

# Gas Turbines for the Petroleum, Chemical, and Gas Industry Services

API STANDARD 616  
FIFTH EDITION, JANUARY 2011



AMERICAN PETROLEUM INSTITUTE

Currently in preview, click buy full version

# Gas Turbines for the Petroleum, Chemical, and Gas Industry Services

**Downstream Segment**

API STANDARD 616  
FIFTH EDITION, JANUARY 2011



AMERICAN PETROLEUM INSTITUTE

## 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.

Copyright © 2011 American Petroleum Institute. No part of this work may be reproduced, translated, 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, NW, Washington, DC 20005.

## Foreword

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

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 improving energy utilization should be thoroughly investigated and brought forth. This is especially true of new equipment proposals since the evaluation or 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 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.

API standards are published as an aid to procurement of standardized equipment and materials. These standards are not intended to inhibit purchasers or producers from purchasing or producing products made to other standards.

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

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

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.

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, NW, Washington, DC 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 by API, 1220 L Street, NW, Washington, DC 20005.

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

## **Important Information Concerning Use of Asbestos or Alternative Materials**

Asbestos is specified or referenced for certain components of the equipment described in some API standards. It has been of extreme usefulness in minimizing fire hazards associated with petroleum processing. It has also been a universal sealing material, compatible with most refining fluid services.

Certain serious adverse health effects are associated with asbestos, among them the serious and often fatal disease of lung cancer, asbestosis, and mesothelioma (a cancer of the chest and abdominal linings). The degree of exposure to asbestos varies with the product and the work practices involved.

Consult the most recent edition of the Occupational Safety and Health Administration (OSHA), U.S. Department of Labor, Occupational Safety and Health Standard for Asbestos, Tremolite, Anthophyllite, and Actinolite, 29 *Code of Federal Regulations* Section 1910.1001; the U.S. Environmental Protection Agency, National Emission Standard for Asbestos, 40 *Code of Federal Regulations* Sections 61.140 through 61.156; and the U.S. Environmental Protection Agency (EPA) rule on labeling requirements and phased banning of asbestos products (Sections 763.160-179).

There are currently in use and under development a number of substitute materials to replace asbestos in certain applications. Manufacturers and users are encouraged to develop and use effective substitute materials that can meet the specifications for, and operating requirements of, the equipment to which they would apply.

SAFETY AND HEALTH INFORMATION WITH RESPECT TO PARTICULAR PRODUCTS OR MATERIALS CAN BE OBTAINED FROM THE EMPLOYER, THE MANUFACTURER OR SUPPLIER OF THAT PRODUCT OR MATERIAL, OR THE MATERIAL SAFETY DATASHEET.

## Contents

	Page
<b>1 Scope</b> .....	<b>1</b>
1.1 General .....	1
1.2 Alternative Designs .....	2
1.3 Conflicts .....	1
<b>2 References</b> .....	<b>1</b>
2.1 Normative References .....	1
2.2 Compliance .....	6
2.3 Responsibilities .....	6
<b>3 Terms, Definitions, Acronyms, Abbreviations, and Symbols</b> .....	<b>7</b>
<b>4 Basic Design</b> .....	<b>17</b>
4.1 General .....	17
4.2 Pressure Casings .....	20
4.3 Combustors and Fuel Nozzles .....	21
4.4 Casing Connections .....	22
4.5 Rotating Elements .....	23
4.6 Seals .....	25
4.7 Dynamics .....	25
4.8 Bearings and Bearing Housing .....	42
4.9 Lubrication .....	45
4.10 Materials .....	46
4.11 Nameplates and Rotational Arrows .....	51
4.12 Quality .....	52
<b>5 Accessories</b> .....	<b>52</b>
5.1 Starting and Helper Driver .....	52
5.2 Gears, Couplings, and Guards .....	54
5.3 Mounting Plates .....	55
5.4 Controls and Instrumentation .....	62
5.5 Piping and Appurtenances .....	71
5.6 Inlet and Exhaust Systems .....	72
5.7 Insulation, Weatherproofing, Fire Protection, and Acoustical Treatment .....	80
5.8 Fuel System .....	83
5.9 Special Tools .....	95
<b>6 Inspection, Testing, and Preparation for Shipment</b> .....	<b>96</b>
6.1 General .....	96
6.2 Inspection .....	96
6.3 Testing .....	98
6.4 Preparation for Shipment .....	104
<b>7 Vendor's Data</b> .....	<b>105</b>
7.1 General .....	105
7.2 Proposals .....	106
7.3 Contract Data .....	109
<b>Annex A (informative) Typical Datasheets</b> .....	<b>113</b>
<b>Annex B (normative) Gas Turbine Vendor Drawing and Data Requirements (VDDR)</b> .....	<b>142</b>
<b>Annex C (normative) Procedure for Determination of Residual Unbalance</b> .....	<b>155</b>

## Contents

	Page
<b>Annex D (normative) Torsional and Lateral Flowcharts</b> .....	<b>160</b>
<b>Annex E (informative) Gas Turbine Nomenclature</b> .....	<b>165</b>
<b>Figures</b>	
<b>1 Rotor Response Plot</b> .....	<b>27</b>
<b>2 Undamped Critical Speed Map</b> .....	<b>28</b>
<b>3 Between Bearing Machines</b> .....	<b>29</b>
<b>4 Overhung Machines</b> .....	<b>30</b>
<b>5 API and ISO Balance Grades</b> .....	<b>39</b>
<b>6 Typical Mounting Plate Arrangement</b> .....	<b>57</b>
<b>7 Typical Mounting Plate Arrangement</b> .....	<b>58</b>
<b>8 Typical Mounting Plate Arrangement</b> .....	<b>59</b>
<b>9 Typical Mounting Plate Arrangement</b> .....	<b>60</b>
<b>10 Fuel Gas System—Minimum Arrangement</b> .....	<b>84</b>
<b>11 Fuel Gas System—Typical Alternative Arrangement</b> .....	<b>84</b>
<b>12 Fuel Gas System—Typical Alternative Arrangement</b> .....	<b>84</b>
<b>13 Typical Liquid Fuel System Arrangement</b> .....	<b>90</b>
<b>14 Performance Curves for a Single-shaft Gas Turbine</b> .....	<b>110</b>
<b>15 Performance Curves for a Multiple-shaft Gas Turbine (Constant Exhaust Temperature)</b> .....	<b>110</b>
<b>16 Performance Curves for a Multiple-shaft Gas Turbine (Varying Exhaust Temperature)</b> .....	<b>111</b>
<b>C.1 Residual Unbalance Worksheet</b> .....	<b>156</b>
<b>C.2 Residual Unbalance Worksheet</b> .....	<b>157</b>
<b>C.3 Sample Calculations for Residual Unbalance</b> .....	<b>158</b>
<b>C.4 Sample Calculations for Residual Unbalance</b> .....	<b>159</b>
<b>D.1 Torsional Analysis Flowchart</b> .....	<b>161</b>
<b>D.2 Lateral Analysis Flowchart</b> .....	<b>163</b>
<b>E.1 Industrial Gas Turbine Nomenclature</b> .....	<b>166</b>
<b>E.2 Aeroderivative Gas Turbine Nomenclature</b> .....	<b>167</b>
<b>E.3 Aeroderivative Gas Turbine Nomenclature</b> .....	<b>168</b>
<b>Tables</b>	
<b>1 Corresponding DN and NPS Pipe Sizes</b> .....	<b>8</b>
<b>2 Various Devices and “On-the-Shelf State”</b> .....	<b>12</b>
<b>3 Pipe Size and Number of Threads per Inch</b> .....	<b>13</b>
<b>4 Vibration Limits According to ISO 10816-4 and ISO 7919-4</b> .....	<b>40</b>
<b>5 Common Hazardous Area Electrical Codes</b> .....	<b>63</b>
<b>6 Typical Alarm and Shutdown Annunciation</b> .....	<b>66</b>
<b>7 Inlet Air Contaminants and Sources</b> .....	<b>74</b>
<b>8 Typical Gas Fuel System Components</b> .....	<b>84</b>
<b>9 Typical Liquid Fuel System Components</b> .....	<b>90</b>

# Gas Turbines for the Petroleum, Chemical, and Gas Industry Services

## 1 Scope

### 1.1 General

This standard covers the minimum requirements for open, simple, and regenerative-cycle combustion gas turbine units for services of mechanical drive, generator drive, or process gas generation. All auxiliary equipment required for operating, starting, controlling, and protecting gas turbine units are either discussed directly in this standard or referred to in this standard through references to other publications. Specifically, gas turbine units that are capable of firing gas or liquid or both are covered by this standard. This standard covers both industrial and aeroderivative gas turbines.

**NOTE** A bullet (●) at the beginning of a paragraph indicates that either a decision is required or further information is to be provided by the purchaser. The information should be indicated on the datasheets (see Annex A); otherwise, it should be stated in the quotation request or in the order.

### 1.2 Alternative Designs

The vendor may offer alternative designs.

### 1.3 Conflicts

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

## 2 References

### 2.1 Normative References

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

API *Manual of Petroleum Measurement Standards (MPMS) Chapter 15:2001, Guidelines for the Use of the International System of Units (SI)*

API Standard 541:2004, *Form-Wound Squirrel Cage Induction Motors—500 Horsepower and Larger*

API Standard 546:2000, *Brushless Synchronous Machines—500 KVA and Larger*

API Standard 547:2005, *General-Purpose Form-Wound Squirrel Cage Induction Motors—250 Horsepower and Larger*

API Standard 611:2008, *General-Purpose Steam Turbines for Petroleum, Chemical, and Gas Industry Services*

API Standard 612:2005, *Special-Purpose Steam Turbines for Petroleum, Chemical, and Gas Industry Services*

API Standard 613:2003, *Special-Purpose Gear Units for Petroleum, Chemical, and Gas Industry Services*

API Standard 614:2008, *Lubrication, Shaft-Sealing, and Oil-control Systems and Auxiliaries*

API Standard 670:2000, *Machinery Protection Systems*