ASME PTC 6-2004
(Revision of ASME PTC 6-1996)

Steam Turbines

Performance Test Codes

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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 included here for emphasis and the convenience of the Code user. 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

HISTORICAL BACKGROUND

The Test Code for Steam Turbines was one of the group of ten codes forming the 1915 edition of the ASME Performance Test Codes. A revision of these codes was begun in 1918, and the Test Code for Steam Turbines was issued in revised form in April, 1928.

In 1932, a decision was reached to undertake a complete revision of the 1928 edition, and the Committee No. 6 was enlarged at the request of Chairman C. H. Berry. Two developments contributed to the making of this decision: first, the increased use of extraction, mixed-pressure, and other types of turbines favored their inclusion within the scope of the Steam Turbine Test Code; second, a broader concept of test codes resulted from international conferences.

The new concept arose in the following manner. In 1925, the U.S. National Committee of the International Electrotechnical Commission (IEC) invited the cooperation of the American Society of Mechanical Engineers in the preparation of an international test code for steam turbines. The invitation was referred to and accepted by the Performance Test Codes Committee. The IEC Secretariat for this project was assigned to the United States, and two international publications were issued, one dealing with specifications and the other covering rules for acceptance tests. Appendices to these international rules were agreed upon, and these appendices included the types of turbines that the ASME Performance Test Codes Committee added to the 1941 edition to its Test Code for Steam Turbines.

The broader concept of the content of test codes of this kind was gained in the course of this international activity. The new concept was discussed by the ASME Performance Test Codes Committee from time to time, and a revision of the Committee's model test code outline was adopted for guidance in the preparation of new codes and the revision of existing codes.

In 1949, a revision of the Code was undertaken because experience with the 1941 edition disclosed differences and ambiguities that required correction and clarification. This revision, approved and adopted by the Council of ASME, was published in January 1949 and designated as PTC 6-1949.

As a result of the evolution of the steam cycle, particularly with the increased application of reheat, consideration was given to revision of PTC 6-1949. Pressures and temperatures had increased, thermal cycles had become complex, and improved measuring techniques became available. In November 1956, Performance Test Codes Committee No. 6 was reorganized for the purpose of preparing a revised code reflecting the status of testing methods, instrumentation, and the current trend of thermal cycle development. A revised Code was published in 1964, and it was primarily concerned with the determination of the absolute level of performance. Much of the 1964 Code reflected the trend of thermal cycle development toward increasing throttle pressures and temperatures, the use of reheated steam, and advanced cycle arrangements.

An additional assignment was given the PTC 6 Committee as a result of a need that had developed over the years for simplified procedures for routine or commercial tests, including their relative accuracies. A thorough study of these problems resulted in two reports prepared by the Committee, PTC 6S and PTC 6 Report.

With the introduction of steam turbines operating predominantly within the moisture region in thermal cycles utilizing nuclear steam supply systems, additional techniques and instrumentation were necessary because of the moist steam that is typical in these applications. An interim Code, PTC 6.1-l 972, was developed and issued for trial use and comment and subsequently merged into PTC 6-1964, along with several desirable revisions, and reissued as PTC 6-1976.

Concurrent with the development of PTC 6-1976, work was underway by the International Electrotechnical Commission, Technical Committee No. 5 on Steam Turbines, to revise their Rules for Acceptance Tests to include procedures for testing turbines operating with dry and saturated steam conditions. This effort resulted in the publication, in 1990, of documents IEC 953-1 and IEC 953-2, the former for high-accuracy testing of large condensing steam turbines and the latter for a wide range of accuracy testing of various types and sizes of turbines.

Several years after PTC 6-1976 was published, it became apparent to the Committee that the majority of steam turbines was not being tested because of the relatively high cost of a full-scale test using these procedures. The Committee investigated alternative testing techniques and developed an alternative procedure for acceptance testing, which meets the criteria of high accuracy but has a lower cost because it does not require all the measurements necessary for determining complete cycle information. These alternative procedures were issued as an Interim Code, PTC 6.1, in 1984 and included only the additional requirements and guidance to meet the objectives; it had to be used in conjunction with PTC 6-1976.

The 1996 revision of PTC 6 was undertaken to merge the Interim Code of 1984 into PTC 6-1976 and incorporate new high-accuracy instrumentation that has been developed since the publication of the 1976 Code.

This revised Code, designated “Performance Test Code 6 on Steam Turbines, PTC 6-1996” was approved by the Board on performance Test Codes, further approved as an American National Standard by the ANSI Board of Standards, and published by ASME on July 31, 1996.

CURRENT STATUS

Simplified test procedures of good relative accuracy, intended for periodic checks of turbine performance, are described in “Procedures for Routine Performance Tests of Steam Turbines,” PTC 6S Report 1988 (Reaffirmed 1993), a separately published report by Performance Test Codes Committee No. 6. Such test procedures may be used throughout the service life of the turbine. They are not intended for acceptance tests and do not fulfill all the requirements of PTC 6-2004.

Tests using alternative instrumentation and procedures are described in “Guidance for Evaluation of Measurement Uncertainty in Performance Tests of Steam Turbines,” PTC 6 Report 1985 (Reaffirmed 1991), a separately published report by Performance Test Codes Committee No. 6. Such test procedures do not fulfill the requirements of PTC 6-2004. They cannot be considered acceptance tests unless both parties to the test have mutually agreed, in writing, on all phases of the test that deviate from PTC 6-2004. Any deviation from Code procedure shall be distinctly described in the test report, along with the corresponding uncertainty as evaluated in accordance with PTC 6 Report 1985.

PTC 6 is most directly targeted for application to steam turbines in regenerative feedwater heater cycles. PTC 6.2, “Steam Turbines in Combined Cycles,” a separately published code by Performance Test Codes Committee No. 6.2, addresses performance testing of steam turbines in combined cycle and cogeneration applications.

Many multi-pressure level combined cycle steam turbine bottoming cycles and cogeneration cycles present different challenges to performance testing from those faced in testing steam turbines in regenerative feedwater heater cycles. The different configurations make the testing of these bottoming and cogeneration cycles in accordance with PTC 6 impractical. PTC 6.2 is the recommended Code for testing steam turbines in combined cycle and cogeneration applications.

Due to the existence of numerous different steam turbine cycle configurations, including hybrids of combined cycles, regenerative feedwater heater cycles, and cogeneration cycles, it is not practical to define every cycle configuration for which PTC 6 is recommended and every cycle configuration for which PTC 6.2 is recommended. For cycle configurations not explicitly addressed by either Code, the Code Users are expected to apply the Code that most closely meets the test objectives. In these cases, the decision about which Code will be applied must be decided upon very early in test planning.

Since this Code was published, there have been several Technical Inquiries requesting clarification of selected Code paragraphs. In response to these Inquiries, the Committee changed Code language as necessary to clarify the intent of the Code. These changes, in addition to the correction of undetected errors, formed the basis for this revision.

This revision was approved by the Board on Performance Test Codes on April 22, 2004 and approved by the American National Standard Institute on December 6, 2004.

PERFORMANCE TEST CODE COMMITTEE 6 ON STEAM TURBINES

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

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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, and attending Committee meetings. Correspondence should be addressed to:

Secretary, PTC 6 Standards Committee
The American Society of Mechanical Engineers
Three Park Avenue
New York, NY 10016-5990

Proposing Revisions. Revisions are made periodically to the Code to incorporate changes which 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.

Interpretations. Upon request, the PTC 6 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 6 Standards Committee.

The request for interpretation should be clear and unambiguous. It is further recommended that the inquirer submit his request in the following format:

Subject:	Cite the applicable paragraph number(s) and a concise description.
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. The inquirer may also include any plans or drawings, which are necessary to explain the question; however, they should not contain proprietary names or information.

Requests that are not in this format will be rewritten in this 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. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

Attending Committee Meetings. The PTC 6 Standards Committee holds meetings or telephone conferences, which are open to the public. Persons wishing to attend any meeting or telephone conference should contact the Secretary of the PTC 6 Standards Committee.

STEAM TURBINES

Section 1
Object and Scope

1-1 OBJECT

This Code provides procedures for the accurate testing of steam turbines. It is recommended for use in conducting acceptance tests of steam turbines and any other situation in which performance levels must be determined with minimum uncertainty. It is the intent of this Code that accurate instrumentation and best possible measurement techniques be used to determine the performance. In planning and running the test, the parties must strive to follow the Code procedures as closely as possible to achieve the lowest level of uncertainty.

1-2 SCOPE

This Code may be used for testing of steam turbines operating either with a significant amount of superheat in the initial steam (typically fossil-fueled units) or predominantly within the moisture region (typically nuclear-fueled units).

This Code contains rules and procedures for the conduct and reporting of steam turbine testing, including mandatory requirements for pretest arrangements, instruments to be employed, their application and methods of measurement, testing techniques, and methods of calculation of test results. The performance parameters which may be determined from a Code test include:

(a) heat rate
(b) generator output
(c) steam flow
(d) steam rate
(e) feedwater flow

It also contains procedures and techniques required to determine enthalpy values within the moisture region and modifications necessary to permit testing within the restrictions of radiological safety requirements in nuclear plants.

1-3 FULL-SCALE AND ALTERNATIVE TESTS

Two steam turbine testing procedures are presented. For either procedure, primary flow may be measured either in the condensate or feedwater line downstream of the final feedwater heater. The parties may agree to variations between the full-scale and alternative tests as long as the philosophy of minimum uncertainty is followed in detail.

1-3.1 Full-Scale Test

The full-scale test requires extensive thermal cycle measurements and calculations which provide detailed information about the turbine HP, IP, and LP individual component performance. A full-scale test will produce results with a minimum of uncertainty.

1-3.2

The full-scale test with condensate flow measurement is recommended for conducting acceptance tests of fossil unit steam turbines. Without prior written agreement between the parties to an acceptance test, this procedure shall be used.

1-3.3 Alternative Test

The alternative test relies on fewer measurements and makes greater use of correction curves for cycle adjustments and heater performance with resultant cost savings over the full-scale test. The test uncertainty is slightly increased compared with the full-scale test. For a nuclear unit, the alternative test with feedwater flow measurement may be preferred depending on the turbine cycle design. Use of this procedure requires agreement between the parties to an acceptance test.

1-3.4

The data from the alternative test procedure may produce a slightly higher uncertainty in results, particularly if there is substantial divergence between the test and specified cycle. The parties to the test must agree on a course of action if the turbine fails to meet specified performance. The alternative test may not provide the information necessary to determine individual component performance compared to expected, because only those measurements needed to calculate test heat rate and permit comparison to specific conditions are required. It is recommended that all provisions and source