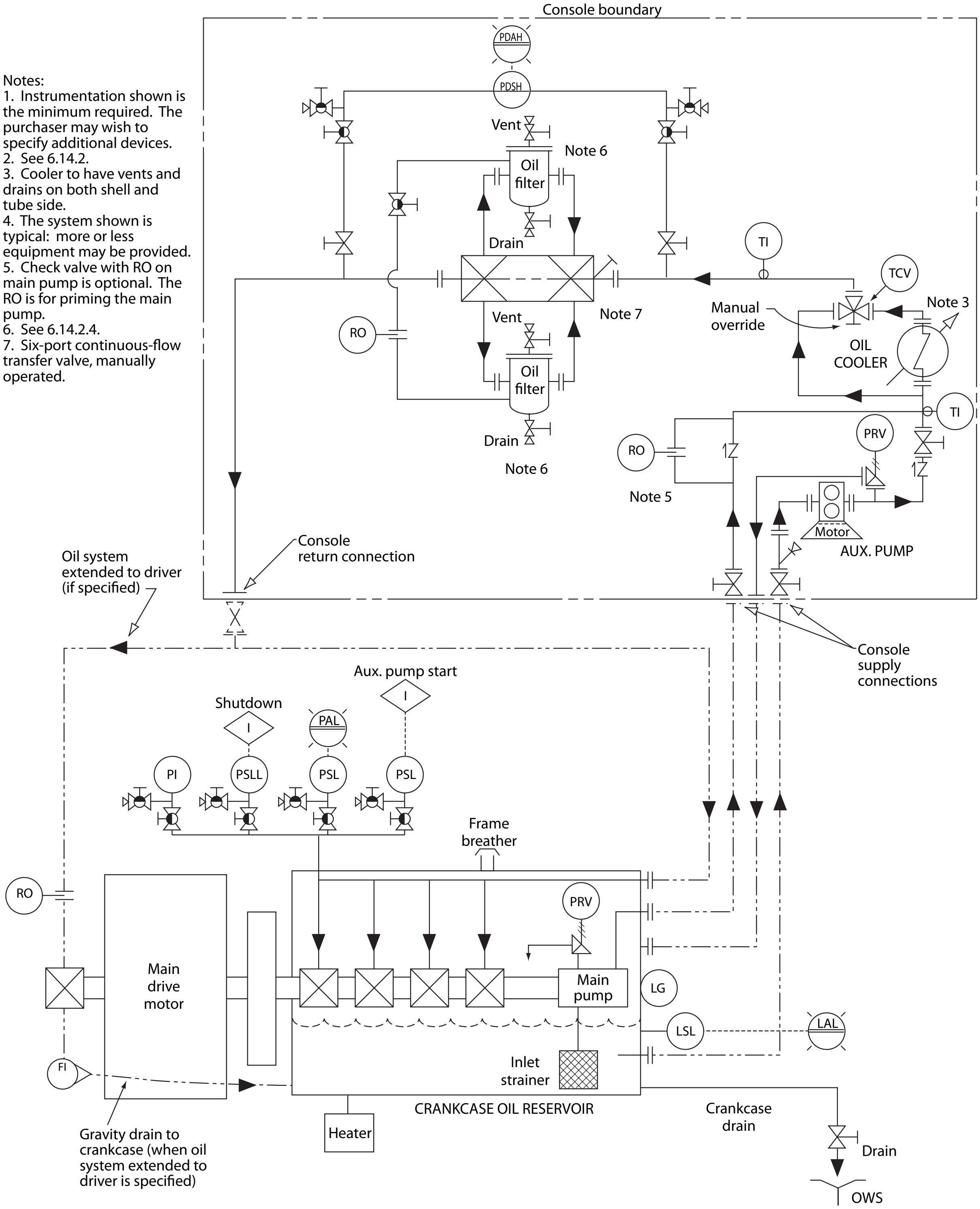
Note 4: If a packing cooling console is not supplied, individual strainers are required (see 6.13.2.6).

Note 5: Cooler to have vents and drains on both shell and tube side.

Note 6: Normal level is above the highest point of the piping on the compressor cylinders.

Note 7: The system shown is typical: more or less equipment may be provided.

Figure G-4—Typical Self-Contained Cooling System for Piston Rod Pressure Packing



Notes:
1. Instrumentation shown is the minimum required. The purchaser may wish to specify additional devices.
2. See 6.14.2.
3. Cooler to have vents and drains on both shell and tube side.
4. The system shown is typical: more or less equipment may be provided.
5. Check valve with RO on main pump is optional. The RO is for priming the main pump.
6. See 6.14.2.4.
7. Six-port continuous-flow transfer valve, manually operated.

Figure G-5—Typical Pressurized Frame Lube Oil System

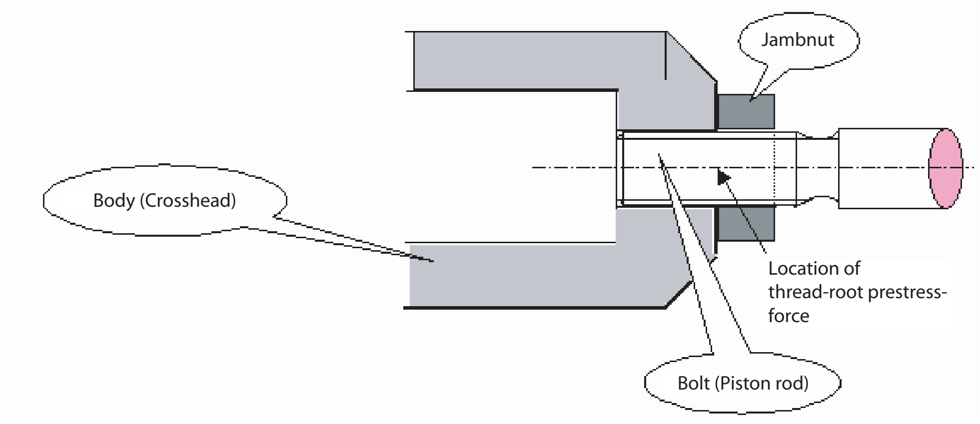


Figure G-6—Conceptual Direct Rod Connection

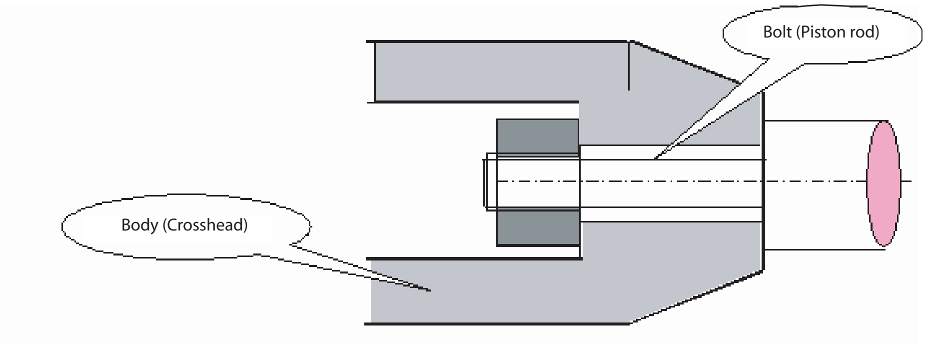


Figure G-7—Conceptual Indirect Rod Connection

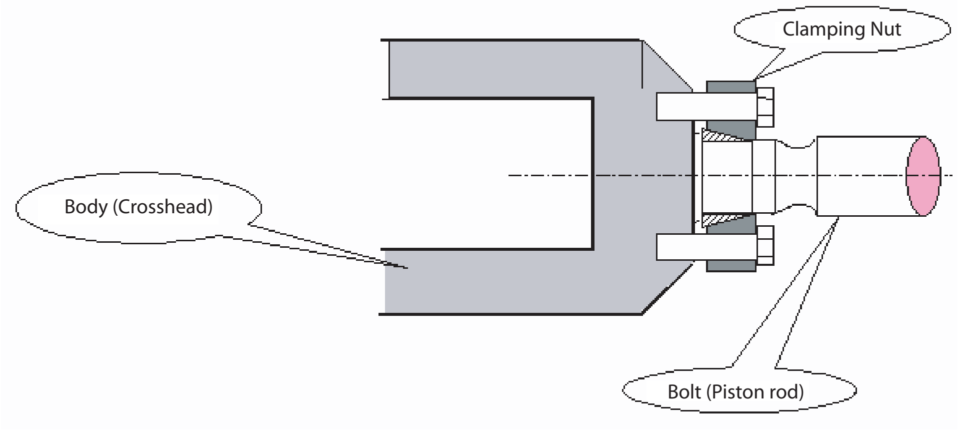
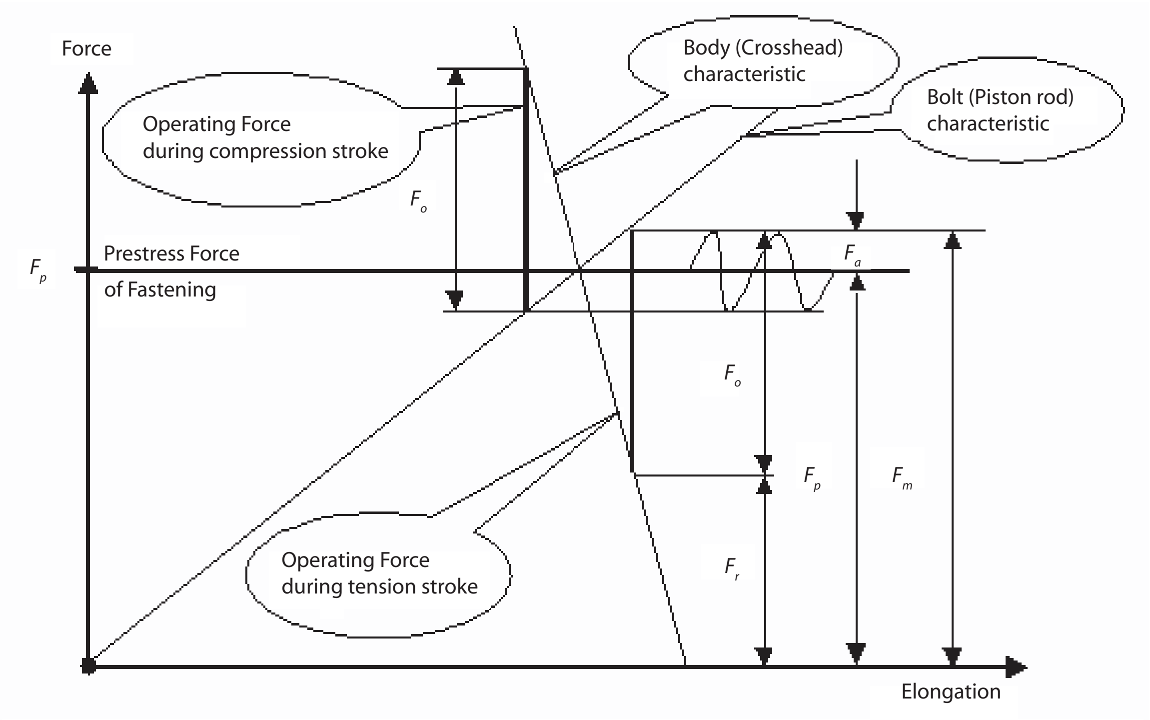


Figure G-8—Conceptual Indirect Clamped Rod Connection



Definitions: F_p = Prestress of the Fastening
F_o = Operating Force (under MAWP-condition, or at maximum allowable continuous rod load)
F_a = amplitude of the alternating Force (in the bolt-shaft and thread)
F_m = max Force (in the bolt-shaft and thread)
F_r = min remaining Force in the fastening
S_{max} = max stress in the thread-root or any other area of the bolt due to F_m
S_a = alternating Stress at the thread-root section due to F_a

Figure G-9—Tightening Diagram (Bolt–Bracing–Diagram)

Annex H
(Informative)

Materials for Major Component Parts

Table H-1—Material Specifications for Reciprocating Compressor Parts

Part	Material	Form
Frame	Cast iron	Cast
Crankshafts	Steel	Forged
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 tailrods	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
	Cast iron	Cast
Valve plates	Stainless steel	Plate
	Non-metallic	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
	Non-metallic	Molded or Sintered

Annex I
(informative)

Distance Piece Vent, Drain and Buffer Systems to Minimize Process Gas Leakage

I.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 vendor. It is good practice for the vendor and purchaser to discuss the vent and drain system, and agree on its design (see 6.12.2).

Instrument piping and valving details are not shown on typical schematics. Such requirements, including on-line testing requirements, should be agreed upon by the purchaser and vendor.

I.2 Abbreviation and Symbols

The abbreviations and symbols used in the schematics in this annex are shown in Annex G.

I.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:

a. confining and collecting the normal leakage from compressor rod pressure packing and carrying the leakage to a safe location;
b. preventing process gas, toxic gas or hazardous gas leakage into the area around the machine;
c. preventing contamination of the crankcase lube oil;
d. atmospheric fugitive emission control;
e. confining and collecting large leakage in the event of compressor pressure packing failure, and directing the leakage to a safe location;
f. helping to prevent an explosive atmosphere from developing in the crankcase;
g. preventing excessive liquid accumulation in the distance piece;
h. avoiding gas leakage to sewer systems;
i. allowing the operator to monitor and determine the condition of compressor rod pressure packing.

I.4 Minimizing Process Gas Leakage

Figures I-1 and I-2 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, Figure I-3, 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 towards the sealing face of the cup. This mechanical axial loading, added to a buffer gas pressure at least 1 bar higher than the disposal pressure, hold the rings positively against their sealing faces minimizing buffer gas leakage and, at the same time, assures that all the process gas that leaks past the cylinder pressure packing cups will be forced out into the disposal system (for example, the flare) through the vent.

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 (see 6.13.1.6).

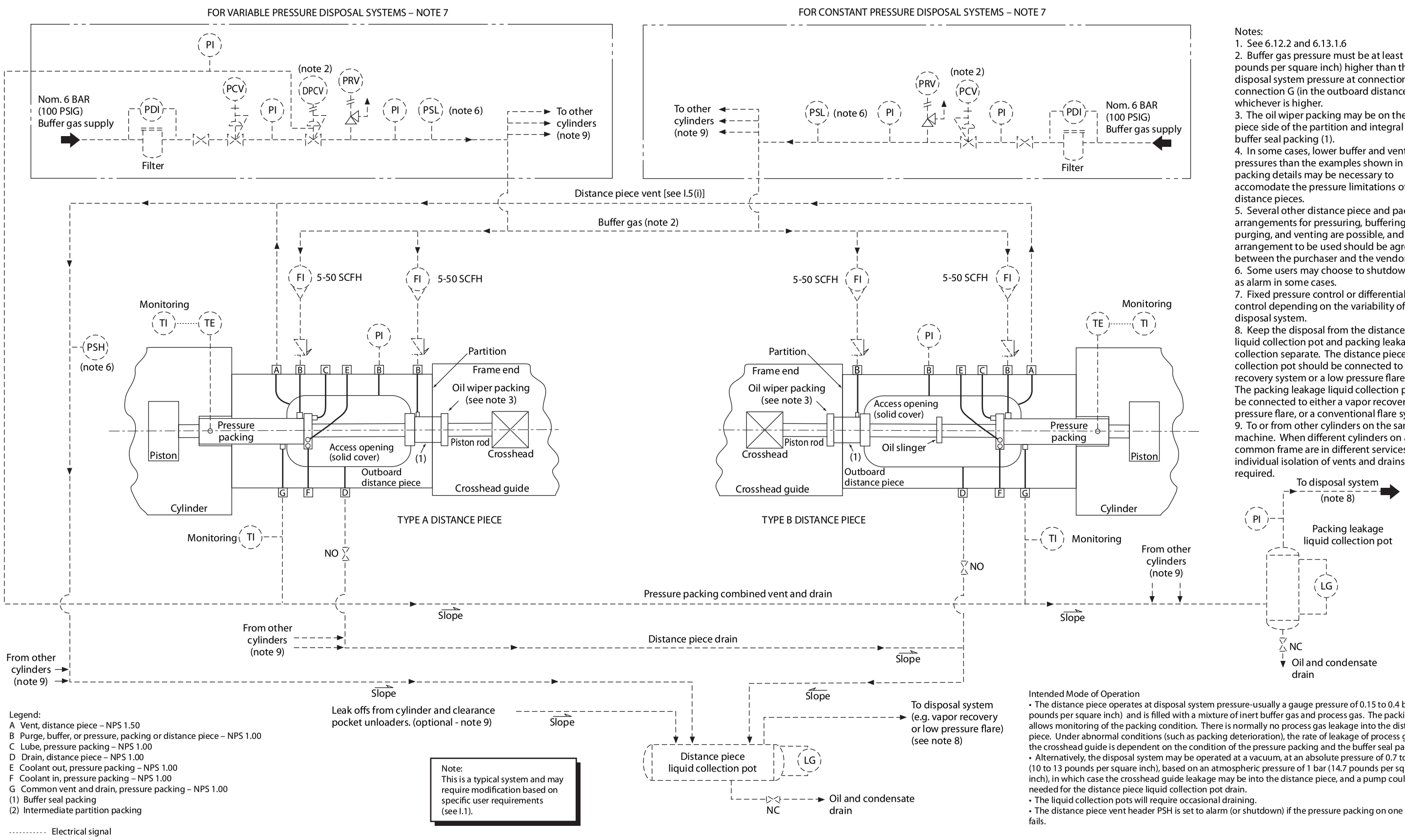
I.5 Design Consideration

In addition to meeting the purposes described in I.2 the following factors should be considered when designing in 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 (see 6.12.2.1).
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). See 6.12.2.3.

Note: Distance pieces are typically designed for a maximum gauge pressure of 2 bar (25 psi). Special designs are required for higher pressures.

f. Typically, the common vent and drain from the pressure packing (connection G in Figure I-1 and I-2) 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. There is concern about the reliability of check valves in safety situations, particularly in low pressure systems such as distance piece vent and drain systems where there is any mixture of gas and liquids. Check valve use should be avoided, where possible.
i. Except for the 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.
j. Large diameter tubing [20 mm ($^3/_4$ in.) OD minimum] can be used between the individual distance pieces and the vent and drain headers. This usually results in a neat, easily maintained installation compared to a piping system.
k. Manifolding and cross-connections with drains and blowoffs from other equipment should be avoided.
l. The buffer gas purge pressure must be limited to the maximum allowable pressure for the distance piece components (see 6.10.4). Some buffer gas will flow into the compressor frame. Frame venting must allow an outlet for this flow (see Figure G-5).
m. Pneumatic trip systems internal to the frame (e.g., crosshead pin temperature) should be energized with nitrogen rather than air to assist in maintaining an inert atmosphere in the crankcase.
n. Effective establishment of an inert atmosphere in the crankcase will necessitate special maintenance safety procedures.
o. Where climatic conditions require, drains should be heat-traced and insulated.
p. Under total packing failure, it should not be possible to over-pressure the distance piece (see 6.10.4 and 6.10.5). If the vent area is not sufficient, additional venting to a safe location by way of emergency pressure relief valves or spring-loaded pressure relief doors may be required.
q. Buffer gas purge rates are typically sized for a flow rate of 0.03 m^3/h (10 standard ft^2/h) per packing set [may reach 0.2 m^3/h (65 standard ft^2/h) per packing set on startup] and are fitted with flow indicators.



Notes:
1. See 6.12.2 and 6.13.1.6
2. Buffer gas pressure must be at least 1 bar (15 pounds per square inch) higher than the disposal system pressure at connection A or connection G (in the outboard distance piece) whichever is higher.
3. The oil wiper packing may be on the distance piece side of the partition and integral with the buffer seal packing (1).
4. In some cases, lower buffer and vent pressures than the examples shown in the packing details may be necessary to accomodate the pressure limitations of large distance pieces.
5. Several other distance piece and packing arrangements for pressuring, buffering, purging, and venting are possible, and the arrangement to be used should be agreed upon between the purchaser and the vendor.
6. Some users may choose to shutdown as well as alarm in some cases.
7. Fixed pressure control or differential pressure control depending on the variability of the disposal system.
8. Keep the disposal from the distance piece liquid collection pot and packing leakage liquid collection separate. The distance piece liquid collection pot should be connected to a vapor recovery system or a low pressure flare system. The packing leakage liquid collection pot can be connected to either a vapor recovery, a low pressure flare, or a conventional flare system.
9. To or from other cylinders on the same machine. When different cylinders on a common frame are in different services, individual isolation of vents and drains may be required.

Intended Mode of Operation
- The distance piece operates at disposal system pressure-usually a gauge pressure of 0.15 to 0.4 bar (2 to 5 pounds per square inch) and is filled with a mixture of inert buffer gas and process gas. The packing vent TI allows monitoring of the packing condition. There is normally no process gas leakage into the distance piece. Under abnormal conditions (such as packing deterioration), the rate of leakage of process gas into the crosshead guide is dependent on the condition of the pressure packing and the buffer seal packing (1).
- Alternatively, the disposal system may be operated at a vacuum, at an absolute pressure of 0.7 to 0.9 bar (10 to 13 pounds per square inch), based on an atmospheric pressure of 1 bar (14.7 pounds per square inch), in which case the crosshead guide leakage may be into the distance piece, and a pump could be needed for the distance piece liquid collection pot drain.
- The liquid collection pots will require occasional draining.
- The distance piece vent header PSH is set to alarm (or shutdown) if the pressure packing on one cylinder fails.

Leak offs from cylinder and clearance pocket unloaders. (optional - note 9)

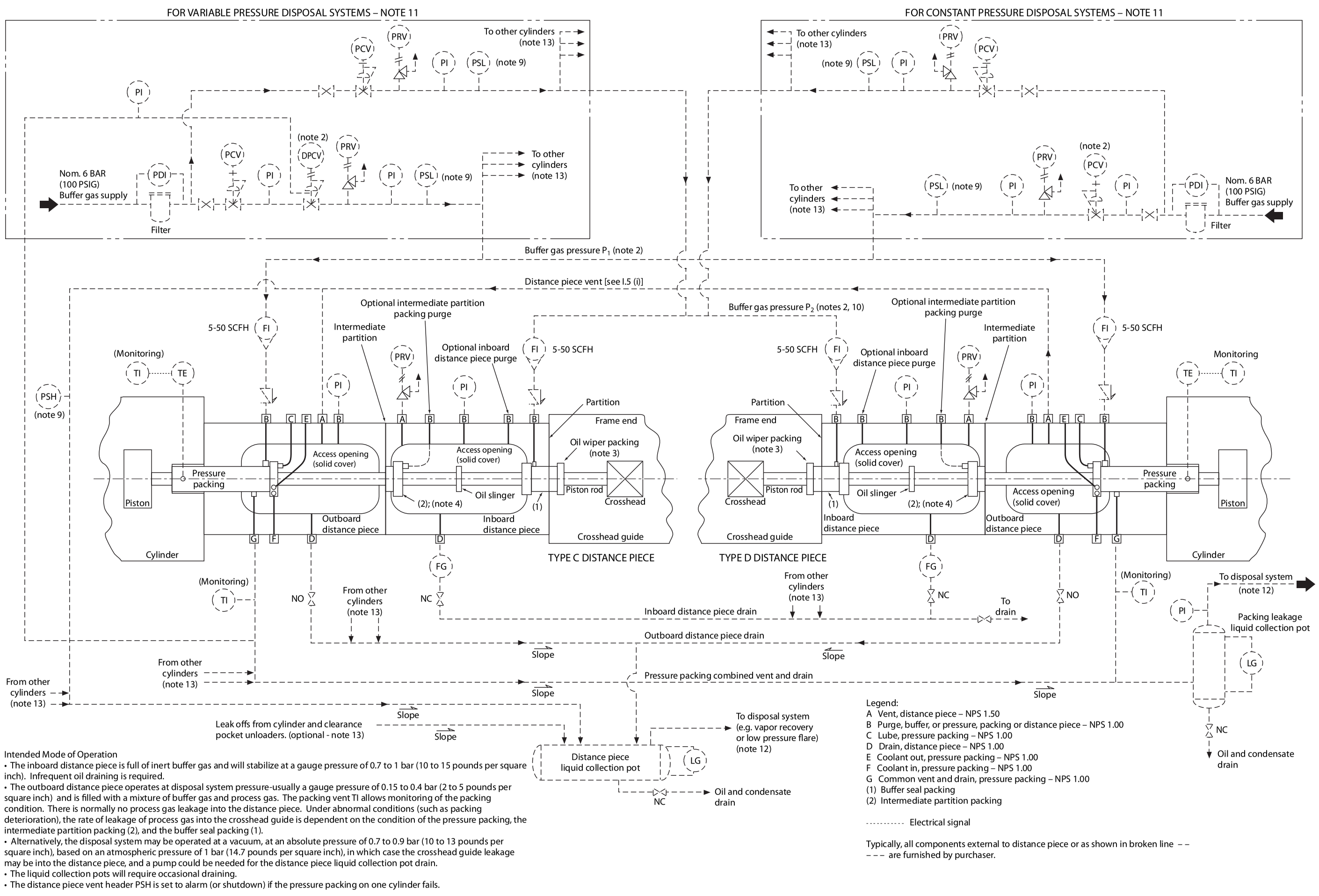
Legend:
A Vent, distance piece – NPS 1.50
B Purge, buffer, or pressure, packing or distance piece – NPS 1.00
C Lube, pressure packing – NPS 1.00
D Drain, distance piece – NPS 1.00
E Coolant out, pressure packing – NPS 1.00
F Coolant in, pressure packing – NPS 1.00
G Common vent and drain, pressure packing – NPS 1.00
(1) Buffer seal packing
(2) Intermediate partition packing

.... Electrical signal

Typically, all components external to distance piece or as shown in broken line – – – – – are furnished by purchaser.

Note:
This is a typical system and may require modification based on specific user requirements (see I.1).

Figure I-1—Typical Buffered Single Compartment Distance Piece Vent, Drain, and Buffer Arrangement to Minimize Process Gas Leakage



Intended Mode of Operation
- The inboard distance piece is full of inert buffer gas and will stabilize at a gauge pressure of 0.7 to 1 bar (10 to 15 pounds per square inch). Infrequent oil draining is required.
- The outboard distance piece operates at disposal system pressure-usually a gauge pressure of 0.15 to 0.4 bar (2 to 5 pounds per square inch) and is filled with a mixture of buffer gas and process gas. The packing vent TI allows monitoring of the packing condition. There is normally no process gas leakage into the distance piece. Under abnormal conditions (such as packing deterioration), the rate of leakage of process gas into the crosshead guide is dependent on the condition of the pressure packing, the intermediate partition packing (2), and the buffer seal packing (1).
- Alternatively, the disposal system may be operated at a vacuum, at an absolute pressure of 0.7 to 0.9 bar (10 to 13 pounds per square inch), based on an atmospheric pressure of 1 bar (14.7 pounds per square inch), in which case the crosshead guide leakage may be into the distance piece, and a pump could be needed for the distance piece liquid collection pot drain.
- The liquid collection pots will require occasional draining.
- The distance piece vent header PSH is set to alarm (or shutdown) if the pressure packing on one cylinder fails.

Legend:

A	Vent, distance piece – NPS 1.50
B	Purge, buffer, or pressure, packing or distance piece – NPS 1.00
C	Lube, pressure packing – NPS 1.00
D	Drain, distance piece – NPS 1.00
E	Coolant out, pressure packing – NPS 1.00
F	Coolant in, pressure packing – NPS 1.00
G	Common vent and drain, pressure packing – NPS 1.00
(1)	Buffer seal packing
(2)	Intermediate partition packing
----------	Electrical signal

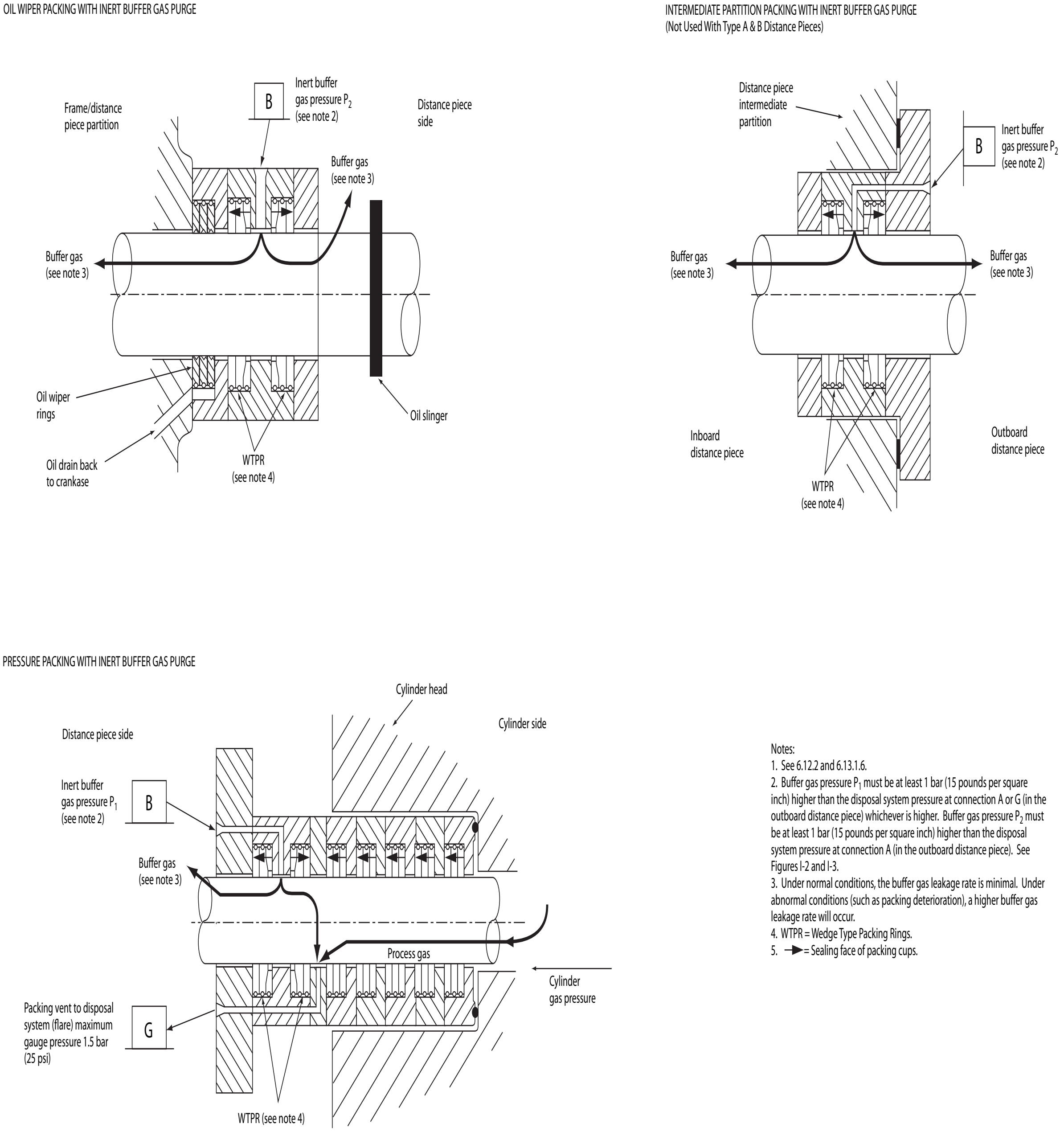
Typically, all components external to distance piece or as shown in broken line – – – – – are furnished by purchaser.

Notes:

1. See 6.12.2 and 6.13.1.6
2. Buffer gas pressure P_1 must be at least 1 bar (15 pounds per square inch) higher than the disposal system pressure at connection A or connection G (in the outboard distance piece) whichever is higher. Buffer gas pressure P_2 must be at least 1 bar (15 pounds per square inch) higher than the disposal system pressure at connection A (in the outboard distance piece).
3. The oil wiper packing may be on the distance piece side of the partition and integral with the buffer seal packing (1).
4. The intermediate partition packing (2) may be buffered in addition to the pressure packing in which case the inboard distance piece may be vented to the atmosphere.
5. In some cases, lower buffer and vent pressures than the examples shown may be necessary to accomodate the pressure limitations of large distance pieces.
6. Several other distance piece and packing arrangements for pressuring, buffering, purging, and venting are possible, and the arrangement to be used should be agreed upon between the purchaser and the vendor.
7. The orientation of the distance piece and packing flange/case connections may vary depending on the individual distance piece and the type of packing case used.
8. The intermediate partition packing (2) may be located in the outboard distance piece on the other side of the partition from that shown.
9. Some users may choose to shutdown as well as alarm in some cases.
10. Buffer gas may be fed either to the buffer seal packing (1) as shown, or directly into the inboard distance piece.
11. Fixed pressure control or differential pressure control depending on the variability of the disposal system.
12. Keep the disposal from the distance piece liquid collection pot and packing leakage liquid collection separate. The distance piece liquid collection pot should be connected to a vapor recovery system or a low pressure flare system. The packing leakage liquid collection pot can be connected to either a vapor recovery, a low pressure flare, or a conventional flare system.
13. To or from other cylinders on the same machine. When different cylinders on a common frame are in different services, individual isolation of vents and drains may be required.

Note:
This is a typical system and may require modification based on specific user requirements (see I.1).

Figure I-2—Typical Buffered Two Compartment Distance Piece Vent, Drain, and Buffer Arrangement to Minimize Process Gas Leakage



OIL WIPER PACKING WITH INERT BUFFER GAS PURGE

INTERMEDIATE PARTITION PACKING WITH INERT BUFFER GAS PURGE
(Not Used With Type A & B Distance Pieces)

PRESSURE PACKING WITH INERT BUFFER GAS PURGE

Notes:
1. See 6.12.2 and 6.13.1.6.
2. Buffer gas pressure P_1 must be at least 1 bar (15 pounds per square inch) higher than the disposal system pressure at connection A or G (in the outboard distance piece) whichever is higher. Buffer gas pressure P_2 must be at least 1 bar (15 pounds per square inch) higher than the disposal system pressure at connection A (in the outboard distance piece). See Figures I-2 and I-3.
3. Under normal conditions, the buffer gas leakage rate is minimal. Under abnormal conditions (such as packing deterioration), a higher buffer gas leakage rate will occur.
4. WTPR = Wedge Type Packing Rings.
5. ➤ = Sealing face of packing cups.

Figure I-3—Typical Purged Packing Arrangements

Annex J
(informative)

Reciprocating Compressor Nomenclature

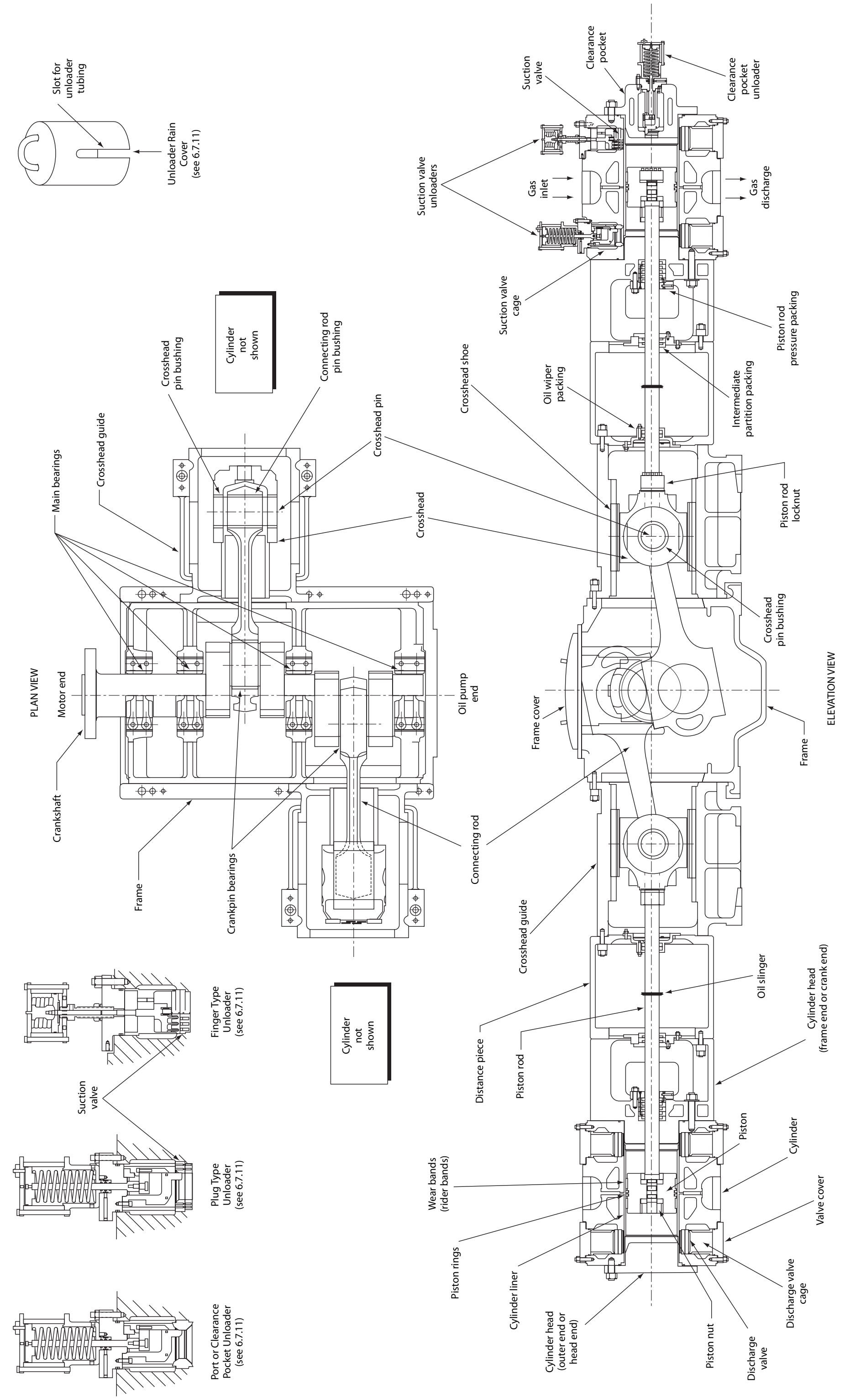


Figure J-1—Reciprocating Compressor Nomenclature

Annex K
(informative)

Inspector's Checklist

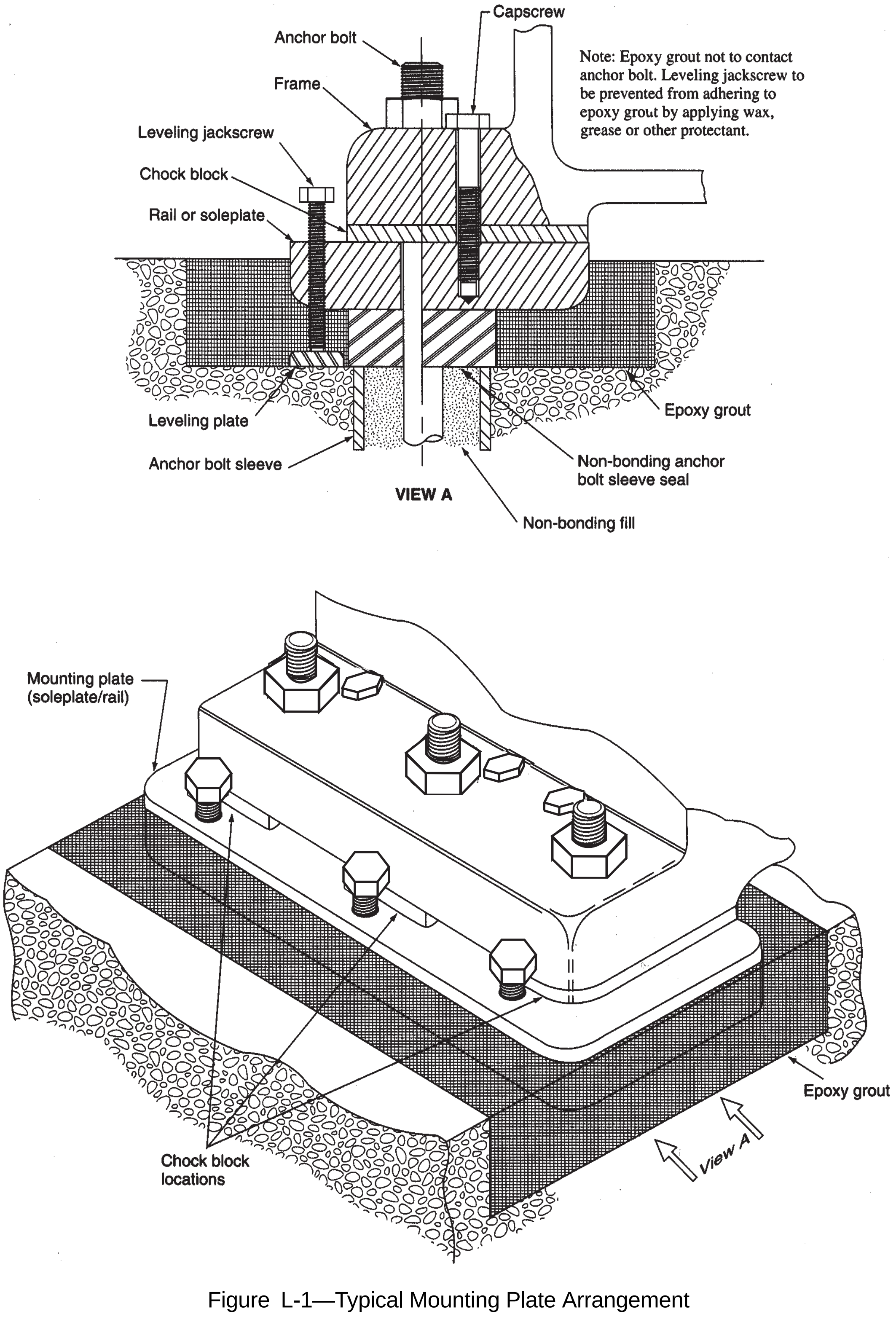
This inspector's checklist represents a summary of the potential inspection points mentioned in the main text. The final inspection plan shall be agreed between purchaser and vendor and reflected in the quality plan.

Table K-1—Inspector's Checklist

Item	Referenced Clause API 618	Date Inspected	Inspected By	Status
Material Inspection	8.2.2.1			
Crankshaft Ultrasonic Inspection	8.2.2.3.3			
Piping Fabrication and Installation				
Hydrostatic Test—Cylinders	8.3.2.1			
Hydrostatic Test—Piping and Vessels	8.3.2.1			
Gas Leakage Test	8.3.2.2			
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	6.16.2			
Overall Dimensions and Connection Locations[a]				
Flange Dimensions and Finish[a]				
Anchor Bolt Layout and Size[a]				
Painting	8.4.5			
Corrosion Protection—Exterior	8.4.6 8.4.17			
Corrosion Protection—Interior	8.4.7 8.4.20			
Corrosion Protection—Lubricated Surfaces	8.4.8			
Closures of All Openings	8.4.10 8.4.11 8.4.12			
Equipment Nameplate Data	6.16.2			
Packing for Shipment	8.4.14			
Equipment Identification	8.4.15			
Piping Connections Identification (Tagging)	8.4.19			
Additional Inspections—As Specified				

[a] Check against certified drawings.

Annex L
(informative)



Note: Epoxy grout not to contact anchor bolt. Leveling jackscrew to be prevented from adhering to epoxy grout by applying wax, grease or other protectant.

Figure L-1—Typical Mounting Plate Arrangement

Annex M
(informative)

Design Approach Work Process Flowcharts

The work processes used in Design Approaches 1, 2 and 3 described in 7.9.4.2 are illustrated in Figures M-1, M-2 and M-3 respectively. The steps in the hierarchy of the Basic Criteria described in 7.9.4.2.5.2 are shown with circled numbers in each figure.

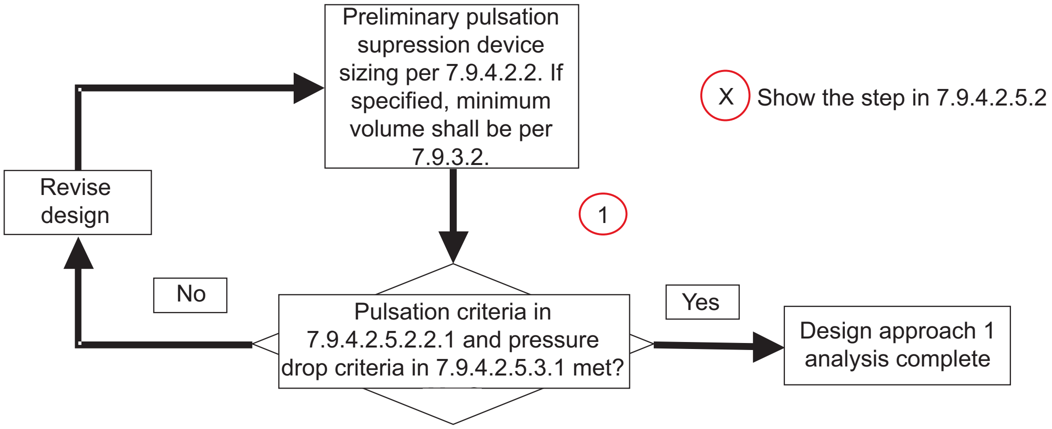
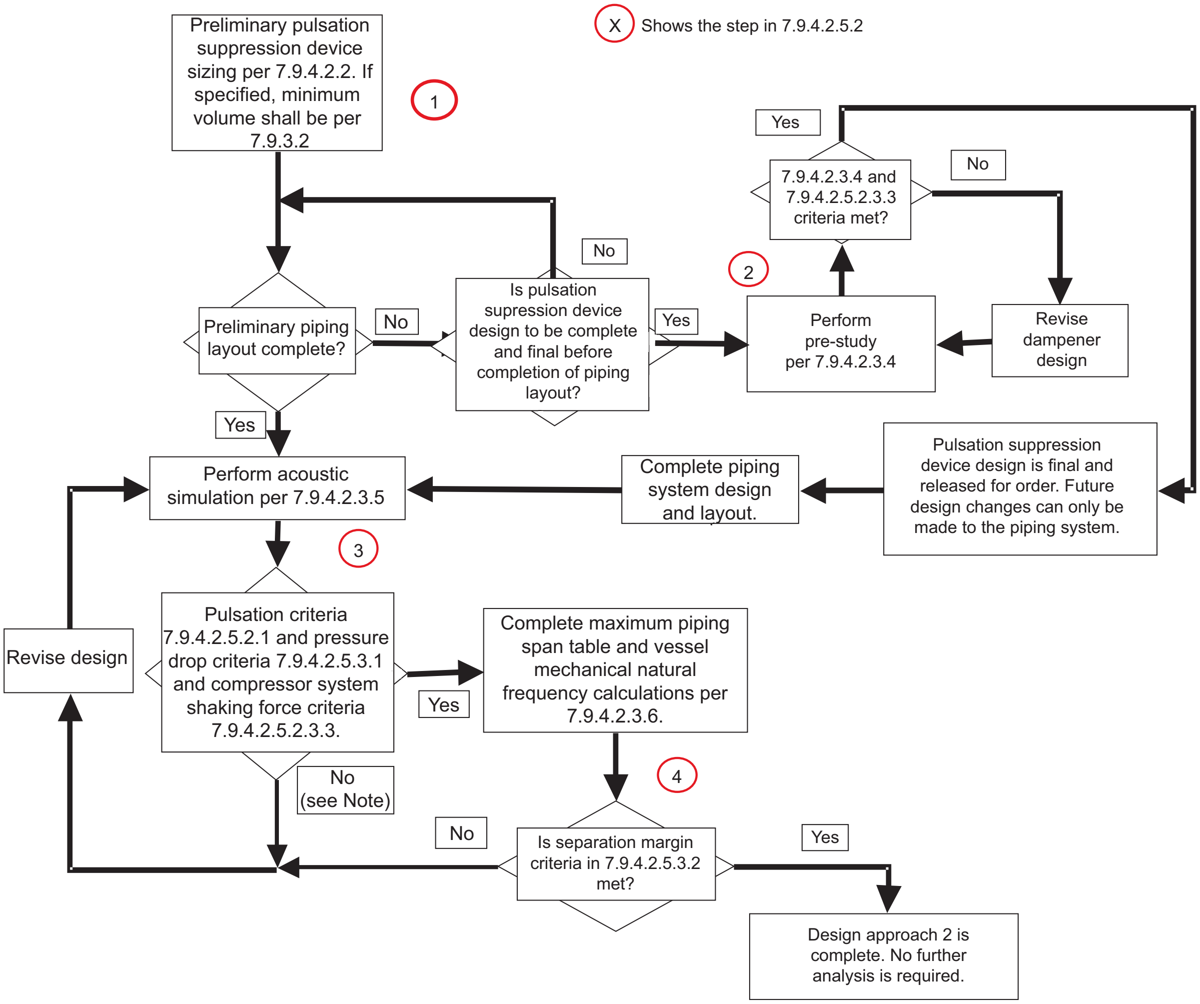
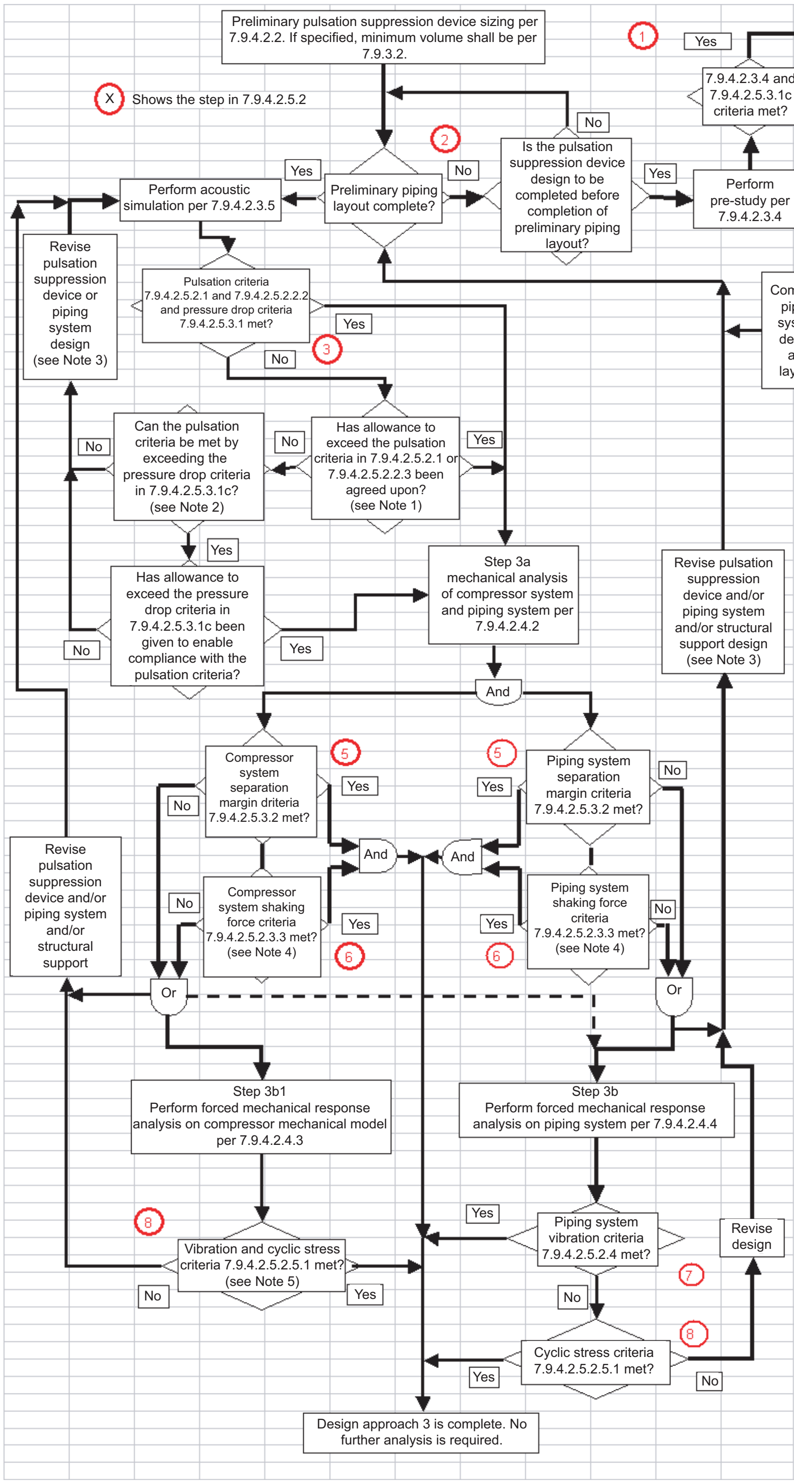


Figure M-1—Design Approach 1



Note: In the event that pulsation suppression device design is fixed, it may be necessary to accept higher pressure drop or perform a Design Approach 3 analysis.

Figure M-2—Design Approach 2



Note 1—The default design philosophy is pressure pulsation control unless otherwise specified. However, when evaluating the need for possible modification to the piping and/or pulsation suppression devices, consideration should be given to acoustical-shaking forces and the effect of pulsations on compressor performance. Also, pulsation levels (expressed as a percentage of line pressure) should not be used as the sole criterion for making modifications.

Note 2—For some applications that have variable operating parameters such as speed or gas composition, it may not be technically possible or economically feasible to simultaneously comply with the pulsation and the pressure drop limitations for all operating conditions. The purchaser and designer should mutually agree upon the most appropriate compromise.

Note 3—When design revisions are complete, the flowchart indicates that the acoustic simulation is run again. In practice, if the revisions (for example, structural support changes) do not impact the acoustic simulation, then the previous simulation is still valid. In this case, the evaluation of the design change would begin with Step 3a; but, the designer is responsible for ensuring that the acoustic simulation is still valid. Also, note that not all options for design revisions listed (for example, modifying the pulsation suppression device) will be available depending upon decisions that have already been made.

Note 4—The requirement to analyze the shaking forces in Step 6 is waived if the compressor vendor analyzes the piping system vibration in Step 7 per 7.9.4.2.4.4. If the shaking forces are not analyzed, then “No” is selected and analysis proceeds to Step 7.

Note 5—The compressor vendor shall supply the allowable vibration criteria for compressor components such as cylinders, distance pieces and crankcases. Due to the variability and complexity of compressor systems, it is not possible to provide vibration criteria that, when met, eliminate the need to calculate stress.

Figure M-3—Design Approach 3

Annex N
(informative)

Guideline for Compressor Gas Piping Design and Preparation for an Acoustic Simulation Analysis

N.1 General

N.1.1 Any reciprocating compressor in conjunction with a piping system forms an interactive dynamic system that cannot be accurately analyzed as two separate systems. Therefore, it is virtually impossible for the pulsation system designer and the piping system designer to arrive at proposed designs on an independent basis that can be guaranteed to work in the final analysis and be cost effective.

N.1.2 This annex gives guidelines for the piping system designer which will help to minimize problems that can occur at the time of the acoustic simulation and it also outlines the information that must be available at the time of this interactive analysis. Communication between the piping system designer, the compressor vendor and the pulsation control system designer during the course of a project is important to minimize problems and develop the best overall compressor system installation. The key times of interaction are at the post order coordination meeting (see 9.1.3), early in the project, and during the interactive acoustic simulation/mechanical analysis.

N.1.3 The purchaser may elect to perform an in-house acoustic simulation, to use equipment vendor services or to use the services of a third party.

N.2 Acoustic Consideration in Piping Designs

N.2.1 The interaction of the compressor, pulsation devices and piping system produces potentially harmful pulsations when there is resonant interaction between the various elements in the system. The system designer can help to minimize this interaction by avoiding resonant lengths of pipe. When resonant lengths of pipe are used and the resonant frequency matches compressing frequency, one can expect major changes to the system as a result of the acoustic simulation analysis. The resonant length of various piping configurations is given in Equation N-1. It is recommended that lengths of these configurations be avoided in a ±10% band for the first four harmonics of compressor speed. The piping areas where this is most important are the sections of piping between the first major volume on the suction side and the first major volume on the discharge side. In piping areas outside major volumes, or those far enough away from the compressor(s) the potential for harmful pulsation buildup is considerably reduced.

N.2.2 For piping sections open at both ends or closed at both ends the length to be avoided can be calculated from the following:

$$L_H = \frac{30c}{nN} \tag{N-1}$$

where

L_H is the pipe length to be avoided in meters (feet);

C is the velocity of sound in gas in meters/second (feet/second);

n is the harmonic number (1, 2, 3 and 4);

N is the compressor speed in revolutions per minute.

Examples of this are lengths between major volumes, length of headers, etc.

N.2.3 For pipe sections open at one end and closed at the other end, the lengths to be avoided can be calculated from the following:

$$L_Q = \frac{15C}{nN} \qquad \text{(N-2)}$$

where

L_Q is the pipe length to be avoided in meters (feet);

C is the velocity of sound in gas in meters/second (feet/second);

n is the harmonic number (1, 2, 3 and 4);

N is the compressor speed in revolutions per minute.

Examples of this are relief valve lines and bypass lines.

Note: A pipe can be considered to have an open end if the diameter increases by a factor of 2 to 1 or more. Similarly, a pipe can be considered to have a closed end if the diameter is reduced by a factor of 2 to 1 or more.

N.2.4 The acoustic simulation should be carried out after a piping static stress analysis has demonstrated that the location and design of the piping restraints result in acceptable piping static stresses.

N.2.5 For variable speed compressors and/or those with varying gas composition and/or varying pressures and temperatures, the separation of resonances is more difficult to calculate and can only be handled properly with an acoustic simulation study.

N.3 Acoustic simulation study

N.3.1 The extent of the piping system to be analyzed by acoustic simulation techniques is usually defined as all associated piping systems to a point where piping changes will have only insignificant effects on the parts of the system under study and in determining the acoustic characteristics of the design. Typically, these requirements are satisfied by beginning the simulation with the inlet of a major process vessel or volume on the suction side of the compressor unit(s), continuing through all interstage systems (if any) and terminating the study at the outlet of a major process vessel or volume on the discharge side of the unit(s). Included are branch connections to or from this system, such as relief valve lines and bypass lines.

N.3.2 When major volumes do not exist or are very remote from the compressor, suitable piping lengths are included in the simulation, such that the pulsation levels are sufficiently low so as to minimize the potential of pulsation driven vibration problems.

N.4 Information required

N.4.1 The acoustic simulation requires a considerable amount of information in order to be properly performed. The purchaser and the vendor should agree upon who is responsible for the development and compilation of the following information:

N.4.1.1 Data sheets showing all compressor operating conditions, analysis of all gases to be compressed, and all unloading steps.

N.4.1.2 Isometric drawings showing all lengths (between bends, valves, diameter changes, etc.) and line sizes and schedules for the complete piping system, including all branch lines and relief valve lines. If a mechanical study is included, the distance between the supports and the type of support and clamp used at each location must be shown on the isometrics. A detailed drawing of each type of support and clamp is required.

N.4.1.3 Piping and instrument diagrams (P&ID’s) are required to ensure that all piping and equipment that may effect the study are included.

N.4.1.4 Layout drawings are required to help determine the practicality of any proposed modifications. Reproducible drawings are useful since they can be marked up and copies can be included in the report.

N.4.1.5 Complete information must be supplied on all of the piping up to and including the first large volume in the suction, the interstage and the discharge piping. Every branch must be included up to a shutoff valve or a large volume.

N.4.1.6 Any orifice or other flow-resistive device must be shown and complete details provided.

N.4.1.7 Detailed drawings of each vessel, showing the location of all nozzles, the internal diameter and the length, as well as details of any vessel internals are required. Normal liquid levels and design pressure drops in these vessels must be shown.

N.4.1.8 TEMA data sheets, or their equivalent, must be provided for all heat exchangers. The data sheets must show whether gas is through the tubes or in the shell; the number, length and gauge of tubes; whether the tubes are plain or finned; the number of passes; the I.D. of the shell; the gas temperature in and out; the gas pressure drop; and the dimensions of the header. A dimensional drawing is preferred.

N.4.1.9 If there are different gas routings, a complete description must be included to show the relative positions of all the valves for each routing. If different process gases are involved, the description must show which routings apply to which gases. Flow from/to any sidestream must be shown, including gas analysis, flow rate and direction.

N.4.1.10 If gas filters are used, the type of filter, internal diameter, length and element pressure drop must be supplied. A dimensional drawing is desirable.

N.4.1.11 When two or more compressors are connected to the same piping system, a clear description of how they will operate (such as unloading steps, speed differences, etc.) is required.

N.4.1.12 Detailed dimensional drawings on each suppressor showing the location of all nozzles, lengths, internal diameters and details on suppressor internals, if any.

N.4.1.13 The information in Table N.1 is required from the compressor vendor.

Table N-1—Compressor Data Required for Acoustic Simulation

Compressor Data	**Design Approach 23a, 3b1, 3b2**	
Compressor data		
Head end fixed clearance volume	X	X
Head end unloader volume(s)	X	X
Crank end fixed clearance volume	X	X
Crank end unloader volume(s)	X	X
Casting drawings		
Compressor cylinder (internal passage)	X	X
Distance piece (inertia and stiffness)		X
Crosshead guide (inertia and stiffness)		X
Assembled cylinder weight		X
Support drawings		
Cylinder support drawings		X
Crosshead guide support drawings		X
Distance piece support drawings		X
Pulsation suppressor support drawings		X
Compressor Dynamic Valve Analysis Results		X
Crank angles between manifolded cylinders		X

N.4.2 It is highly recommended that a piping system design representative who is familiar with the piping system be present at the acoustical simulation analysis, in order to make piping changes as the need arises.

Annex O
(informative)

Guidelines for Sizing Low Pass Acoustic Filters

O.1 General

The general configuration for an acoustic filter is shown in Figure O-1.

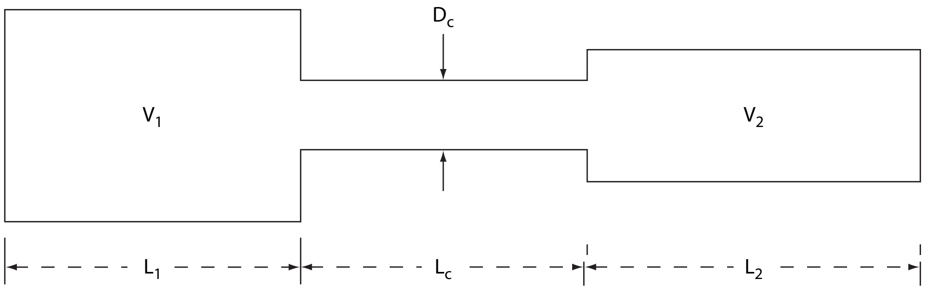


Figure O-1—Nonsymmetrical Filter

The lowest acoustic resonant frequency of the filter system, is referred to as Helmholtz frequency (f_H). An accepted generalized equation for Helmholtz frequency is

$$f_H = \frac{c}{2\pi}\left(\frac{\mu}{V_1} + \frac{\mu}{V_2}\right)^{\frac{1}{2}} \tag{O-1}$$

where

f_H	is the Helmholtz frequency in Hertz;
c	is the velocity of sound in gas in meters per second (feet per second);
V_1	is the volume in cylinder bottle (chamber) in cubic meters (cubic feet);
V_2	is the volume in filter bottle (chamber) in cubic meters (cubic feet);
μ	is the acoustic conductivity in meters or feet.

where

$$\mu = \frac{A}{L_c + 0.6D_c} = \frac{A}{L}$$

A	is the internal cross-sectional area of choke in square meters (square feet);
L_c	is the actual length of choke in meters (feet);
L	is the acoustic length of choke in meters (feet);
D_c	is the diameter of choke in meters (feet).

The filter cut-off frequency (f_{co}), which is the frequency above which pulsation attenuation is achieved, is usually defined as follows

$$f_{co} = (\sqrt{2})f_H$$

The acoustic filter can be either symmetrical or non-symmetrical. As shown in Figure O-1 and Equation 1, the non-symmetrical filter can have different volumes (lengths and diameters) and a different length of choke. For a symmetrical filter, the volumes are equal and the acoustic length of the choke L is equal to the length of each volume that is $L_c = L$. This is valid when L_c is much larger than D_c. This also means that the diameter of each volume is equal.

Substituting into Equation O-1, the Helmholtz frequency for a symmetrical filter becomes:

$$f_H = \frac{1}{\sqrt{2}}\frac{c}{\pi}\frac{D_c}{LD_B} \qquad \text{(O-2)}$$

where

D_B = inside diameter of pulsation suppression devices in meters (feet).

O.2 Guidelines

The following guidelines may be used for the preliminary sizing of acoustic filters.

O.2.1 SELECTION OF HELMHOLTZ FREQUENCY (F_H)

The preferred Helmholtz frequency is:

$$f_H = \frac{s}{85}$$

where

s is the compressor speed in r/min.

Only when conditions are such that it is uneconomical, or physically impractical, should a higher Helmholtz frequency be considered, that is, only when pressure drop is very critical—as in the case of low suction pressure, or when space is limited by the compressor system layout. In that instance, a higher Helmholtz frequency may be chosen. Generally, the Helmholtz frequency should not be higher than

$$f_H = \frac{\mathrm{s}}{45}$$

unless the acoustic simulation proves otherwise. For compressor speeds above 500 rpm, the Helmholtz frequency should not exceed:

$$f_H = \frac{\mathrm{s}}{85}$$

O.2.2 RELATIONSHIPS OF FILTER ELEMENT DIAMETERS

For acoustic considerations, the diameter of the cylinder bottle (chamber) V_1 should be equal to, or greater than, two times the diameter of the cylinder connection (flange). Larger ratios generally improve acoustic characteristics but may result in unacceptable mechanical characteristics. The final design ratio must be determined by both acoustic and mechanical analysis.

The diameter of the filter bottle (chamber) V_2 should be equal to, or greater than, three times the diameter of the line piping.

O.2.3 RELATIONSHIP OF FILTER ELEMENT LENGTHS

The preferred filter system is with equal lengths of cylinder bottle (chamber), choke tube and filter bottle (chamber) that is $L_1 = L_C = L_Z$. In cases where the physical restrains (piping layout) and the required sizes do not permit equal lengths, the next best alternative is with equal length of choke and filter (chamber) $L_1 \neq L_C = L_2$.

O.2.4 SIZING OF THE DIAMETER OF THE CHOKE TUBE (D_C)

Unless otherwise specified, calculate the maximum allowable pressure drop per the applicable Equation 13 in 7.9.4.2.5.2.3.2. Using maximum allowable pressure drop and appropriate pressure drop relationship, calculate the minimum diameter choke tube which can be used considering all operating conditions expected.

O.2.5 ACOUSTIC SIMULATION OF THE PRELIMINARY DESIGN

These sizing guidelines cannot be used to determine the final dimensions of the filter elements without an acoustic simulation. Once the preliminary design of the filter is completed, an acoustic simulation must be performed to evaluate the unbalanced shaking forces within the components of the filter and the pulsation levels at the nozzles. Adjustments to the filter component dimensions are almost always made during the acoustic simulation.

Annex P
(informative)

Piping and Pulsation Suppression Device Shaking Force Guidelines

P.1 General

Shaking force guidelines provide an alternative evaluation tool to determine the need for forced mechanical response analysis. The foundation for deriving appropriate shaking force guidelines is knowledge of stiffness and acceptable vibration for the structure. Knowledge of the structure's stiffness may be based on experience with similar structures, or based on calculation varying in precision from assuming minimum stiffness values to stiffness determined by detailed structural simulation. Similarly, knowledge of acceptable vibration may be experience based or determined by detailed structural modeling.

The adopted shaking force guidelines work in concert with the separation margin and the design vibration guidelines. The simplification to a non-resonant shaking force guideline requires simultaneous compliance with both the shaking force and separation margin guidelines.

Figure P-1 shows the piping non-resonant shaking force guideline versus a corresponding shaking force guideline accounting for resonance. The non-resonant shaking force guideline results in acceptable vibration when the separation margin guidelines are met. Meeting both the minimum natural frequency guideline and the non-resonant shaking force guideline ensures acceptable vibration for the first and second orders of compressor speed. Meeting both the 20% separation margin from natural frequencies and the non-resonant shaking force guideline will also ensure acceptable vibration at higher orders of compressor speed. Therefore, the piping non-resonant shaking force guideline applies when the separation margin guidelines are met. When the separation margin guidelines are not met, much lower piping shaking forces are required to ensure acceptable vibration.

Figure P-2 shows the pulsation suppression device non-resonant shaking force guideline versus a corresponding shaking force guideline accounting for typical resonance. As with the piping, the pulsation suppression device non-resonant shaking force guideline applies when the separation margin guidelines are met. When the separation margin guidelines are not met, much lower pulsation suppression device shaking forces are required to ensure acceptable vibration.

Figures P-1 and P-2 demonstrate the importance of meeting the separation margins when applying the non-resonant shaking force guidelines.

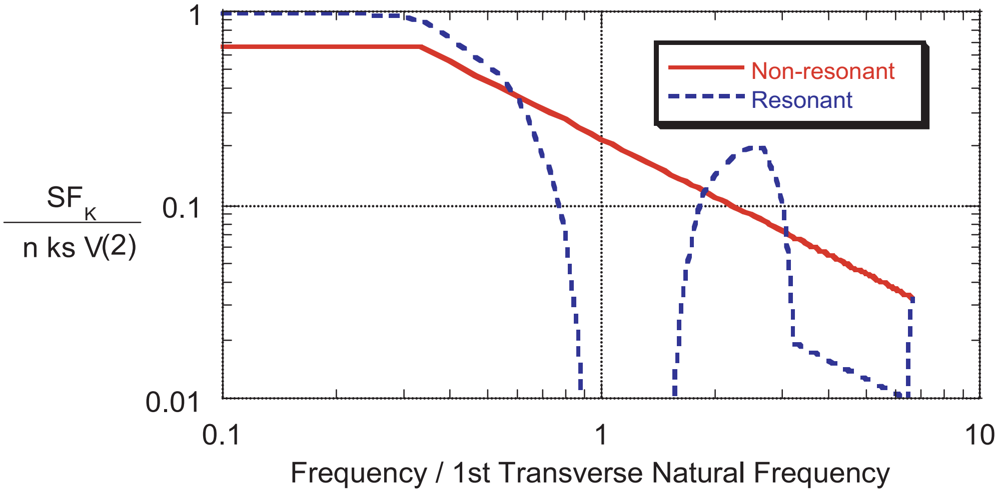


Figure P-1—Non–dimensional Piping Shaking Force Guidelines

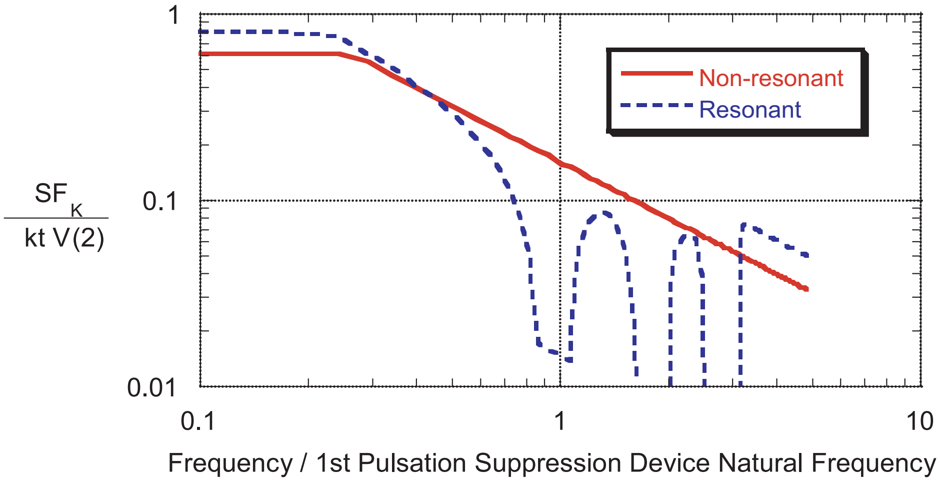


Figure P-2—Non-dimensional Pulsation Suppression Device Shaking Force Guidelines

P.2 Orientation of Shaking Forces

P.2.1 PIPING ORIENTATION

The piping non-resonant shaking force guideline applies to shaking forces acting along the piping axis, as shown in Figure P-3, which cause non-resonant vibration. The piping non-resonant shaking force guideline cannot be applied when resonant vibration occurs in either the run containing the shaking force or in adjoining perpendicular piping.

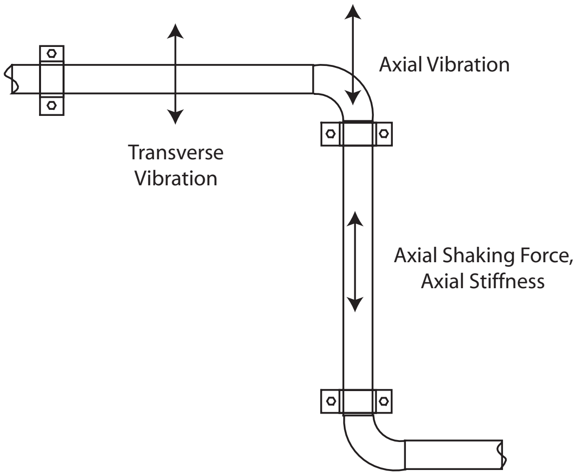


Figure P-3—Shaking Forces along the Piping Axis

P.2.2 CYLINDER MOUNTED PULSATION SUPPRESSION DEVICE ORIENTATION

The pulsation suppression device non-resonant shaking force guideline applies to shaking forces acting along the pulsation suppression device axis, as shown in Figure P-4, which cause non-resonant vibration.

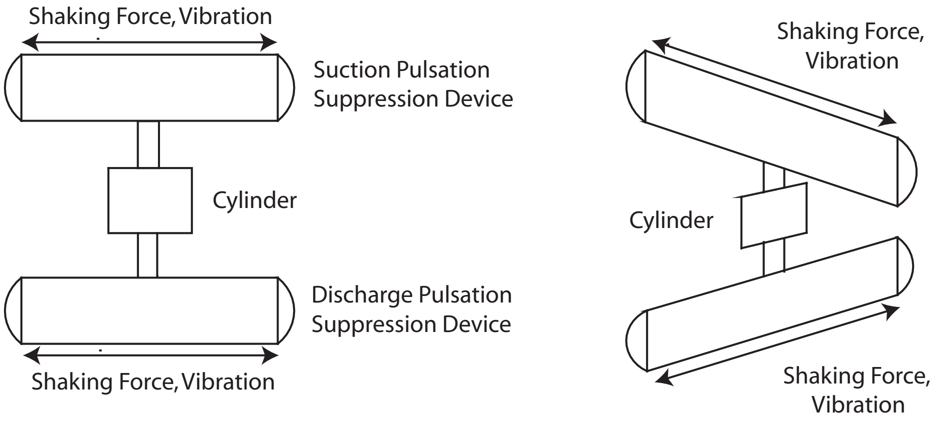


Figure P-4—Shaking Forces along the Pulsation Suppression Device Axis

P.3 Determination of Effective Static Stiffness

P.3.1 GENERAL

Suggested equations for effective stiffness of piping and pulsation suppression devices are provided in P.3.2 and P.3.3. In addition, meeting the minimum mechanical natural frequency guideline can be used to establish a required minimum effective static stiffness. Equations for minimum effective static stiffness of piping and pulsation suppression devices are also given below.

P.3.2 PIPING EFFECTIVE AND MINIMUM STATIC STIFFNESS

P.3.2.1 The effective axial stiffness of piping is usually determined by the axial stiffness of the supports as shown in Equation P-1.

.
$$k_{\text{eff}} = 0.66 \times n \times k_{\text{s}} \tag{P-1}$$

where

k_{eff} is the effective static stiffness along the piping where the shaking force acts in N/mm (lbf/in.);

0.66 is the dynamic design factor to account for reduced stiffness as resonance is approached (see Figure P-1);

n is the number of active axial supports (see P.2.1.1 when supports are not collinear with the pipe run where the shaking force is acting);

k_{S} is the axial static support stiffness in N/mm (lbf/in.).

To satisfy the minimum natural frequency guideline (see clause 7.9.4.2.5.3.2), the active axial support stiffness must at least meet the minimum k_{S} defined in Equation P-2. Equation P-2 satisfies the minimum required support stiffness for all practical piping configurations with maximum acceptable spans (see P.2.1.2 and P.2.1.3 regarding lumped masses and equipment).

$$\text{minimum } k_{\text{s}} = C_{KS} \times A^{0.75} \times I^{0.25} \times f_{\text{n,T}}{}^{1.5}(n - 1/n) \tag{P-2}$$

where

C_{KS} is the constant dependent on support stiffness units (SI units: $^1/_{130}$; USC units: 25);

A is the pipe cross-sectional metal area in mm^2 (in.^{2});

= $^{\pi}/_4 \times (OD^2 – ID^2)$;

I is the pipe cross-sectional area moment of inertia in mm^4 (in.^{4});

= $^{\pi}/_{64} \times (OD^4 – ID^4)$;

OD is the pipe outer diameter in mm (in.);

ID is the pipe inner diameter in mm (in.);

$f_{n,T}$ is the minimum transverse natural frequency in Hz (see P 3.2.5);

n is the number of active supports (or n = 2 as a minimum, see P 3.2.7).

The actual value of k_s should be determined and compared to the minimum k_s requirement. When the actual *ks* is greater than minimum k_s there is sufficient support stiffness to constrain higher shaking forces (up to the limit defined by Equation 10 in 7.9.4.2.5.2.3.2 and P.1). When the actual k_s is lower than minimum k_s, the minimum mechanical natural frequency separation margin guideline will not be met, and the possibility of operating on resonance within the first two orders of compressor speed must be considered.

The actual and minimum k_s values should also be compared with the range of typical support stiffness values found in Note 2 of 7.9.4.2.5.2.3. The actual k_s should fall within the range of the corresponding support type. When the minimum k_s required exceeds the range of the corresponding support type, the actual k_s must be carefully determined and either a sufficiently stiff type of structure must be used or the shaking force guideline must be reduced.

P.3.2.2 When supports are not collinear with the pipe run where the shaking force is acting (such as the middle section of U, Z or 3D bends), the perpendicular pipe sections clamped by the supports may be more flexible than the supports, and k_{eff} must correspondingly be reduced. Flexibility of the perpendicular pipe section should be considered when the support is offset greater than 25% of the maximum acceptable span length.

P.3.2.3 The calculation of minimum k_s does not include lumped masses, but results in a conservative shaking force criteria when the separation margin minimum natural frequency guideline is satisfied. To ensure the separation margin criteria are satisfied, the support requirements of each lumped mass, such as valves, must additionally be provided.

P.3.2.4 The calculation of minimum k_s is based on the minimum number of supports required to satisfy the minimum mechanical natural frequency guideline. When more than the minimum number of supports are present, the minimum k_s can be reduced by the ratio of the minimum number required divided by the number of active supports.

P.3.2.5 The minimum transverse natural frequency ($f_{n,T}$) required is dependent on the frequency of the shaking force. For example, to comply with the first part of the separation margin criteria, it is typically chosen as 2.4 times maximum rated speed. In higher speed compressors, this is not always practical to achieve, however Equation P-2 can still be used to determine the minimum support stiffness required for the given $f_{n,T}$.

P.3.2.6 The minimum axial support stiffness requirements of vessels and equipment (such as secondary pulsation dampeners, separators, cooler sections and heat exchangers) should be determined directly from the equipment mass to meet the separation margin criteria.

P.3.2.7 The number of active supports include all axial restraints along the run containing the shaking force and restraints offset from the run less than 25% of the maximum acceptable span length.

P.3.2.8 Vessels and equipment may also be restraints. See examples in Figure P-5.

P.3.2.9 Pipe wall thickness is specified based on design pressure using applicable design codes and is not increased as a method to control vibration.

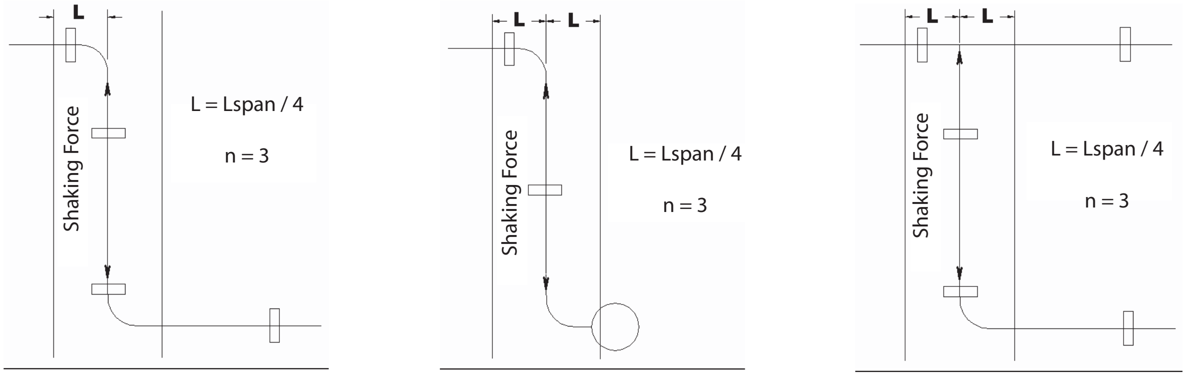


Figure P-5—Examples of Shaking Force Restraints

P.3.3 CYLINDER MOUNTED PULSATION SUPPRESSION DEVICE EFFECTIVE AND MINIMUM STATIC STIFFNESS

The effective axial stiffness of cylinder mounted pulsation suppression devices is the result of a complex interaction between many structures requiring detailed analysis or field measurement to determine. Expressed in the same form as the effective stiffness for piping yields Equation P-3.

$$k_{\text{eff}} = 0.66 \times k_t \qquad \text{(P-3)}$$

where

k_{eff}	is the effective static stiffness along the pulsation suppression axis where the shaking force acts in N/mm (lbf/in.);
0.66	dynamic design factor to account for reduced stiffness as resonance is approached (see Figure P-2);
k_t	is the pulsation suppression device axial static support stiffness in N/mm (lbf/in.).

Noting that the cylinder assembly stiffness is a critical component of the pulsation suppression device stiffness, and considering reasonable supporting of typical cylinder assemblies, a minimum k_t can be established based on the number of cylinders as shown in Equation P-4.

$$\text{minimum}kt = k_{\text{min}} \times n_{\text{cyl}}$$

where

k_{min}	is the minimum pulsation suppression device axial static stiffness per cylinder nozzle (SI units: 50 × 103 N/mm; USC units: 3 × 105 lbf/in.);
n_{cyl}	is the number of cylinders attached to pulsation suppression device.

CAUTION: Long cylinder nozzles, double compartment and small cross-section distance pieces may not provide the minimum axial stiffness.

Also, on higher speed units, larger and higher pressure cylinders may require greater than the minimum axial stiffness to meet the minimum natural frequency guideline. Cylinders heavier than shown in Table P-1 may require additional supporting.

Table P-1—Cylinder Assembly Weights Possibly Requiring Strengthening

Maximum Compressor Speed (rpm)	300	600	900	1000	1200	1500
Cylinder Assembly Weight (N)	89000	22000	9800	8000	5500	3500
Cylinder Assembly Weight (lbf)	20000	5000	2200	1800	1250	800

The maximum cylinder assembly weight for compressor speeds not shown in the Table P-1 can be obtained using Equation P-5.

.

$$W_{\text{cyl}} = C_c / S^2$$

where

W_{cyl} is the maximum cylinder assembly weight in N (lbf);

C_c is the constant dependent on weight and stiffness units (SI units: 8.0 × 109; USC units: 1.8 × 109);

S is the compressor rotational speed in r/min.

P.4 Evaluation of Shaking Forces

Making modifications to reduce predicted shaking forces is referred to as shaking force control (see API RP 688 for a complete discussion of the various control methods). As a minimum, shaking force control is required for all cylinder mounted pulsation suppression devices. When the purchaser agrees, shaking force control may be used in place of piping pressure pulsation guidelines.

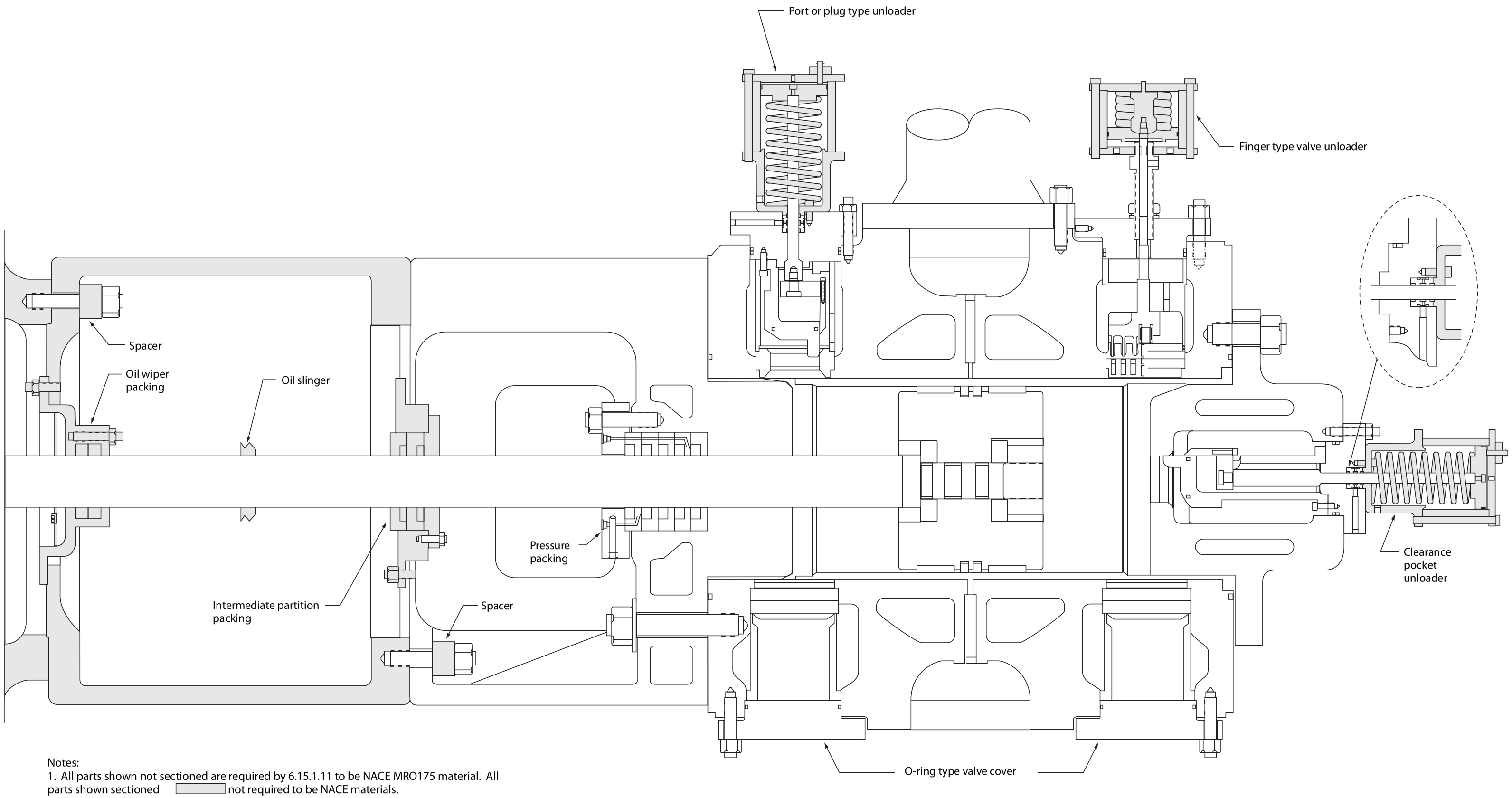
The first step in the shaking force control method is to determine the shaking force guidelines using the equations and methods shown in 7.9.4.2.5.3 and Annex P. Then, the predicted shaking forces are compared to the shaking force and separation margin guidelines. When predicted shaking forces do not meet these guidelines, then one or more of the following actions must be taken to obtain acceptable results:

- modify system acoustics to reduce predicted shaking forces;
- modify support structure to meet separation margin guidelines;
- perform forced mechanical response analysis and satisfy vibration guideline.

Combinations of the above options are often employed in an iterative fashion to arrive at acceptable predicted shaking forces for the entire system.

Annex Q
(informative)

Compressor Components—Compliance with NACE MR0175



Notes:
1. All parts shown not sectioned are required by 6.15.1.11 to be NACE MRO175 material. All parts shown sectioned ▨ not required to be NACE materials.
2. Applying NACE exposure guidelines allow the use of non-NACE bolting materials for external fasteners on the cylinder and internal fasteners within the distance pieces.
3. See Figure J-1 for reciprocating compressor nomenclature.

Figure Q-1—Material Guidelines for Compressor Components—Compliance with NACE MR0175

Date of Errata Issue: November 2009
Affected Publication: API Standard 618, *Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services*, Fifth Edition, December 2007

ERRATA 1

This errata corrects editorial errors in the fifth edition of API 618.

Page 139, Annex F, F.1, insert the following VDDR forms:

TYPICAL
VENDOR DRAWING AND DATA REQUIREMENTS

JOB NO. ____________ ITEM NO. ____________
PURCHASE ORDER NO. ____________ DATE ____________
REQUISITION NO. ____________ DATE ____________
INQUIRY NO. ____________ DATE ____________
PAGE 1 OF 2 BY ____________
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REVISION ____________
SITE ____________
UNIT ____________
SERVICE ____________
NO. REQUIRED ____________

Proposal [a] Bidder shall furnish _____ copies of data for all items indicated by an X.

Review [b] Vendor shall furnish _____ copies and _____ transparencies of drawings and data indicated.

Final [c] Vendor shall furnish _____ copies and _____ transparencies of drawings and data indicated.
Vendor shall furnish _____ operating and maintenance manuals.

DISTRIBUTION RECORD

Final-Received from vendor
Final-Due from vendor [c]
Review-Returned to vendor
Review-Received from vendor
Review-Due from vendor [c]

			DESCRIPTION					

---

[a] Proposal drawings and data do not have to be certified or as-built. Typical data shall be clearly identified as such.

[b] Purchaser shall indicate in this column the timeframe for submission of materials using the nomenclature given at the end of this form.

[c] Bidder shall complete these two columns to reflect their actual distribution schedule and include this form with their proposal.

TYPICAL VENDOR DRAWING AND DATA REQUIREMENTS

JOB NO. ____________ ITEM NO. ____________
PAGE 2 OF 2 BY ____________
DATE ____________ REVISION ____________

Proposal [a] Bidder shall furnish _____ copies of data for all items indicated by an X.

Review [b] Vendor shall furnish _____ copies and _____ transparencies of drawings and data indicated.

Final [c] Vendor shall furnish _____ copies and _____ transparencies of drawings and data indicated.
Vendor shall furnish _____ operating and maintenance manuals.

DISTRIBUTION RECORD

Final-Receive from vendor
Final-Due from vendor [c]
Review-Returned to vendor
Review-Received from vendor
Review-Due from vendor [c]

			DESCRIPTION					

[a] Proposal drawings and data do not have to be certified or as-built. Typical data shall be clearly identified as such.

[b] Purchaser shall indicate in this column the timeframe for submission of materials using the nomenclature given at the end of this form.

[c] Bidder shall complete these two columns to reflect their actual distribution schedule and include this form with their proposal.

Notes:

1. Send all drawings and data to ____________________
2. All drawings and data shall show project, purchase order, and item numbers in addition to the plant location and unit. In addition to the copies specified above, one set of the drawings/instructions necessary for field installation must be forwarded with the shipment.

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)

Date of Errata Issue: July 2010
Affected Publication: API Standard 618, *Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services*, Fifth Edition, December 2007

ERRATA 2

This errata corrects editorial errors in the fifth edition of API 618.

Page 18, Section 6.9.1.1, the definition for D should read:

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

API

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	C61404	Std 614, Lubrication, Shaft-sealing, and Control-oil Systems and Auxiliaries for Petroleum, Chemical and Gas Industry Services		$167.00	
	C61707	Std 617, Axial and Centrifugal Compressors and Expander-compressors for Petroleum, Chemical and Gas Industry Services		$195.00	
	C61904	Std 619, Rotary-Type Positive Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries		$175.00	
	C67004	Std 670, Machinery Protection Systems		$160.00	
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