ASME PTC 10-2022
[Revision of ASME PTC 10-1997 (R2014)]

Axial and Centrifugal Compressors

Performance Test Codes

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

ASME PTC 10-2022
[Revision of ASME PTC 10-1997 (R2014)]

Axial and Centrifugal Compressors

Performance Test Codes

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers
Two Park Avenue • New York, NY • 10016 USA

Date of Issuance: August 24, 2023

The next edition of this Code is scheduled for publication in 2027.

The American Society of Mechanical Engineers
Two Park Avenue, New York, NY 10016-5990

CONTENTS

Figures

Tables

NOTICE

All ASME Performance Test Codes (PTCs) shall adhere to the requirements of ASME PTC 1, General Instructions. It is expected that the Code user is fully cognizant of the requirements of ASME PTC 1 and has read them before applying ASME PTCs.

ASME PTCs provide unbiased test methods for both the equipment supplier and the users of the equipment or systems. The Codes are developed by balanced committees representing all concerned interests and specify procedures, instrumentation, equipment-operating requirements, calculation methods, and uncertainty analysis. Parties to the test can reference an ASME PTC confident that it represents the highest level of accuracy consistent with the best engineering knowledge and standard practice available, taking into account test costs and the value of information obtained from testing. Precision and reliability of test results shall also underlie all considerations in the development of an ASME PTC, consistent with economic considerations as judged appropriate by each technical committee under the jurisdiction of the ASME Board on Standardization and Testing.

When tests are run in accordance with a Code, the test results, without adjustment for uncertainty, yield the best available indication of the actual performance of the tested equipment. Parties to the test shall ensure that the test is objective and transparent. All parties to the test shall be aware of the goals of the test, technical limitations, challenges, and compromises that shall be considered when designing, executing, and reporting a test under the ASME PTC guidelines.

ASME PTCs do not specify means to compare test results to contractual guarantees. Therefore, the parties to a commercial test should agree before starting the test, and preferably before signing the contract, on the method to be used for comparing the test results to the contractual guarantees. It is beyond the scope of any ASME PTC to determine or interpret how such comparisons shall be made.

FOREWORD

Revisions to test codes are inevitable in an effort to incorporate new technology and lessons learned. As is typical with this type of revision and update, committee members working to achieve an improved code have employed the previous code editions extensively throughout their professional careers. This leads to modifications, additions, and deletions to the code based on firsthand experience. However, the same ultimate goal sought by committees that rewrote previous editions remains. For the ASME PTC 10 Committee, that goal is to provide the best possible guidance and a set of rules to ensure that a compressor tested according to the Code reveals its true performance capabilities that will manifest when applied in the field. It is important to note that an acceptable ASME PTC 10 test simply means the results were obtained with adherence to Code requirements developed via dimensional analysis. The Code does not have rules concerning compressor acceptability to meet project guarantees agreed between vendors and users.

Historic and developing technical literature for compressor performance abounds with recommended changes and improvements to ASME PTC 10. These cover such technical areas as numerical solution algorithms, advances in equation of state accuracy and access, instrumentation, testing logic, and compressor hardware. The committee has reviewed and debated many proposed technical advances and judiciously applied sound engineering judgment tempered by collective experience, varied professional backgrounds, and a healthy dose of guidance from ASME.

Three major changes that previous Code users will notice are worthy of mention. These are

(a) ideal gas considerations replaced by real gas methods

(b) performance calculations based on the Schultz method replaced by an option to select from three polytropic computational methods

(c) replacement and expansion of Reynolds number correction calculations

The first change is driven by industry's need to address fluid conditions well in excess of pressures and temperatures that previously were thought of as being in the near-ideal gas behavior region of a fluid's phase diagram. Nonideal fluid behavior has been a concern and historically has presented numerous discrepancies between predicted and measured compressor performance. These issues are much better understood today, and this revised Code requires all fluids be treated as real rather than ideal. Vast expansion in availability and access to reference-quality fluid equations of state assists in easing this transition.

The second major change has been driven by peer-reviewed published documentation showing the magnitude of relative differences introduced by various polytropic work computational methods. The polytropic methods previously embraced by the Code served analysts well for many years. The historical origins of those methods date back to the 1860s but they were thoroughly documented and expanded by Schultz (1962). Schultz's methods served as the basis for incorporation into ASME PTC 10-1965 and were retained in the 1997 edition. For this revised edition, the use of pv^n to develop a closed-form solution for the integral of polytropic work (vdp) has been abandoned in favor of methods with lower uncertainty over a broad range of fluid conditions. The three methods included in the current Code range from simple to complex with uncertainty decreasing with complexity. Computerized numerical tools render straightforward implementation of any of the three methods. The committee has expended a great amount of energy and resources in determining the methods to include in the Code and proving their ability to yield accurate results over a wide range of fluids and conditions. In addition, the isentropic relations that were included in previous editions of the Code have been deleted. While the isentropic model was necessary to calculate the Schultz correction factor that was then applied to modify the polytropic calculation results, it was also used in some cases to provide alternate isentropic model performance calculations.

The third major change is the replacement and expansion of the Reynolds number correction methods. In actual practice, most vendors and users have replaced the methods adapted from Wiesner and included in ASME PTC 10-1997. Type 2 tests performed according to this Code now apply the International Compressed Air and Allied Machinery Committee (ICAAMC) 1987 method for this subject. Nondimensional test results for polytropic efficiency, polytropic work coefficient, work input coefficient, and flow coefficient will all be corrected accordingly.

While it is not possible to describe all the changes incorporated into this revised Code in this Foreword, users should be aware that many additions, improvements, deletions, and changes have been made. Embracing the resulting Code will provide compressor performance analysts with accurate methods and testing guidance. Several appendices have been provided that will assist in explanations and illustrate sample calculations. Nonmandatory Appendix D, References, has been greatly expanded to provide users with a resource listing that will augment their own individual study of compressor performance.

This Code is available for public review on a continuing basis. This provides an opportunity for additional input from industry, academia, regulatory agencies, and the public-at-large.

ASME PTC 10-2022 was approved by the PTC Standards Committee on September 27, 2022, and was approved as an American National Standard by the American National Standards Institute (ANSI) Board of Standards Review on December 12, 2022.

ASME PTC COMMITTEE
Performance Test Codes

(The following is the roster of the committee at the time of approval of this Code.)

STANDARDS COMMITTEE OFFICERS

S. A. Scavuzzo, *Chair*
T. K. Kirkpatrick, *Vice Chair*
D. Alonzo, *Secretary*

STANDARDS COMMITTEE PERSONNEL

P. G. Albert, Consultant
D. Alonzo, The American Society of Mechanical Engineers
J. M. Burns, Burns Engineering Services, Inc.
A. E. Butler, General Electric Power and Water
W. C. Campbell, True North Consulting, LLC
J. Gonzalez, Iberdrola Igenieria y Construcción
R. E. Henry, Consultant
D. R. Keyser, Survice Engineering
T. K. Kirkpatrick, McHale & Associates, Inc.
M. P. McHale, McHale & Associates, Inc.
J. W. Milton, Chevron, USA
S. P. Nuspl, Consultant
S. A. Scavuzzo, The Babcock & Wilcox Co.
J. A. Silvaggio, Jr., Siemens Demag Delaval Turbomachinery, Inc.
T. L. Toburen, T2E3, Inc.
W. C. Wood, WW Services
R. P. Allen, *Honorary Member,* Consultant
P. M. McHale, *Honorary Member,* McHale & Associates, Inc.
R. R. Priestley, *Honorary Member,* Consultant
R. E. Sommerlad, *Honorary Member,* Consultant

PTC 10 COMMITTEE — AXIAL AND CENTRIFUGAL COMPRESSORS

M. Taher, *Chair,* Bechtel
M. Pagano, *Secretary,* The American Society of Mechanical Engineers
L. Baldassarre, Baker Hughes
C. Beckers, Atlas Copco Energas GmbH
Y. Biba, Siemens Energy
K. Brun, Elliot Group
F. Evans, Consultant
R. Huntington, Oak Hill Turbo and Associates, LLC
R. Kurz, Solar Turbines, Inc.
M. Sandberg, Consultant
M. Scholtysik, MAN Energy Solutions Schweiz AG
H. Weyermann, Consultant
E. Toci, *Alternate,* Baker Hughes

CORRESPONDENCE WITH THE PTC COMMITTEE

General. ASME codes and standards are developed and maintained by committees with the intent to represent the consensus of concerned interests. Users of ASME codes and standards may correspond with the committees to propose revisions or cases, report errata, or request interpretations. Correspondence for this Code should be sent to the staff secretary noted on the committee's web page, accessible at https://go.asme.org/PTCcommittee.

Revisions and Errata. The committee processes revisions to this Code on a continuous basis to incorporate changes that appear necessary or desirable as demonstrated by the experience gained from the application of the Code. Approved revisions will be published in the next edition of the Code.

In addition, the committee may post errata on the committee web page. Errata become effective on the date posted. Users can register on the committee web page to receive e-mail notifications of posted errata.

This Code is always open for comment, and the committee welcomes proposals for revisions. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent background information and supporting documentation.

Cases

(a) The most common applications for cases are

(1) to permit early implementation of a revision based on an urgent need

(2) to provide alternative requirements

(3) to allow users to gain experience with alternative or potential additional requirements prior to incorporation directly into the Code

(4) to permit the use of a new material or process

(b) Users are cautioned that not all jurisdictions or owners automatically accept cases. Cases are not to be considered as approving, recommending, certifying, or endorsing any proprietary or specific design, or as limiting in any way the freedom of manufacturers, constructors, or owners to choose any method of design or any form of construction that conforms to the Code.

(c) A proposed case shall be written as a question and reply in the same format as existing cases. The proposal shall also include the following information:

(1) a statement of need and background information

(2) the urgency of the case (e.g., the case concerns a project that is underway or imminent)

(3) the Code and the paragraph, figure, or table number(s)

(4) the edition(s) of the Code to which the proposed case applies

(d) A case is effective for use when the public review process has been completed and it is approved by the cognizant supervisory board. Approved cases are posted on the committee web page.

Interpretations. Upon request, the committee will issue an interpretation of any requirement of this Code. An interpretation can be issued only in response to a request submitted through the online Interpretation Submittal Form at https://go.asme.org/InterpretationRequest. Upon submitting the form, the inquirer will receive an automatic e-mail confirming receipt.

ASME does not act as a consultant for specific engineering problems or for the general application or understanding of the Code requirements. If, based on the information submitted, it is the opinion of the committee that the inquirer should seek assistance, the request will be returned with the recommendation that such assistance be obtained. Inquirers can track the status of their requests at https://go.asme.org/Interpretations.

ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME committee or subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

Interpretations are published in the ASME Interpretations Database at https://go.asme.org/Interpretations as they are issued.

Committee Meetings. The PTC Standards Committee regularly holds meetings that are open to the public. Persons wishing to attend any meeting should contact the secretary of the committee. Information on future committee meetings can be found on the committee web page at https://go.asme.org/PTCcommittee.

Section 1
Object and Scope

1-1 OBJECT

The object of this Code is to provide a test procedure to determine the thermodynamic performance of an axial or centrifugal compressor doing work on a gas of known or measurable properties under specified conditions.

This Code is written to provide a test procedure, which will yield the highest level of accuracy consistent with the best engineering knowledge and practice currently available. Nonetheless, no single universal value of the uncertainty is, or should be, expected to apply to every test. The uncertainty associated with any individual ASME PTC 10 test will depend on practical choices made in terms of instrumentation and methodology. Rules are provided to estimate the uncertainty for individual tests.

The expectation of the Code is that a compressor performance test will be executed in a shop or factory environment to provide for the special instrumentation, calibration requirements, meter run designs, and other controlled test conditions needed by the Code. This Code may be applied to the extent that its requirements are satisfied elsewhere, such as at a user's site or field installation.

An important assumption of this Code is that the performance of a compressor may be determined either by testing at conditions that are close to those that are specified, including gas composition, pressures, and temperatures, or by testing at alternative conditions that preserve key design parameters of the compressor. Such alternative conditions may allow the test to be conducted with a suitable test gas, at suitable test pressures and temperatures, at a suitable test speed and a flow rate that preserve similitude between the specified conditions and the scaled test conditions. These alternative conditions require that the ratio of the inlet specific volume versus the discharge specific volume at test conditions and at specified conditions is within permissible tolerance. These alternative conditions also require that the nondimensional flow rate (i.e., the flow coefficient) at the test conditions and at specified conditions is within a permissible tolerance. By maintaining similitude between test conditions and specified conditions, the Code assumes that the results of the test, including flow rate, work, and efficiency, can be converted from test conditions to specified conditions.

1-2 SCOPE

1-2.1 General

The scope of this Code includes instructions on test arrangement and instrumentation, test procedure, and methods for evaluation and reporting of final results.

This Code provides rules for establishing the following quantities, corrected as necessary to represent expected performance under specified operating conditions with the specified gas:

(a) quantity of gas delivered
(b) pressure rise produced
(c) volume reduction ratio
(d) polytropic work
(e) shaft power required
(f) polytropic efficiency
(g) surge point
(h) choke point

Other than providing methods for calculating mechanical power losses, this Code does not cover rotor dynamics or other mechanical performance parameters.

1-2.2 Compressor Arrangements

This Code is designed to allow the testing of single- or multiple-casing axial or centrifugal compressors or combinations thereof, with one or more sections per casing and with sidestreams.