ASME PTC 46-2015
(Revision of ASME PTC 46-1996)

Overall Plant Performance

Performance Test Codes

AN AMERICAN NATIONAL STANDARD

The American Society of
Mechanical Engineers

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Two Park Avenue • New York, NY • 10016 USA

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This Code will be revised when the Society approves the issuance of a new edition.

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The American Society of Mechanical Engineers
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NOTICE

All Performance Test Codes must adhere to the requirements of ASME PTC 1, General Instructions. The following information is based on that document and is included here for emphasis and for the convenience of the user of the Code. It is expected that the Code user is fully cognizant of Sections 1 and 3 of ASME PTC 1 and has read them prior to applying this Code.

ASME Performance Test Codes provide test procedures that yield results of the highest level of accuracy consistent with the best engineering knowledge and practice currently available. They were developed by balanced committees representing all concerned interests and specify procedures, instrumentation, equipment-operating requirements, calculation methods, and uncertainty analysis.

When tests are run in accordance with a Code, the test results themselves, without adjustment for uncertainty, yield the best available indication of the actual performance of the tested equipment. ASME Performance Test Codes do not specify means to compare those results to contractual guarantees. Therefore, it is recommended that the parties to a commercial test 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 Code to determine or interpret how such comparisons shall be made.

FOREWORD

ASME Performance Test Codes (PTCs) have been developed and have long existed for determining the performance of most major components used in electric power production facilities. These major component focused performance test codes served the industry well until changes in the electric power generation industry exposed the need for a code addressing overall power plant performance testing. In response to these needs, the ASME Board on Performance Test Codes approved the formation of a committee (ASME PTC 46) in June 1991 with the charter of developing a code for the determination of overall power plant performance. The organizational meeting of this Committee was held in September 1991. The resulting Committee included experienced and qualified users, manufacturers, and general interest category personnel from both the regulated and non-regulated electric power generating industry.

In developing the first issue of this Code, the Committee reviewed common industry practices with regard to overall power plant and cogeneration facility testing. The Committee was not able to identify any general consensus testing methods, and discovered many conflicting philosophies. The Committee has strived to develop an objective code which addresses the multiple needs for explicit testing methods and procedures, while attempting to provide maximum flexibility in recognition of the wide range of plant designs and the multiple needs for this Code.

The first edition of ASME PTC 46 was found to be very beneficial to the industry, as predicted. It was applied around the world by reference in contracts, as well as applied as the basis of ongoing plant performance engineering activities.

The committee members met about seven years after the initial publication to discuss lessons-learned from experience with code applications that required strengthening or otherwise modifying the Code. New members with extensive experience using the Code were at that time brought on to the committee.

All sections were revamped, based on the lessons-learned study and industry assessment, to clarify unforeseen misinterpretations and to add more necessary information.

Section 3 was revised to sharpen the descriptions of the fundamental principles used for an overall plant performance test, and to present information in a more organized fashion.

Section 4 was rewritten. The instrumentation technology was brought up-to-date, and more in-depth information was provided for each type of instrument, including harmonization with ASME PTC 19.5. ASME PTC 46 was the first ASME Performance Test Code to clearly differentiate between calculated variables and measured parameters, and classify them as primary or secondary. Instrumentation requirements were thus determined as being Class 1 or Class 2. As such, selection of instrumentation was made more structured, economical, and efficient. This information was clarified further in the Section 4 revision. Details concerning calibration methodology both in the instrumentation laboratory as well as for field calibrations were also added to Section 4.

Details regarding application of the generalized performance equations to specific power technologies and test goals have been clarified and expanded in Section 5, providing additional guidance for various types of plants and cycles. In the decade and a half since the publication of the original version of this Code, the industry has had sufficient time to study the uncertainty implications of testing plants with the inlet air conditioning equipment in service and also to accrue a significant body of practical experience in the application of the Code. These developments have led the authors to conclude that testing with inlet air conditioning equipment in service can be accomplished within required considerations of practicality and test uncertainty. Based on this, Section 5 was revised to recommend testing with the inlet air conditioning systems configured to match the reference conditions provided the ambient conditions allow. The combined cycle plant phase testing methodology was updated to account for additional parameters when going from simple cycle to combined cycle operation and incorporates the use of "non-phased" CC plant correction curves in combination with GT correction curves, which leads to a more accurate test result while providing more usability for the set of correction curves. Section 5 also provides more background on development of correction curves from integrated heat balance computer models as opposed to non-integrated heat balance computer models of Rankine cycle power plants. By integrated model, it is meant that the steam generator is integrated into the heat balance computer model. Additionally, Nonmandatory Appendix H was added to define a methodology to determine part load test corrected heat rate at a specified reference condition. More direction is given for testing Rankine cycle power plants in Nonmandatory Appendix E, with two new detailed sample calculations (one using an integrated model and one using a non-integrated model) given in the appendices for a coal-fired steam power plant.

A far more detailed uncertainty analysis was published than in the previous edition, and is in harmony with ASME PTC 19.1. Detailed explanations are provided for each step of the calculation in Nonmandatory Appendix F.

Lastly, ASME PTC 46 was perceived by some in the industry who had only passing acquaintance with it as being applicable to combined cycle power plants only. The strengthening of Section 5 applications to Rankine cycles and the more thorough coal-fired plant sample calculations should go far to change that perception. Performance test engineers who are experienced users of the Code also recognize the applicability of the generalized performance equations and test methods of ASME PTC 46 to tests of nuclear steam cycles or, to the thermal cycle of solar power plants, and other power generation technologies. The committee has added language to the Code to confirm its applicability to such technologies, and looks forward to adding sample calculations for nuclear, thermal solar, geothermal, and perhaps other power generation technologies in the next revision.

This Code was approved by the PTC 46 Committee and the PTC Standards Committee on March 12, 2015. It was then approved as an American National Standard by the American National Standards Institute (ANSI) Board of Standards Review on September 25, 2015.

ASME PTC COMMITTEE
Performance Test Codes

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

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The Committee Personnel wish to express their sincere thanks to Mr. Jeffrey Russell Friedman for the defining role he has played in the development of this Code.

Before his passing on August 24, 2012, Jeff acted with great passion and leadership in his role of Committee Chair.

CORRESPONDENCE WITH THE PTC COMMITTEE

General. ASME Codes are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Code may interact with the Committee by requesting interpretations, proposing revisions or a case, and attending Committee meetings. Correspondence should be addressed to:

Secretary, PTC Standards Committee
The American Society of Mechanical Engineers
Two Park Avenue
New York, NY 10016-5990
http://go.asme.org/Inquiry

Proposing Revisions. Revisions are made periodically to the Code 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 periodically.

The Committee welcomes proposals for revisions to this Code. 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 documentation.

Proposing a Case. Cases may be issued to provide alternative rules when justified, to permit early implementation of an approved revision when the need is urgent, or to provide rules not covered by existing provisions. Cases are effective immediately upon ASME approval and shall be posted on the ASME Committee Web page.

Requests for Cases shall provide a Statement of Need and Background Information. The request should identify the Code and the paragraph, figure, or table number(s), and be written as a Question and Reply in the same format as existing Cases. Requests for Cases should also indicate the applicable edition(s) of the Code to which the proposed Case applies.

Interpretations. Upon request, the PTC Standards Committee will render an interpretation of any requirement of the Code. Interpretations can only be rendered in response to a written request sent to the Secretary of the PTC Standards Committee.

Requests for interpretation should preferably be submitted through the online Interpretation Submittal Form. The form is accessible at http://go.asme.org/InterpretationRequest. Upon submittal of the form, the Inquirer will receive an automatic e-mail confirming receipt.

If the Inquirer is unable to use the online form, he/she may e-mail the request to the Secretary of the PTC Standards Committee at SecretaryPTC@asme.org, or mail it to the above address. The request for an interpretation should be clear and unambiguous. It is further recommended that the Inquirer submit his/her request in the following format:

Subject:	Cite the applicable paragraph number(s) and the topic of the inquiry in one or two words.
Edition:	Cite the applicable edition of the Code for which the interpretation is being requested.
Question:	Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for an approval of a proprietary design or situation. Please provide a condensed and precise question, composed in such a way that a "yes" or "no" reply is acceptable.
Proposed Reply(ies):	Provide a proposed reply(ies) in the form of "Yes" or "No," with explanation as needed. If entering replies to more than one question, please number the questions and replies.
Background Information:	Provide the Committee with any background information that will assist the Committee in understanding the inquiry. The Inquirer may also include any plans or drawings that are necessary to explain the question; however, they should not contain proprietary names or information.

Requests that are not in the format described above may be rewritten in the appropriate format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

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.

Attending Committee Meetings. The PTC Standards Committee regularly holds meetings and/or telephone conferences that are open to the public. Persons wishing to attend any meeting and/or telephone conference should contact the Secretary of the PTC Standards Committee. Future Committee meeting dates and locations can be found on the Committee Page at go.asme.org/PTCcommittee.

INTRODUCTION

APPLICATIONS AND LIMITATIONS

This Test Code provides explicit procedures for the determination of power plant thermal performance and electrical output. Test results provide a measure of the performance of a power plant or thermal island at a specified cycle configuration, operating disposition and/or fixed power level, and at a unique set of base reference conditions.

Test results can then be used as defined by a contract for the basis of determination of fulfillment of contract guarantees. Test results can also be used for comparison to a design number, to trend performance changes over time, to help evaluate possible modifications or to validate them, or for any application in which the overall plant performance is needed.

The results of a test conducted in accordance with this Code will not provide the sole basis for comparing the thermo-economic effectiveness of different plant designs, or to compare different generation technologies.

Power plants, which produce secondary energy outputs, i.e., cogeneration facilities, are included within the scope of this Code. For cogeneration facilities, there is no requirement for a minimum percentage of the facility output to be in the form of electricity; however, the guiding principles, measurement methods, and calculation procedures are predicated on electricity being the primary output. As a result, a test of a facility with a low proportion of electric output may not be capable of meeting the maximum allowable test uncertainties of this Code.

Power plants are comprised of many equipment components. Test data required by this Code may also provide limited performance information for some of this equipment; however, this Code was not designed to facilitate simultaneous code level testing of individual components of a power plant. ASME PTCs that address testing of major power plant equipment provide a determination of the individual equipment isolated from the rest of the system. ASME PTC 46 has been designed to determine the performance of the entire heat cycle as an integrated system. Where the performance of individual equipment operating within the constraints of their design specified conditions are of interest, ASME PTCs developed for the testing of specific components should be used. Likewise, determining overall plant performance by combining the results of ASME Code tests conducted on each plant component is not an acceptable alternative to an ASME PTC 46 test, and an incorrect application of the other Codes.

GUIDANCE IN USING THIS CODE

As with all PTC's, ASME PTC 46 was initially developed primarily to address the needs of contract acceptance or compliance testing. This is not intended, however, to limit or prevent the use of this Code for other types of testing where the accurate determination of overall power plant performance is required. ASME PTC 46 is appropriate for all applications of Performance Test Codes tabulated in ASME PTC 1, see subsection 1-4.

This Code is not a tutorial. It is intended for use by persons experienced in power plant performance testing per ASME Performance Test Codes. A detailed knowledge of power plant operations, thermodynamic analysis and heat balance development, test measurement methods, and the use, control, and calibration of measuring and test equipment are presumed prerequisites. Additional Performance Test Codes that the user should be highly experienced in using include the following:

(a) ASME PTC 1, General Instructions

(b) ASME PTC 4, Fired Steam Generators, (if testing, for example, a Rankine cycle plant with a coal-fueled fired steam generator in the test boundary)

(c) ASME PTC 19.1, Test Uncertainty

Other ASME PTC 19 Instrument and Apparatus Supplement series codes and other referenced Codes & Standards will need to be consulted during the planning and preparation phases of a test, as applicable. Use of ASME PTC 46 is recommended whenever the performance of a heat cycle power plant must be determined with minimum uncertainty.

OVERALL PLANT PERFORMANCE

Section 1
Object and Scope

1-1 OBJECT

The object of this Code is to provide uniform test methods and procedures for the determination of the thermal performance and electrical output of heat-cycle electric power plants and cogeneration facilities.

This Code provides explicit procedures for the determination of the following performance results:

(a) corrected power
(b) corrected heat rate or efficiency
(c) corrected heat input

Tests may be designed to satisfy different goals, including specified unit disposition, specified corrected power, and specified measured power.

1-2 SCOPE

1-2.1 General Scope

This Code applies to any plant size. It can be used to measure the performance of a plant in its normal operating condition, with all equipment in a clean and fully functional condition. This Code provides explicit methods and procedures for combined cycle power plants and for most gas, liquid, and solid fueled Rankine cycle plants. There is no intent to restrict the use of this Code for other types of heat cycle power plants, providing the explicit procedures can be met. For example, the performance equations and test methods herein are applicable to the steam cycle portion of a solar plant, or of a nuclear plant steam cycle. Refer to ASME PTC 47 for power block thermal performance test procedures associated with an IGCC plant (Integrated Gasification Combined Cycle).

This Code does not apply to component testing, for example, gas turbines (ASME PTC 22) or steam turbines (ASME PTC 6 or ASME PTC 6.2) or other individual components. To test a particular power plant or cogeneration facility in accordance with this Code, the following must be met:

(a) a means must be available to determine, through either direct or indirect measurements, all of the heat inputs entering the test boundary and all of the electrical power and secondary outputs leaving the test boundary;

(b) a means must be available to determine, through either direct or indirect measurements, all of the parameters to correct the results from the test to the base reference condition;

(c) the test result uncertainties should be less than or equal to the uncertainties given in subsection 1-3 for the applicable plant type; and

(d) the working fluid for vapor cycles must be steam. This restriction is imposed only to the extent that other fluids may require measurements or measurement methods different from those provided by this Code for steam cycles.

1-2.2 Tests Outside the Scope of ASME PTC 46

Tests addressing other power plant performance-related issues are outside the scope of this Code. These include the following:

(a) emissions tests: testing to verify compliance with regulatory emissions levels (e.g., airborne gaseous and particulate, solid and wastewater, noise, etc.), or required for calibration and certification of emission-monitoring systems.

(b) operational demonstration tests: the various standard power plant tests typically conducted during start-up, or periodically thereafter, to demonstrate specified operating capabilities (e.g., minimum load operation, automatic load control and load ramp rate, fuel switching capability, etc.).

(c) reliability tests: tests conducted over an extended period of days or weeks to demonstrate the capability of the power plant to produce a specified minimum output level or availability. The measurement methods, calculations, and corrections to design conditions included herein may be of use in designing tests of this type; however, this Code does not address this type of testing in terms of providing explicit testing procedures or acceptance criteria.

1-3 TEST UNCERTAINTY

The explicit measurement methods and procedures have been developed to provide a test of the highest level of accuracy consistent with practical limitations.