

Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services

Downstream Segment

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

ERRATA 1, NOVEMBER 2009
ERRATA 2, JULY 2010



Special Notes

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be utilized. The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

All rights reserved. No part of this work may be reproduced, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Contact the Publisher, API Publishing Services, 1220 L Street, N.W., Washington, D.C. 20005.

Copyright © 2007 American Petroleum Institute

Foreword

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

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

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

Portions of this publication have been changed from the previous edition. The locations of changes have been marked with a bar in the margin, as shown to the left of this paragraph. The bar notations in the margins are provided as an aid to users, but API makes no warranty as to the accuracy of such bar notations.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually and updated quarterly by API, 1220 L Street, N.W., Washington, D.C. 20005.

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

Contents

	Page
1	Scope 1
2	Normative References 1
3	Definitions of Terms 4
4	General 8
4.1	Unit Responsibility 8
4.2	Unit Conversion 8
4.3	Nomenclature 8
5	Requirements 8
5.1	Dimensions 8
5.2	Statutory Requirements 8
5.3	Conflicting Requirements 8
6	Basic Design 8
6.1	General 8
6.2	Bolting 11
6.3	Calculating Cold Runout 11
6.4	Allowable Speeds 12
6.5	Allowable Discharge Temperature 12
6.6	Rod and Gas Loads 12
6.7	Critical Speeds 13
6.8	Compressor Cylinders 13
6.9	Valves and Unloaders 18
6.10	Pistons, Piston Rods, and Piston Rings 20
6.11	Crankcases, Crankshafts, Connecting Rods, Bearings and Crossheads 22
6.12	Distance Pieces 23
6.13	Packing Cases and Pressure Packing 24
6.14	Lubrication 25
6.15	Materials 29
6.16	Nameplates and Rotation Arrows 36
7	Accessories 36
7.1	Drivers 36
7.2	Couplings and Guards 39
7.3	Reduction Gears 40
7.4	Belt Drives 41
7.5	Mounting Plates 41
7.6	Controls and Instrumentation 44
7.7	Piping and Appurtenances 48
7.8	Intercoolers, Aftercoolers, and Separators 50
7.9	Pulsation and Vibration Control 52
7.10	Air Intake Filters 65
7.11	Special Tools 65
8	Inspection and Testing 65
8.1	General 65
8.2	Inspection 66
8.3	Testing 68
8.4	Preparation for Shipment 70

9	Vendor's Data	71
9.1	General	71
9.2	Proposals	72
9.3	Contract Data	73
	Annex A (informative) Data Sheets	77
	Annex B (informative) Capacity Rating and Tolerance	113
	Annex C (informative) Piston Rod Runout	115
	Annex D (informative) Repairs to Gray or Nodular Iron Castings	133
	Annex E (informative) Purchaser's Checklist	135
09 	Annex F (normative) Vendor Drawing and Data Requirements	139
	Annex G (normative) Figures and Schematics	147
	Annex H (informative) Materials for Major Component Parts	157
	Annex I (informative) Distance Piece Vent, Drain and Buffer Systems to Minimize Process Gas Leakage ..	159
	Annex J (informative) Reciprocating Compressor Nomenclature	165
	Annex K (informative) Inspector's Checklist	169
	Annex L (informative)	171
	Annex M (informative) Design Approach Work Process Flowcharts	173
	Annex N (informative) Guideline for Compressor Gas Piping Design and Preparation for an Acoustic Simulation Analysis	177
	Annex O (informative) Guidelines for Sizing Low Pass Acoustic Filters	181
	Annex P (informative) Piping and Pulsation Suppression Device Shaking Force Guidelines	183
	Annex Q (informative) Compressor Components—Compliance with NACE MR0175	189
Figures		
1	Plate Loaded in Tension in the Through-thickness Direction and its Area Requiring Ultrasonic Inspection	32
2	Plate Loaded in Bending and its Area Requiring Ultrasonic Inspection	33
3	Axially Loaded Plate	33
4	Piping Design Vibration at Discrete Frequencies	61
A-1	Reciprocating Compressor Data Sheet (U.S. Customary Units)	79
A-2	Reciprocating Compressor Data Sheet (SI Units)	96
C-1	Basic Geometry with Cold Vertical Runout	116
C-2	Vertical Runout Geometric Relationships Based on No Rod Sag	116
C-3	Rod Runout Table	117
C-4	Rod Runout Attributable to Piston Rod Sag with Δ DROP = 0	119
C-5	Rod Runout Attributable to Piston Rod Sag with Δ DROP > 0	120
C-6A	Data for Rod Runout Calculation	121
C-6B	Rod Runout Calculation Example	122
C-6C	Sample Printout for Rod Runout	125
C-7	Graphical Illustration of Rod Runout at 0.080 in. Cylinder Running Clearance	126
C-8	Graphical Illustration of Rod Runout at 0.060 in. Cylinder Running Clearance	127
C-9	Graphical Illustration of Rod Runout at 0.040 in. Cylinder Running Clearance	128

	Page
C-10 Graphical Illustration of Rod Runout at 0.020 in. Cylinder Running Clearance	129
C-11 Graphical Illustration of Rod Runout at 0.010 in. Cylinder Running Clearance	130
G-1 Cylinder Cooling System	149
G-2 Typical Cylinder Indicator Tap Connection	150
G-3 Distance Piece and Packing Arrangements	151
G-4 Typical Self-Contained Cooling System for Piston Rod Pressure Packing	152
G-5 Typical Pressurized Frame Lube Oil System	153
G-6 Conceptual Direct Rod Connection	154
G-7 Conceptual Indirect Rod Connection	154
G-8 Conceptual Indirect Clamped Rod Connection	154
G-9 Tightening Diagram (Bolt–Bracing–Diagram)	155
I-1 Typical Buffered Single Compartment Distance Piece Vent, Drain, and Buffer Arrangement to Minimize Process Gas Leakage	161
I-2 Typical Buffered Two Compartment Distance Piece Vent, Drain, and Buffer Arrangement to Minimize Process Gas Leakage	162
I-3 Typical Purged Packing Arrangements	163
J-1 Reciprocating Compressor Nomenclature	167
L-1 Typical Mounting Plate Arrangement	171
M-1 Design Approach 1	173
M-2 Design Approach 2	174
M-3 Design Approach 3	175
O-1 Nonsymmetrical Filter	181
P-1 Non-dimensional Piping Shaking Force Guidelines	183
P-2 Non-dimensional Pulsation Suppression Device Shaking Force Guidelines	184
P-3 Shaking Forces along the Piping Axis	184
P-4 Shaking Forces along the Pulsation Suppression Device Axis	185
P-5 Examples of Shaking Force Restraints	187
Q-1 Material Guidelines for Compressor Components—Compliance with NACE MR0175	190

Tables

1 Cooling System Conditions	9
2 Driver Trip Speed	10
3 Maximum Gauge Pressures for Cylinder Materials	31
4 Relief Valve Settings	46
5 Minimum Alarm and Shutdown Requirements	47
6 Design Approach Selection	54
7 Maximum Severity of Defects in Castings	67
E-1 Purchaser’s Checklist	135
H-1 Material Specifications for Reciprocating Compressor Parts	157
K-1 Inspector’s Checklist	169
N-1 Compressor Data Required for Acoustic Simulation	179
P-1 Cylinder Assembly Weights Possibly Requiring Strengthening	187

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

Std 613	<i>Special Purpose Gear Units for Petroleum, Chemical and Gas Industry Services</i>
Std 614	<i>Lubrication, Shaft-sealing, and Control-oil Systems and Auxiliaries for Petroleum, Chemical and Gas Industry Services</i>
Std 616	<i>Gas Turbines for the Petroleum, Chemical and Gas Industry Services</i>
Std 670	<i>Machinery Protection Systems</i>
Std 671	<i>Special-Purpose Couplings for Petroleum, Chemical and Gas Industry Services</i>
Std 677	<i>General-Purpose Gear Units for Petroleum, Chemical and Gas Industry Services</i>
RP 686	<i>Recommended Practices for Machinery Installation and Installation Design</i>
<i>Measurement of Petroleum Measurement Standards (MPMS)</i>	
Ch. 15	Guidelines for Use of the International System of Units (SI) in the Petroleum and Allied Industries
AGMA ¹	
9002	<i>Bores and Keyways for Flexible Couplings (Inch Series)</i>
ANSI ²	
S2.19	<i>Mechanical Vibration-Balance Quality Requirements of Rigid Motors—Part 1: Determination of Possible Unbalance, Including Marine Applications</i>
ASME ³	
B1.1	<i>Unified Inch Screw Threads (UN & UNR Thread Form)</i>
B16.1	<i>Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250</i>
B16.5	<i>Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard</i>
B16.11	<i>Forged Fittings, Socket-Welding and Threaded</i>
B16.42	<i>Ductile Iron Pipe Flanges & Flanged Fittings: Classes 150 and 300</i>
B16.47	<i>Large Diameter Steel Flanges</i>
B31.3	<i>Process Piping</i>
<i>Boiler and Pressure Vessel Code</i>	
	Section V, “Nondestructive Examination”
	Section VIII, Division 1, “Rules for Construction of Pressure Vessels”
	Section IX, “Welding and Brazing Qualifications”
ASTM ⁴	
A 193	<i>Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and other Special Purpose Applications</i>
A 194	<i>Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both</i>
A 216	<i>Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service</i>
A 247	<i>Standard Test Method for Evaluating the Microstructure of Graphite in Iron Castings</i>
A 278	<i>Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650°F (350°C)</i>
A 307	<i>Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength</i>
A 320	<i>Standard Specification for Alloy-Steel And Stainless Steel Bolting Materials for Low-Temperature Service</i>
A 388	<i>Standard Practice for Ultrasonic Examination of Heavy Steel Forgings</i>
A 395	<i>Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures</i>
A 503	<i>Standard Specification for Ultrasonic Examination of Forged Crankshafts</i>
A 515	<i>Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate and Higher-Temperature Service</i>
A 668	<i>Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use</i>

¹American Gear Manufacturers Association, 500 Montgomery Street, Suite 350, Alexandria, Virginia 22314-1581, www.agma.org.

²American National Standards Institute, 25 West 43rd Street, 4th floor, New York, New York 10036, www.ansi.org.

³ASME International, Three Park Avenue, New York, New York 10016-5990, www.asme.org.

⁴ASTM 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*
- AWS⁵
 D 1.1 *Structural Welding Code—Steel*
- IEC⁶
 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 *GRAF CET Specification Language for Sequential Function Charts*
- ISO⁷
 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*
- NACE⁸
Corrosion Engineer's Reference Book

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

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

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

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

MR0175	<i>Petroleum and Natural Gas Industries—Materials for use in H₂S-Containing Environments in Oil and Gas Production</i>
NEMA ⁹	
MG 1	<i>Motors and Generators</i>
NFPA ¹⁰	
70	<i>National Electrical Code</i>
SSPC ¹¹	
SP 6/NACE No. 3	<i>Commercial Blast Cleaning</i>

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).

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

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

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