ASME PTC 4-2008

(Revision of ASME PTC 4-1998)

Fired Steam Generators

Performance Test Codes

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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Errata
to
ASME PTC 4-2008
Fired Steam Generators

The errata corrections listed below apply to ASME PTC 4-2008. These corrections will be incorporated into the next edition of ASME PTC 4.

This Code contains a mass balance/efficiency error on units utilizing sorbent. This discrepancy was traced to the need for a dry gas flow correction for the O_3 in air required to form SO_3, which becomes a solid in the form of $CaSO_4$ and $MgSO_4$. To address this error, which required changes to many parts of the Code, a PTC 4 Code Case was issued. This can be found on the PTC 4 Committee Page.

Page	*Location*	*Change*
18	Figure 3-1-1	For NOx formation loss, correct *QDLNUX* to read *QpLNOx*
45	Table 4-3-1	Delete the first sentence of Note (5), "The ash content of the bottom ash is usually lower than the fly ash" and change the location of Note (5) to Note (9) and Note (9) to Note (5)
78	5-10.5	Correct eq. (5-10-9) to read $MpH2b = MpH2F - MpUbH2$
80	5-11.3	Correct eq. (5-11-8) to read $MFrThACr = 0.1151\ MpCb + 0.3429\ MpH2F + 0.0431(1+0.5\ MFrSc)\ MpSF - 0.0432\ MpO2$
91	5-14.9	Correct eq. (5-14-20) to read $Hcaz$ = the larger of $0.2\ (MnAfz - TMnAz)^{0.33}$ or $0.35\ VAz^{0.8}$
92, 93	5-14.13.1	(1) Correct eq. (5-14-25) to read $QrLAp = QrApW + QrApEv + QrRsWLv$ (2) Correct eq. (5-14-26) to read $QrApW = MrW39\ (HW39 - HW38)$ (3) Correct eq. (5-14-28) to read $QRsWLV = \left(\dfrac{MrRsW37}{1 + MFrWRs}\right) HRs37 + MFrWRs\ (HW37 - HW38)$
	5-14.14.1	Correct eq. (5-14-31) to read $QrLRyRs = MrRyRs\ (HRsLv - HRsEn)$
95	5-15.7	Correct eq. (5-15-8) to read $QrBWAd = \Sigma\ MrStEnz\ (HStEnz - HWRe)$
102	5-18.3	In the third paragraph, correct "65" to "±5" and "610" to "±10"
103	5-18.5.1	Correct equation reference after the definitions to read eq. (5-18-8)
106	5-18.13.1	Correct eq. (5-18-19) to read $QrShCr = MrSt32d\ (HSt32 - HSt31) + MrW25\ (HSt31 - HW25) + MrSt46A\ (HSt46A - HSt31)$
	5-18.13.2	Correct eq. (5-18-20) to read $RqQrSh = MrSt32d\ (HSt32d - HSt31Cr) + MrSt46Ad\ (HSt46A - HSt31Cr)$

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Page	*Location*	*Change*
	5-18.13.3	(1) Correct eq. (5-18-21) to read $QrRhCr = MFrStCr\ MrSt33\ (HSt34 - HSt33) + MrW26\ (HSt34 - HW26)$ (2) Correct definition after "where" to read *MFrStCr*
	5-18.13.4	Correct eq. (5-18-22) to read $RqQrRh = MrSt33d\ (HSt34d - HSt33d)$
110	5-19.1	Correct eq. (5-19-1) to read $HA = (1 - MFrWA)\ HDA + MFrWA\ \ HWv$
111	5-19.6	Correct eq. (5-19-8) to read $HCoal = MFrFc\ HFc + MFrVm1\ HVm1 + MFrVm2\ HVm2 + MFrWF\ HW + MFrAsF\ HRs$
266	D-1	Correct eq. (D-1-2) to read $EGr = QrF + QrB$
	D-2	Add missing term *QpB* to the definition of "summation of credits, percent (%) basis"

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Performance Test Codes

AN AMERICAN NATIONAL STANDARD

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Date of Issuance: January 9, 2009

This Code will be revised when the Society approves the issuance of a new edition. There will be no addenda issued to this edition.

ASME issues written replies to inquiries concerning interpretations of technical aspects of this code. Periodically certain actions of the ASME PTC Committee may be published as Cases. Cases and interpretations are published on the ASME Web site under the Committee Pages at http://cstools.asme.org as they are issued.

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Nonmandatory Appendices

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

The Test Code for Stationary Steam Generating Units was one of the group of 10 forming the 1915 Edition of the ASME Power Test codes. A revision of these codes was begun in 1918, and the Test Code for Stationary Steam Generating Units was reissued in revised form in October 1926. Further revisions were issued in February 1930 and January 1936.

In October 1936 the standing Power Test Code Committee requested Committee No. 4 to consider a revision of the Code to provide for heat balance tests on large steam generating units. In rewriting the Code, advantage was taken of the experience of the several companies in the utility field that had developed test methods for large modern units including the necessary auxiliary equipment directly involved in the operation of the units. At the same time the needs of the small installations were not overlooked. At the November 3, 1945, meeting of the standing Power Test Codes Committee, this revision was approved. On May 23, 1946, the Code was approved and adopted by the Council.

In view of the continuously increasing size and complexity of steam generating units, it was obvious that changes were required in the 1946 Edition of the Test Code. In May 1958 the technical committee was reorganized to prepare this revision. The completely revised Code, the Test Code for Steam Generating Units, was approved by the Power Test Codes Committee on March 20, 1964. It was further approved and adopted by the Council as a standard practice of the Society by action of the Board on Codes and Standards on June 24, 1964.

The Board on Performance Test Codes (BPTC) in 1980 directed that the Code be reviewed to determine whether it should be revised to reflect current engineering practices. A committee was soon formed, and it had its first meeting in May 1981. The Committee soon recognized that the Code should be totally rewritten to reflect several changes in steam generator technology (primarily the increasing usage of fluidized bed combustors and other technologies for emission control) and in performance testing technology (primarily the widespread use of electronic instrumentation and the consideration of test uncertainty analysis as a tool for designing and measuring the quality of a performance test).

The Committee decided that the new code should discourage the use of an abbreviated test procedure (commonly known as "The Short Form" from PTC 4.1). The PTC 4 Code supersedes PTC 4.1, which is no longer an American National Standard or ASME Code. (Technical Inquiry #04-05 describes the differences between the PTC 4 and the invalid PTC 4.1.) The Committee reasoned that the best test is that which requires the parties to the test to deliberate on the scope of the performance test required to meet the objective(s) of the test. Measurement uncertainty analysis was selected as the tool whereby the parties could design a test to meet these objectives. (See para. 3-2.1.) As this Code will be applied to a wide configuration of steam generators, from small industrial and commercial units to large utility units, the soundness of this philosophy should be self-evident.

This expanded edition of the Code was retitled Fired Steam Generators to emphasize its limitation to steam generators fired by combustible fuels. The Code was subjected to a thorough review by Industry, including members of the BPTC. Many of their comments were incorporated and the Committee finally approved the Code on June 23, 1998. It was then approved and adopted by the Council as a Standard practice of the Society by action of the Board on Performance Test Codes on August 3, 1998. It was also approved as an American National Standard by the ANSI Board of Standards Review on November 2, 1998.

Calculations associated with the application of this Code can be facilitated by the use of computer software. Software programs that support calculations for this Code may become available at a future date on the ASME Web site. Any such software that may be furnished would not have been subject to the ASME consensus process and ASME would make no warranties, express or implied, including, without limitation, the accuracy or applicability of the program.

Work on the current edition began even before the 1998 edition was published. The purpose of this revision is to include a general update of the Code to bring it into compliance with the definitions and terminology used in the revised PTC 19.1, Test Uncertainty. The major issue in this regard was to change all references to "bias" and "precision" to "systematic" and "random," respectively. Also, "precision index" was changed to "standard deviation." In conformance with PTC 19.1, a value of 2 was stipulated for the "Student's *t*" parameter, which simplifies the uncertainty calculations. This revision also includes the addition of para. 5-18.14, which contains procedures for calculating the uncertainty of corrected results. Also the procedures for determining the average value of spatially nonuniform parameters were simplified.

In addition to these changes, discussed above, all the Code Sections were reviewed to correct minor errors and omissions, to update references, and to revise text for better clarity.

The following is a summary of major changes to each Section:

In Section 1, Figs. 1-4-3, 1-4-4, 1-4-5, 1-4-6, and 1-4-7 were revised. These revisions/corrections included adding location designators, adding missing elements (such as APH coils and condensate returns), and adding notes for additional clarity.

In Section 2, some definitions were deleted, others revised, and some new ones added. Most of the changes were related to the change in definition of "bias" to "systematic," "precision" to "random," and "precision index" to "standard deviation of the mean."

In Section 3, Fig. 3-1-1 was edited to improve clarity, references to Codes and Standards were updated, and discussion on LHV was added.

In Section 4, Table 4-2-1 was split into two tables, one for energy credits and one for energy losses. All the tables were edited to correct errors, improve clarity, and to make them consistent with other Code Sections. The recommended values for systematic error (bias) were reviewed and updated. The recommended fuel sampling process was reviewed and revised. The discussions on triple midpoint and composite midpoint rules were eliminated.

In Section 5, a general revision of the Section was done to comply with the definitions and terminology used in PTC 19.1. Procedures for determining the uncertainty of corrected results were developed and included in para. 5-18.14. The procedure for correcting entering air temperature as a function of ambient conditions was added. Paragraphs 5-13.1 and 5-13.2 were revised. The discussions on multiple midpoint and composite midpoint rules were eliminated. Many changes and corrections were made to formulas and acronyms. Also text was revised and notes added to improve clarity. References were corrected and updated.

In Section 7, a general revision of the Section was done to comply with the definitions and terminology used in PTC 19.1. In conformance with PTC 19.1, a value of 2 was stipulated for the Student's *t* parameter.

In Appendices A and B, a general revision of the Appendices was done to comply with the definitions and terminology used in PTC 19.1. Many changes, corrections, and additions were made to the forms to improve clarity.

In Appendix C, a section on derivation for loss from hot air quality control equipment was added.

In Appendix D, discussion on LHV was added.

This revision was approved by the PTC Standards Committee on October 16, 2007 and approved and adopted as a Standard practice of the Society by action of the Board on Standardization and Testing on February 19, 2008. It was also approved as an American National Standard by the ANSI Board of Standards Review on October 14, 2008.

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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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 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 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 Code Case. Code Cases may be issued for the purpose of providing 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. Code Cases are effective immediately upon ASME approval and shall be posted on the ASME PTC Committee Web page.

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

Interpretations. Upon request, the PTC 4 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 4 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 that 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 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 Standards Committee or check our Web site http://cstools.asme.org.

FIRED STEAM GENERATORS

Section 1
Object and Scope

1-1 OBJECT

The object of this Code is to establish procedures for conducting performance tests of fuel fired steam generators. This Code provides standard test procedures that can yield results giving the highest level of accuracy consistent with current engineering knowledge and practice.

The accuracy of a particular test may be affected by the fuel fired during the test or other factors within the discretion of the operator. A test is considered an ASME Code test only if the following conditions are met:

(a) Test procedures comply with procedures and allowed variations defined by this Code.

(b) Uncertainties of test results, determined in accordance with Section 7 of this Code, do not exceed target test uncertainties defined by prior written agreement in accordance with Section 3 of this Code.

1-1.1 Determination of Performance Characteristics

This Code can be used to determine the following performance characteristics:

(a) efficiency
(b) output
(c) capacity
(d) steam temperature/control range
(e) exit flue gas and entering air temperature
(f) excess air
(g) water/steam pressure drop
(h) air/flue gas pressure drop
(i) air infiltration
(j) sulfur capture/retention
(k) calcium to sulfur molar ratio
(l) fuel, air, and flue gas flow rates
(m) unburned carbon and unburned carbon loss

It is not necessary that all of these parameters be determined simultaneously for each and every test.

1-1.2 Purpose of Performance Characteristics

These performance characteristics are typically required for the following purposes:

(a) comparing actual performance to guaranteed performance
(b) comparing actual performance to a reference
(c) comparing different conditions or methods of operation
(d) determining the specific performance of individual parts or components
(e) comparing performance when firing an alternate fuel
(f) determining the effects of equipment modifications

This Code also provides methods for converting certain performance characteristics at test conditions to those that would exist under specified operating conditions.

1-2 SCOPE

1-2.1 General Scope

The rules and instructions presented in this Code apply to fired steam generators. These include coal, oil, and gas-fired steam generators as well as steam generators fired by other hydrocarbon fuels. The scope also includes steam generators with integral fuel-sulfur capture utilizing chemical sorbents.

Steam generators that are not fired by coal, oil, or gas may be tested using the concepts of this Code, but it should be noted that the uncertainty caused by variability of the fuel may be difficult to determine and is likely to be greater than the uncertainties in sampling and analysis of coal, oil, or gas.

Gas turbine heat recovery and other heat recovery steam generators designed to operate with supplemental firing should be tested in accordance with Performance Test Code (PTC) 4.4, Gas Turbine Heat Recovery Steam Generators.

This Code does not apply to nuclear steam supply systems, which are specifically addressed in PTC 32.1, Nuclear Steam Supply Systems. This Code does not apply to the performance testing of chemical heat recovery steam generators, municipal waste fired steam generators, pressurized steam generators with gas side pressure greater than five atmospheres, or incinerators. Municipal waste fired steam generators can be tested in accordance with PTC 34, Waste Combustors with Energy Recovery.