ASME PTC 52-2020

Concentrating Solar Power Plants

Performance Test Codes

AN AMERICAN NATIONAL STANDARD

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 with 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 with the contractual guarantees. It is beyond the scope of any code to determine or interpret how such comparisons shall be made.

FOREWORD

In the early 2000s, concentrating solar power (CSP) plants were being built in several locations around the world. The plants varied in size and in the type of technology they used, but they shared at least one difficulty: there was no industry standard for testing their performance. Recognizing the importance of developing a performance test code (PTC) for solar power plants, ASME brought together in July 2009 more than 30 electric-power industry volunteers from several countries to begin work on ASME PTC 52. This diverse group provided insight into each of the relevant technologies as well as expertise in plant design, power plant operation, and performance testing requirements. After agreeing that the industry needed a Code for acceptance testing of CSP plants, the Committee decided to limit the scope of the Code to CSP plants. The Code is intended for facilities that convert solar radiation into thermal energy for their own use. In most cases, the CSP plant is part of a complete electric power generation facility with CSP replacing fossil fuel as the thermal energy source. The Code does not address any photovoltaic solar fields or other systems where a heat balance at the boundary of the thermal system cannot be evaluated separately (e.g., dish-Stirling systems).

Initially, the Code was going to cover each CSP technology individually (tower, trough, linear Fresnel, storage, etc.). However, after a few meetings the Committee realized that if the solar field components were all kept within the test boundary and if the testing was concerned only with the energy streams crossing the boundary, all the technologies could be tested using the same guidelines. The final Code reflects this approach.

To prepare the Code, the Committee faced two fundamental differences between an acceptance test for a CSP plant and a test for a conventional fossil-fired system. The first difference is the transient nature of the energy source, and the second is the need to consider the role of an analytical performance model in the acceptance process. These factors bring into play the impacts of transient processes, uncertainties introduced by a model, and the need to test the accuracy of the model in predicting long-term performance. That means considering daily, seasonal, and annual solar cycles within the scope of the acceptance test procedure. Different types of tests are described in the Code, including short-term steady-state tests and longer multiday tests.

Facilities that include thermal energy storage facilities can also be tested using this Code, so long as the storage is within the test boundary. The Committee has also developed an appendix to discuss the approach for testing thermal energy storage systems independently.

The Committee recognizes that the development of new technologies, processes, and fluids is ongoing and may bring changes and improvements to the design, operation, efficiency, and output potential of the existing technologies, processes, and fluids. This Code has considered the range of conventional, proven CSP methods as those are relevant at this time. These technologies include

(a) parabolic trough with linear receiver(s)

(b) compact linear Fresnel reflectors with linear receiver(s)

(c) central tower receiver with a heliostat field (both open and cavity style receivers)

(d) thermal energy storage using a hot tank–cold tank system

Systems using different technologies than those listed can also be tested for acceptance using the guidance of ASME PTC 52.

This Code was approved by the PTC 52 Committee and the PTC Standards Committee on August 1, 2019. It was then approved as an American National Standard by the ANSI Board of Standards Review on March 23, 2020.

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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 Standards 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 PTCStandards Committee. Future Committee meeting dates and locations can be found on the Committee Page at http://go.asme.org/PTCcommittee.

Section 1
Object and Scope

1-1 OBJECT

This Code provides procedures, methods, and definitions for performance testing the solar-to-thermal conversion systems (i.e., solar thermal systems) associated with concentrating solar power (CSP) plants of parabolic trough, linear Fresnel, and power tower designs.

Accurate instrumentation and measurement techniques shall be used to determine the following performance results:

(a) thermal power output of solar field
(b) thermal energy production of solar field
(c) solar thermal efficiency
(d) heat transfer fluid (HTF) system parameters[1]
(e) auxiliary loads

This Code also provides methods for calculating performance test results.

The level to which the solar field can be tested is directly affected by the actual direct normal irradiance (DNI), performance of the downstream equipment (which is not part of this Code), and ambient conditions. Therefore, the parties to the test should pay particular attention to the combined effect of actual test conditions compared to the design values.

1-2 SCOPE

This Code applies to testing of solar-to-thermal conversion systems for parabolic trough, linear Fresnel, and power tower CSP systems. A unique feature of these systems is the variability of the input energy from the sun. Therefore, recommendations regarding the instrumentation required to measure the DNI are provided in this Code.

This Code also provides guidance on thermal energy storage systems that are often integral parts of CSP plant designs. This Code recognizes that many forms of energy storage systems with varying test goals are likely to be of interest to the industry. In the absence of any other Code-level guidance, this Code provides input related to testing thermal storage systems in Nonmandatory Appendix A.

This Code does not apply to systems where a heat balance at the boundary of the thermal system cannot be evaluated separately, such as

(a) concentrating photovoltaics (CPV) plants
(b) concentrating photovoltaics and thermal (CPT) plants
(c) concentrating thermophotovoltaics (CTPV) plants
(d) dish and engine plants

This Code contains methods for conducting and reporting performance tests of solar-energy-to-thermal-energy conversion systems that may include thermal energy storage systems. This Code includes requirements for pretest arrangements, testing methods, instrumentation, recommendations for measurement, and methods (or guidelines) for calculating test results and uncertainty. This Code does not apply to the determination of balance-of-plant or power-cycle performance.

1-3 UNCERTAINTY

A primary goal of this Code is to achieve test results of the lowest uncertainty consistent with the best engineering knowledge and practice in the industry while taking into account test costs and the value of information obtained from testing. The nature of CSP plants and their various design configurations result in a wide variation in the expected uncertainty of test results. Uncertainty levels are dependent on the technology used, varying ambient conditions, measurement uncertainty, and mode of operation during a test. There can be significant variation in the parameters that must be measured and the suitable instrumentation for doing so. For instance, testing in a location with a high

[1] Parameters include temperature, pressure, and flow.