Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services

Downstream Segment

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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*

[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

[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).

[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.