ASME PTC 47-2020
[Revision of ASME PTC 47-2006 (R2011)]

Integrated Gasification Combined Cycle Power Generation Plants

Performance Test Codes

AN AMERICAN NATIONAL STANDARD

The American Society of
Mechanical Engineers

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Date of Issuance: July 23, 2021

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

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The PTC Committee Page can be found at http://go.asme.org/PTCcommittee. There is an option available to automatically receive an e-mail notification when errata are posted to a particular code or standard. This option can be found on the appropriate Committee Page after selecting "Errata" in the "Publication Information" section.

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. A Performance Test Code has heretofore not existed to determine the overall performance of an integrated gasification combined cycle (IGCC) power generation plant. The ability to fire a wide range of fuels has been a key advantage of gas turbines over competing technologies. Until recently, the traditional fuels for gas turbines have been natural gas and distillate fuels. Today, future environmental concerns and future economic scenarios are causing power generation suppliers to develop gasification systems that can use solid and liquid fuels (e.g., coal, biomass, waste, heavy oils, etc.). Preparation of an alternative fuel suitable for a gas turbine includes removal of ash, contaminants, and erodents/corrodents. In response to these needs, the ASME Board on Performance Test Codes approved the formation of a committee (PTC 47) in 1993 with the charter of developing a Code for the determination of overall power plant performance for gasification power generation plants. The organizational meeting of this committee was held in November 1993. The resulting committee included experienced and qualified users, manufacturers, and general interest category personnel.

The committee has striven to develop an objective code that 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 PTC 47 Committee approved the Code on March 28, 2006. It was also approved by the PTC Standards Committee on March 28, and approved and adopted as a Standard practice of the Society by action of the Board on Standardization and Testing on May 18, 2006. Finally, it was approved as an American National Standard by the ANSI Board of Standards Review on July 26, 2006.

In ASME PTC 47-2020, paras. 3-5.1, 3-5.2, 3-5.3, 3-5.6, 4-7.1, 5-1.3, 5-1.4.2, 5-1.4.3, 5-4(b), 5-4.1, and 5-4.2.1; subsections 4-1, 4-2, 4-3, and 4-10; and Nonmandatory Appendix B have been revised. In addition, para. 3-5.9 and Nonmandatory Appendix E have been deleted, and para. 4-7.2 and subsections 4-4 and 4-6 have been added.

ASME PTC 47-2020 was approved by the PTC 47 Committee and the PTC Standards Committee on August 5, 2020. It was then approved as an American National Standard by the ANSI Board of Standards Review on November 9, 2020.

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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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 mail the request to the Secretary of the PTC Standards Committee at 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.

Moreover, 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 inquiry information submitted, it is the opinion of the Committee that the Inquirer should seek assistance, the inquiry will be returned with the recommendation that such assistance be obtained.

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 http://go.asme.org/PTCcommittee.

INTRODUCTION

Applications and Limitations. This Code provides procedures for the determination of integrated gasification combined cycle (IGCC) power plant thermal performance, electrical output, and product gas and/or process steam output. Test results provide measures and evaluations of the overall thermal performance of an IGCC power plant and other subsystems at a specified cycle configuration, operating disposition, and/or fixed power level, and at a specific set of base reference conditions.

Test results can be used as defined by a contract to determine the fulfillment of contract guarantees. Test results can also be used by a plant owner to compare plant performance to a design number, or to trend plant performance changes in time. However, the results of a test conducted in accordance with this Code will not provide a basis for comparing the thermoeconomic effectiveness of different plant designs.

Power plants are composed of many equipment components. Test data required by this Code may also provide limited performance information for some of this equipment. PTC 47, in conjunction with PTC 46, has been designed to determine the performance of the entire gasification combined cycle power generation plant as a whole system. Where the performance of individual equipment operating within the constraints of its design-specified conditions is of interest, ASME PTCs developed for testing of the specific components should be used.

This document is part of the following set of proposed related documents:

(a) PTC 47, Integrated Gasification Combined Cycle Plants, for testing the overall plant performance of an IGCC plant.

(b) PTC 47.1, Cryogenic Air Separation Unit, for testing the performance of the air separation unit (ASU). If the physical IGCC plant includes an ASU, the inclusion of the ASU within the overall test envelope is recommended, but not required.

(c) PTC 47.2, Gasification System, for testing the thermal performance of the combined gasifier and fuel gas cleaning equipment.

(d) PTC 47.3, Fuel Gas Cleaning, for testing the contaminant content of gas delivered to the power block.

(e) PTC 47.4, IGCC Power Block, for testing the thermal performance of the gas turbine combined cycle power block.

The term *IGCC plant* as used within this Code refers to any plant that converts a hydrocarbon-containing feed or primary fuel into a clean fuel gas for a gas turbine combined cycle. The term *integration* is not precisely defined; it refers to the general coupling of gasification equipment and power generation equipment within a single facility. Integration, within IGCC plants, may also refer to gasifiers with heat recovery connected to the steam power cycle, extraction steam from the power block used for gasification, an ASU that delivers oxygen to an oxygen-blown gasifier or nitrogen to the gas turbine, or an ASU that receives some or all of its air supply or power supply from the gas turbine combined cycle.

IGCC plants may also generate products other than electricity, such as synthesis gas and process steam.

Guidance in Using This Code. As with all Performance Test Codes, PTC 47 was 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.

This Code is not a tutorial. It is intended for persons experienced in performance testing. A working knowledge of power plant operations; thermodynamic analysis; test measurement methods; and the use, control, and calibration of measuring and test equipment are presumed prerequisites. Proper use and interpretation of this Code also requires a working knowledge of ASME Performance Test Codes. At a minimum, users of this Code should be familiar and knowledgeable with PTC 1, General Instructions, and PTC 19.1, Test Uncertainty.

Other PTC 19 Instrument and Apparatus supplement series codes may need to be consulted during the planning and preparation phases of a test. In addition, some measurement methods specified in PTC 47 refer to other PTCs for testing of specific equipment.

PTC 47 is recommended for use whenever the performance of an IGCC plant must be determined with minimum uncertainty. It is suitable for incorporation into commercial agreements to serve as the means of determining fulfillment of contract obligations. However, incorporation of PTC 47 into a contract does not eliminate the need for test planning. PTC 47 provides the protocol, or framework, for a test. As defined in Section 3, the use of PTC 47 requires the development of a detailed test plan that must be reviewed and approved by all parties prior to the start of testing.

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Section 1
Object and Scope

1-1 OBJECT

This Code provides procedures for performance testing of integrated gasification combined cycle (IGCC) power plants to determine fuel gas flow and quality, energy efficiency, heat rate, and power output at specified operating conditions.

It also provides procedures to determine the flow and quality of cleaned fuel gas produced by the IGCC plant.

(a) If electric power is the only product of the IGCC plant, this Code provides procedures for determining

(1) corrected net power
(2) corrected heat rate
(3) corrected heat input

(b) If the IGCC plant performance test also includes exported synthesis gas and/or process steam, this Code provides procedures for determining

(1) corrected net power
(2) corrected heat input
(3) export syngas pressure
(4) export syngas temperature
(5) export syngas composition
(6) export syngas flow
(7) export syngas heating value
(8) product gas contaminant content (see subsection 1-2)
(9) export steam pressure
(10) export steam temperature
(11) export steam composition
(12) export steam flow

(c) Tests may be designed to satisfy different goals. Two such tests are

(1) Specified Corrected Net Power Test
(2) Specified Disposition Test

1-2 SCOPE

This Code covers a defined range of primary fuel characteristics, but is limited to combined-cycle, power-generation systems using gas and steam turbines. This Code defines the boundaries of the overall IGCC power plant to encompass three major plant sections — the air separation unit (ASU, for oxygen-blown gasifiers or plants that use nitrogen), the gasification process (including gas cleanup), and the power block. Tests conducted by this Code determine the quantity and quality of fuel gas by its flow, temperature, pressure, composition, heating value, and its content of contaminants. Contaminants are compounds that are potentially deleterious to the gas turbine and power block in general, or are precursors to stack emissions. Contaminants to be measured are sodium (Na), potassium (K), vanadium (V), lead (Pb), calcium (Ca), barium (Ba), manganese (Mn), phosphorus (P), sulfur compounds (H_2S and COS), nitrogen compounds (HCN and NH_3), chlorine compounds (HCl), and particulate matter.

Recommendations are included for the following in pretest agreements: testing procedures, types of instruments, methods of measurement, methods of calculation, and contents of test reports.

Regulatory compliance testing of IGCC power plants is not covered by this Code.

1-3 UNCERTAINTY

Calculation procedures in accordance with those set forth in PTC 19.1 are presented to determine the uncertainty in measurements and performance parameters associated with the specified test procedures of this Code.

Under typical conditions and with currently available instruments, the largest expected total uncertainties in the test results are those in Table 1-3-1.

A post-test uncertainty analysis is required. However, a post-test uncertainty analysis is optional if parties to the test agree that the test adhered to all instrumentation requirements and procedures contained in this Code and to the agreed test procedure.