ASME PTC 1-2004
(Revision of ASME PTC 1-1999)

General Instructions

Performance Test Codes

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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Three Park Avenue • New York, NY 10016

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The American Society of Mechanical Engineers
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CONTENTS

FOREWORD

This Code on General Instructions was first printed in a preliminary form in *Mechanical Engineering* in 1920 and was presented at a public hearing at the ASME spring meeting held in Chicago, Illinois in 1921. It was approved and adopted as a standards practice of ASME in 1924.

Between 1920 and 1970, the function of the Power Test Codes (as they were then known) continued to evolve and broaden. In recognition of these developments, the Code on General Instructions was revised twice. The revisions were approved by the Council on Codes and Standards on June 17, 1945 and May 7, 1970, respectively.

The scope of the Power Test Codes, now known as Performance Test Codes (PTCs), was further broadened in the 15 years that followed. As a result of the designation of PTCs as American National Standards by the American National Standards Institute (ANSI), an increased awareness of the relationship between U.S. domestic and international standards and the need to reconcile substantially conflicting requirements, and clarification on the use of uncertainty in test codes, several additional revisions to the Code on General Instructions resulted. These were approved by the Board on Performance Test Code (BPTC) on May 13, 1970 (with an October 1971 Addenda), October 29, 1979, June 18, 1986, and June 12, 1991.

The next revision of this Code was initiated in 1998. A Project Team was appointed by the BPTC to develop this revision under the ASME Redesign Process. The revised document was approved by the BPTC on November 19, 1998.

The current revision was a major updating of PTC 1. The existing information contained in PTC 1 was divided into two separate documents: PTC 1, General Instructions and PTC 1, Template. The Template is the code writer's guide and the General Instructions are mandatory information for all code users. This revision was approved by the BPTC on December 9, 2003. It was also approved as an American National Standard by the ANSI Board on Standards Review on March 10, 2004.

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(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 1 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.

Interpretations. Upon request, the PTC 1 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 1 Standards Committee.

The request for 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.
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.

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INTRODUCTION

This document provides directions to code users and code-writing committees of Performance Test Codes (PTCs). Code users shall consider it as part of each test.

The objectives of PTC 1, General Instructions are as follows:

(a) Define the purpose and scope of ASME PTCs.

(b) List major industry applications where PTCs can be used.

(c) Provide direction on the use of equipment PTCs concerning the planning, preparation, implementation, and reporting of test results.

A separate document, the PTC 1 Template, was developed to provide guidelines and directions to code-writing committees. Relevant material was excerpted from PTC 1, General Instructions and should be incorporated in all PTCs. Use of this information ensures PTCs attain minimum standards and are consistent as a group. The Template will not be published but will be listed on the PTC Committee Web pages. It may be revised as the need arises. ANSI approval is not required.

The objectives of the Template are as follows:

(a) Define the purpose and scope of ASME PTCs.

(b) List major industry applications where PTCs can be used.

(c) Specify the required content in each equipment PTC.

(d) Define the standard format for the content of individual equipment PTCs.

GENERAL INSTRUCTIONS

Section 1
Purpose, Scope, and Organization

1-1 DEFINITION AND PURPOSE

ASME Performance Test Codes (PTCs) provide uniform rules and procedures for the planning, preparation, execution, and reporting of performance test results. Test results provide numerical characteristics to the performance of equipment, systems, and plants being tested. Throughout ASME PTC 1, when the term equipment is used with reference to the object of a performance test, it can refer to specific equipment, systems, or to entire plants.

1-2 SCOPE AND ORGANIZATION OF PTCs

Most ASME PTCs are applicable to a specified type of equipment defined by the respective code. There may be several subcategories of equipment covered by a single code. Types of equipment for which PTCs apply can be classified into five broad categories as follows:

(a) electrical or mechanical power producing
(b) combustion and heat transfer
(c) fluid handling
(d) emission control
(e) other equipment

The quantities that characterize performance are defined in each code for the equipment within its scope. Absolute performance characteristics determined by adherence to a PTC can be evaluated compared to design or predicted characteristics, to previous test results, or they can be used to benchmark or ascertain performance at a particular time.

Some PTCs are written as general documents for reference in support of the equipment PTCs. These can be considered technical reference material for the equipment codes; three types of reference codes exist.

The first type covers instrumentation used in the measurement of thermodynamic or process fluid parameters, such as pressure, temperature, flow, and steam quality, as well as how to analyze the uncertainties associated with measurement of all primary parameters to develop overall test uncertainty. Such individual codes referring to process or thermodynamic quantities are known as PTC Instruments and Apparatus Supplements. They are supplementary to the information on mandatory instrumentation requirements contained in the equipment codes. Instrumentation information in equipment test codes supersedes the information given in these supplements, but otherwise these supplements should be incorporated by reference in equipment test codes where deemed appropriate by the committee.

The second type covers miscellaneous general information and currently consists of ASME PTC 1, General Instructions, and ASME PTC 2, Definitions and Values. ASME PTC 2 contains standards for terms, units, values of constants, and technical nomenclature.

The third type addresses the measurement of phenomena closely associated with the equipment performance, such as emissions.

Figures 1-2-1 and 1-2-2 show the organization of ASME PTC categories.

1-3 PHILOSOPHY

The codes provide guidelines for test procedures that yield results of the highest level of accuracy based on current engineering knowledge, taking into account test costs and the value of information obtained from testing. Precision and reliability of test results must underlie all considerations in the development of an ASME PTC, consistent with economic considerations as judged appropriate by each technical committee and in keeping with the philosophy of the ASME Board on Performance Test Codes (BPTC).

1-4 CODE USE

Code tests are suitable for use whenever performance must be determined with minimum uncertainty. They are meant specifically for equipment operating in an industrial setting. Typical uses include the following:

(a) determination if equipment meets design or expected performance criteria

(b) incorporation by reference into contracts to serve as a means to determine fulfillment of guarantees

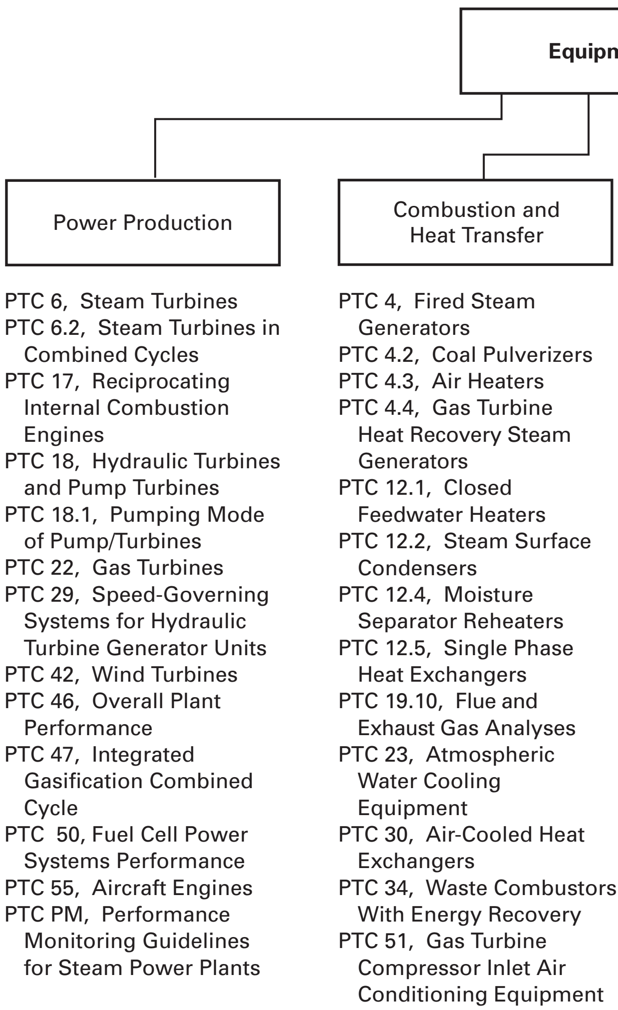


Fig. 1-2-1 Organization of Equipment PTCs

(c) evaluation of equipment performance following modification, change in operating conditions, or any suspected change in performance for which such investigation is required

(d) studies to help determine the value of possible upgrades or modifications to equipment

(e) benchmarking of equipment performance, sometimes to help determine necessity for specific preventative maintenance or possible upgrade or modification

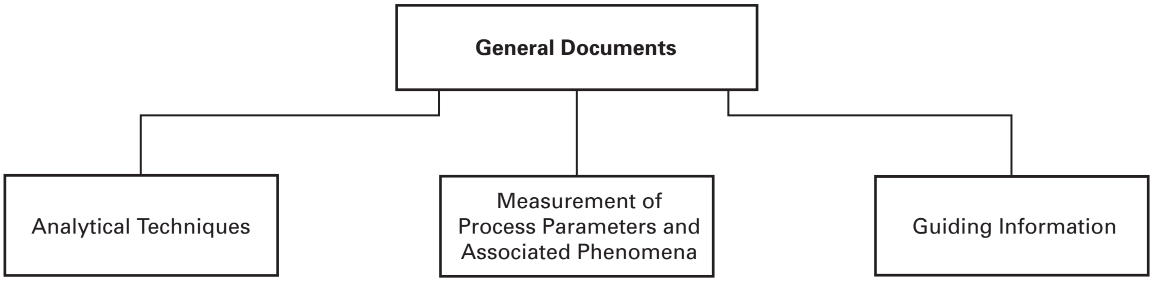
(f) validation of results from online or continuous performance-monitoring systems, which are usually less accurate than results of tests conducted in accordance with PTCs

PTCs are generally not used in troubleshooting equipment. However, they can be used to quantify the magnitude of performance anomalies of equipment that is suspected to be performing poorly or to confirm the need for maintenance, if simpler means are not adequate. PTCs are excellent sources or references for simpler routine or special equipment test procedures. Conducting periodic performance tests on equipment can uncover the need for further investigation, which can lead to preventative maintenance or modification.

1-5 TEST UNCERTAINTY

1-5.1 Definition

Test uncertainty is an estimate of the limit of error of a test result. It is the interval about a test result that contains the true value with a given probability or level of confidence. It is based on calculations using statistics, instrumentation information, calculation procedure, and actual test data. ASME PTC 19.1 is the PTC Supplement that covers general procedures for calculation of test uncertainty. PTCs maintain a 95% level of confidence for which uncertainty is calculated as their standard.



PTC 19.1, Test Uncertainty
PTC 19.25, Transient Measurement Uncertainty
PTC 60, Validation and Verification of Computational Solid Mechanics
PTC 61, Validation and Verification of Computational Fluid Dynamics and Heat Transfer

PTC 19.2, Pressure Measurement
PTC 19.3, Temperature Measurement
PTC 19.5, Flow Measurement
PTC 19.6, Electrical Power Measurement
PTC 19.7, Measurement of Shaft Power
PTC 19.22, Digital Systems Techniques
PTC 36, Measurement of Industrial Sound

PTC 1, General Instructions
PTC 2, Definitions and Values

Fig. 1-2-2 Organization of General Documents

1-5.2 Applications of Test Uncertainty Analysis, General

Test uncertainty analysis is useful because it

(a) identifies dominant sources of error, their effects on a test result, and estimates of their limits.

(b) serves to validate the quality of test results.

(c) facilitates communication regarding results.

(d) facilitates the choice of appropriate and cost-effective measurement devices and procedures.

(e) reduces the risk of making erroneous decisions.

(f) demonstrates compliance with test requirements.

(g) facilitates interpretation of test results.

(1) Pretest Uncertainty Analysis. In planning a test, a pretest uncertainty analysis allows corrective action to be taken prior to the test, either to decrease the uncertainty to a level consistent with the overall objective of the test or to reduce the cost of the test while still attaining the objective. This is most important when deviations from code-specified instruments or methods are expected. An uncertainty analysis is useful to determine the number of observations.

(2) Post-Test Uncertainty Analysis. A post-test uncertainty analysis determines the uncertainty intervals for the actual test. This analysis should confirm the pretest systematic and random uncertainty estimates. It serves to validate the quality of the test results or to expose problems.

1-5.3 ASME PTC Treatment and Uses of Test Uncertainty

Code-writing committees shall state the magnitude of the uncertainties expected in individual measurements and instruct the user in calculation of uncertainty of the final test results. A sample post-test uncertainty analysis based on ASME PTC 19.1 shall be included. This shall include typical random uncertainties (also called precision uncertainties) based on the experience of the committee.

Application of test uncertainty analysis can vary based on the experience of each committee and on the many different types of equipment for which codes are written. There are several acceptable ways to use test uncertainty analysis in ASME PTCs.

1-5.3.1 The following uses of test uncertainty to prepare for and validate the acceptability of a test are permissible. One or more shall be used in a single code.

(a) Specify the maximum uncertainty above which the test is not acceptable for each type or configuration of equipment. The maximum uncertainty is a limit and not a target in designing a test.

(b) Specify the typical uncertainty of a test for each type or configuration of equipment. This can be done only if the range of acceptable uncertainties is small, i.e., no more than 20% of a typical mean uncertainty, based on the experience of the committee. A statement should be included that significant deviations from the typical uncertainty in either direction indicate that something is amiss. For example, if a typical test uncertainty of 1.0% were reported, then the committee would not expect a valid test with an uncertainty of larger than 1.2%; likewise, a calculated post-test uncertainty of less than 0.8% is unlikely.

(c) For some types or configurations of equipment, it is preferable to specify a typical range of acceptable uncertainties, particularly when sensitivity factors tend to be very nonlinear and much higher during some acceptable test conditions than during others. This should be done if treating uncertainty per para. (b) above to determine the validity of a test in which the range of typical uncertainties is larger than 20%. The range of acceptable test uncertainties based on the causative sensitivities should be indicated.

(d) In cases of equipment for which there are usually large uncertainties, which are acceptable based on the committee's experience, the reasons should be discussed. Details should be given in an uncertainty calculation appendix. Examples of such reasons are

(1) inhomogenous fuels

(2) unusually high and variable sensitivity factors

It should be discussed broadly how to minimize uncertainty, with further details given in the body of the code. Then any of the other acceptable methods of using test uncertainty principles to prepare for and validate a test may be used.

(e) Most committees require that a post-test uncertainty analysis be performed using the methods described in ASME PTC 19.1 and that the validity of the test be determined by any of the previous methods. Some committees, however, prefer to define the required instrumentation rigidly and also specify the maximum allowable fluctuations of data during the test. This is equivalent to putting an upper limit on the allowable post-test uncertainty, since the post-test precision is calculated from the actual fluctuations of the data. If a committee prefers to tabulate the maximum allowable data fluctuations and rigidly define the test instrumentation in lieu of a post-test uncertainty analysis, then it must be stated that this is specifically the method of ensuring the validity of a test preferred by the committee. In this case, the sensitivity coefficients must be very nearly linear so that the total uncertainty is not affected by the magnitude of any corrections.

1-5.3.2 The following uses of or references to test uncertainty are not permissible in a code:

(a) The minimum achievable test uncertainty cannot be given exclusively without reference to a range of, a typical, or a maximum allowable test uncertainty per paras. 1-5.3.1(a) through (e). Stating only the best achievable uncertainty gives no guidance to the code user as to whether a test is valid or not and allows for poor tests to be conducted in violation of the philosophy of PTCs.

(b) Reference to any commercial issues contained in contracts shall not be made, such as the method of comparing a test result to a contract guarantee by offsets or deadbands related to test uncertainty. Commercial issues are outside the scope of PTCs; assigning or suggesting values for commercial tolerance or any other discussion of commercial issues is not permitted.

1-6 OTHER CODES AND STANDARDS

PTCs must be developed in strict accordance with the philosophy stated in para. 1-3. Wherever possible, they should be harmonized with international codes and standards such as those of the International Organization for Standardization (ISO). Some equations and techniques are referenced as joint ASME/ISO equations or techniques in the professional literature. Related codes and standards or additional measuring procedures developed by other organizations, such as the American Society for Testing and Materials, the Institute of Electrical and Electronics Engineers, the American Institute of Chemical Engineers, and the Environmental Protection Agency, may be referenced by PTCs.

1-7 STANDARDS COMMITTEES

ASME PTCs are developed by Standards Committees that are governed, organized, and appointed by the ASME BPTC. Each code-writing committee is organized to include representatives of several interest groups. The qualifications of each member of a code-writing committee are subject to examination and approval by the BPTC. Members of code-writing committees are highly qualified, technically competent professionals, generally members of ASME, who have expertise in the field or in an area of expertise needed by the committee, such as special instrumentation. They present their views on matters under consideration as members of a learned profession and not as representatives of employers or special interest groups.

Section 2
Standard Form of Individual Test Codes

2-1 INTRODUCTION

Individual test codes and their revisions shall contain a table of contents and the standard form, arrangement, scope, and contents shall comply with the following specifications.

2-2 SECTION 1, OBJECT AND SCOPE

In this Section, the individual codes shall outline the test objectives and define the scope of the test, size and types of equipment, and processes embraced by or excluded from the code.

2-2.1 Object

The Object must clearly state

(a) the type(s) of equipment being covered.

(b) the physical results that can be determined regarding the performance of the covered equipment (e.g., capacity, efficiency, power output or input, specific process results such as temperatures, and sulfur capture). Not all results that can be determined by application of the code need to be included in the objectives of a specific test.

(c) the specific goals of tests that can be designed according to the code, such as the determination of performance at specific operating conditions or with certain fixed parameters.

2-2.2 Scope

The Scope must clearly state

(a) a specific definition of the types of equipment to which the code may be applied.

(b) the identity of any similar equipment to which the code does not apply.

(c) other minimum conditions that must be met for the code to be applied.

(d) similar tests that can be performed on the equipment within the scope of the code, which are not part of the code such as preoperational or startup tests; these are discussed to avoid misapplication of the code.

2-2.3 Uncertainty

Section 1 shall also address the uncertainty of tests performed using the code. It shall include a discussion of the test uncertainty per one or more of the approaches given in para. 1-5.3. For cases in which there are various industrial applications and configurations of mechanical equipment, processes, or systems that might be addressed by a particular code committee, the uncertainty of several representative configurations shall be addressed.

2-3 SECTION 2, DEFINITIONS

Section 2 shall contain a list of terms employed with definitions for those not given in ASME PTC 2, Definitions and Values. Symbols and abbreviations shall be specified for equations and should conform to ASME PTC 2. Figures that are useful for the clarification of terms or symbols may also be included.

2-4 SECTION 3, GUIDING PRINCIPLES

Section 3 shall discuss in detail that which shall be completed prior to the test and describe all those who have test responsibilities (being parties to the test). These include

(a) rules covering test preparations

(b) arrangements of test apparatus

(c) starting and stopping procedures

(d) selection and qualifications of test personnel including the test coordinator

(e) methods of operation during test

(f) provisions for equipment inspection

(g) provisions for preliminary tests

(h) permissible and nonpermissible adjustments during test

(i) degree of constancy of test conditions

(j) duration of test runs

(k) recommended number of test runs

(l) repeatability requirements

(m) causes for rejection of inconsistent test readings or results

(n) methods of comparing results with specified performance

(o) limits of uncertainty not promulgated in the object and scope

A table of permissible data fluctuations is not required if a maximum allowable uncertainty or an uncertainty range is mandated in the code. Fluctuations do affect the random component of test uncertainty and that effect can be estimated prior to starting a test. Maximum permissible data fluctuations of multiple parameters, when combined in aggregate, can lead to a very high final test uncertainty.

2-5 SECTION 4, INSTRUMENTS AND METHODS OF MEASUREMENT

Section 4 shall cover choice of instruments, required sensitivity or precision of instruments, expected or allowable uncertainty of instruments, and calibration corrections to readings and measurements. Instructions for methods of measurement, location of measuring systems, and precautions to be taken shall be included in this Section. The Supplements on Instruments and Apparatus (ASME PTC 19 series) describe methods of measurement, instrument types, limits, sources of error, corrections, and calibrations. When appropriate and to avoid repetition, individual codes may refer to and make mandatory the applicable ASME PTC 19 Supplement(s). Specific references may be made to an ASME PTC 19 Supplement by particular paragraph number and date of Supplement. General references to an ASME PTC 19 Supplement are also permitted. All required instruments that are not covered by the ASME PTC 19 Supplements are to have any further rules and precautions described completely in Section 4.

2-6 ALTERNATIVE METHODS

If an individual code provides for alternative testing method(s), that code shall

(a) indicate the specific conditions under which any one method should be used or may be used.

(b) require prior agreement among the interested parties as to which of the methods is to be adopted.

(c) determine and report the effect on test uncertainty.

2-7 SECTION 5, COMPUTATION OF RESULTS

Section 5 shall contain formulas and directions for calculating results from test observations, including correction of instrument readings. It shall address calculation and application of corrections for deviations of test operating conditions from base reference conditions. The details of computations and data assembled shall be included either here or in an appendix, along with the derivations of pertinent equations and determination of test uncertainty.

2-8 SECTION 6, REPORT OF RESULTS

Section 6 shall state what general information regarding the plant and the particular equipment under test shall be reported. For acceptance tests, this Section shall state that the report shall include an outline of specified operating conditions and guarantees; corrections for deviation from specified conditions; magnitude of the uncertainty of test observations and overall results, if agreed to by the parties to the test; methods adopted for measurement if choices are permitted; test methods when those prescribed have, by prior agreement, not been followed; mean observations derived from log sheets; test results under the test operating conditions and corrected to specified conditions; and test conclusions. If a post-test uncertainty analysis is to be used to establish the validity of the test, Section 6 shall require that the report document such validity.

2-9 SECTION 7, TEST UNCERTAINTY

Section 7 shall contain formulas and directions for calculating uncertainty of test results. ASME PTC 19.1, Test Uncertainty is the primary reference for uncertainty calculations, and any uncertainty analysis that conforms to ASME PTC 19.1 shall be acceptable. Any deviations from the methods described in ASME PTC 19.1 shall be noted and explained in detail. Also, this Section should provide guidance for estimating the systematic component(s) of uncertainty. Section 7 together with ASME PTC 19.1 shall enable users of the code to perform complete pretest and post-test uncertainty analyses, which are sufficient for the uses of uncertainty described in para. 1-5.3 of this Code.

2-10 ADDITIONAL SECTIONS

Additional sections may be included to give detailed background information that shows or supports methods or formulas included in the code or to give additional data and guidance to the user. Examples of subjects included in additional sections are rationale and derivation of expected uncertainty, derivation of formulas, derivation of figures, examples of use of figures or curves, detailed description of methods of measurement or techniques not covered in the ASME PTC 19 series, a list of references, sample calculations, and alternative test methods. It should be noted that it is not mandatory that codes have additional sections. However, additional sections (e.g., Section 8 and Appendix I) may be defined as mandatory if the committee deems it necessary. Lettered appendices are nonmandatory and provide information explaining the rationale of the code or other useful information to the code user. The number of expository sections shall be minimized.

Section 3
Information for ASME PTC Users

3-1 INTRODUCTION

This Section contains common rules for conducting tests on most equipment. An official test is any test conducted in accordance with a PTC.

3-2 PARTIES TO A TEST

The parties to a test are those persons and companies interested in the results. In commercial tests, the parties may include the owner(s), the supplier(s), the equipment manufacturers, the architect engineer, firms hired to conduct the tests, the engineering analysts, the financiers, and any of their representatives. In other noncommercial tests, the parties to a test might all be from the same company and representing different functions and interests, e.g., testing, analysis, plant operations, performance engineering, purchasing, research, and plant maintenance.

3-3 PREPARATIONS FOR TESTING

3-3.1 General Precaution

Reasonable precautions should be taken when preparing to conduct a code test. Indisputable records shall be established and maintained to identify and distinguish the equipment to be tested and the exact method of testing selected. Descriptions, drawings, or photographs all may be used to give a permanent, explicit record. Instrument location shall be predetermined and described in detail in test records.

3-3.2 Agreements

Section 3 of each code may contain language providing general guidance for the application of a code. This guidance shall include a list of preparatory items, which must be completed, understood, and agreed upon by the parties to a test, that are recommended for the legitimate execution of a code test; recommendations for the timing of testing of new or modified equipment; and allowance for equipment inspections. These include

(a) object of test
(b) location and timing of test
(c) test boundaries
(d) selection of instruments
(e) method of calibration of instruments
(f) confidentiality of test results
(g) number of copies of original data required
(h) data to be recorded and the method of recording and archiving data
(i) values of measurement uncertainty and method of determining overall test uncertainty
(j) method of operating equipment under test, including that of any auxiliary equipment, the performance of which may influence the test result
(k) methods of maintaining constant operating conditions as near as possible to those specified
(l) method of determining duration of operation under test conditions before test readings are started
(m) system alignment or isolation
(n) organization of personnel, including designation of engineer in responsible charge of test
(o) duration and number of test runs
(p) frequency of observations
(q) base reference conditions
(r) methods of correction and values used for corrections for deviations of test conditions from those specified
(s) methods of computing results
(t) method of comparing test results with specified performance
(u) conditions for rejection of outlier data or runs
(v) intent of contract or specification if ambiguities or omissions appear evident
(w) pretest inspections

3-3.3 Timing

For a commercial test, the purchase contract can specify the time limit, following the first dependable commercial operation, within which a field acceptance test should be undertaken. Failing this, an acceptance test should be undertaken within the period stated in the test code but not over 6 months from the time the equipment is first put into operation, except with written agreement to the contrary. Deterioration from use of the equipment during such prior operation, which may adversely affect the results, should be corrected by the purchaser before acceptance tests are conducted, or an agreement should be reached for adjusting the test results to compensate for such deterioration. The parties to a commercial test should recognize the impracticability of exact prediction of equipment availability for test purposes and should seek a mutually satisfactory adjustment of any unforeseen situation. An official test for other purposes may be conducted at any time.

3-3.4 Preparation

For acceptance and other official tests, the manufacturer or supplier shall have reasonable opportunity to examine the equipment, correct defects, and render the equipment suitable to test. The manufacturer, however, is not thereby empowered to alter or adjust the equipment or conditions in such a way that regulations, contract, safety, or other stipulations are altered or voided. The manufacturer may not make adjustments to the equipment for test purposes that may prevent immediate, continuous, and reliable operation at all capacities or outputs under all specified operating conditions. Any actions taken must be documented and immediately reported to all parties to the test.

3-3.5 Starting and Stopping

Acceptance and other official tests shall be conducted as promptly as possible following initial equipment operation and preliminary test runs. The equipment should be operated for sufficient time to demonstrate that intended test conditions have been established (e.g., steady state). The means to determine that intended operating conditions have been attained are equipment specific and, therefore, are specified in respective individual equipment test codes. Agreement on procedures and time should be reached before commencing the test.

3-3.6 Acceptability of Equipment and Instruments

Equipment and instruments shall be examined as necessary to ensure validity of test and operating procedures and suitability of instruments. Calibrated redundant instruments should be provided for those instruments susceptible to in-service failure or breakage.

3-3.7 Preliminary Test Runs

Preliminary test runs, with records, serve to determine if equipment is in suitable condition to test, to check instruments and methods of measurement, to check adequacy of organization and procedures, and to train personnel. All parties to the test may make reasonable preliminary test runs as necessary. Observations during preliminary test runs should be carried through to the calculation of results as an overall check of procedure, layout, and organization. If such a preliminary test run complies with all the necessary requirements of the appropriate test code, it may be used as an official test run within the meaning of the applicable code.

3-4 TESTS

3-4.1 Readjustments

Once testing has started, readjustments made to the equipment that can influence the test results require the repetition of all test runs conducted prior to the adjustment(s). No adjustments are permissible, solely for the purpose of a test, that are inappropriate for reliable and continuous service/operation following a test under any and all specified outputs and operating conditions.

3-4.2 Data Collection

Data shall be taken by automatic data collecting equipment or by a sufficient number of competent observers. Automatic data logging and advanced instrument systems shall be calibrated to the required accuracy. No observer shall be required to take so many readings that lack of time may result in insufficient care and precision. Consideration shall be given to specifying duplicate instrumentation and taking simultaneous readings for certain test points to attain the specified accuracy of the test.

3-4.3 Conduct of Test

The parties to the test shall designate a person to direct the test, hereafter called a test coordinator. Intercommunication arrangements between the test coordinator and all test personnel/test parties should be established. Complete written records of the test, even including details that at the time may seem irrelevant, should be reported. Controls by ordinary operating (indicating, reporting, or integrating) instruments, preparation of graphical logs, and close supervision should be established to give assurance that the equipment under test is operating in substantial accord with the intended conditions. For a commercial test, accredited representatives of the purchaser and the manufacturer or supplier should be present at all times to assure themselves that the tests are being conducted according to the test code and prior agreements.

3-5 INSTRUMENTS

3-5.1 Use of Supplements on Instrumentation and Apparatus

The ASME PTC 19 Supplements contain guidance for developing test uncertainty and descriptions of instruments, devices, and methods of measurement likely to be required in any test of equipment. They include directions regarding instrument applications, limits and sources of error, range, sensitivity, precision, and methods of calibration. Individual test codes shall specify instruments and methods of measurement applicable to that code. In making arrangements and in selecting instruments and methods of measurement, the guiding principles should ensure that

(a) the requisite degree of accuracy of measurement is attainable.

(b) the selected test apparatus and methods are practicable.

When an individual test code references a Supplement, it and the referenced provisions will be treated in the same manner as the code.

3-5.2 Location and Identification of Instruments

Transducers shall be located to minimize the effect of ambient conditions on uncertainty, e.g., temperature or temperature variations. Care shall be used in routing lead wires to the data collection equipment to prevent electrical noise in the signal. Manual instruments shall be located so that they can be read with precision and convenience by the observer. All instruments shall be marked uniquely and unmistakably for identification. Calibration tables, charts, or mathematical relationships shall be readily available to all parties to the test. Observers recording data shall be instructed on the desired degree of precision of readings.

3-5.3 Frequency and Timing of Observations

The timing of instrument observations will be determined by an analysis of the time lag of both the instrument and the process so that a correct and meaningful mean value and departure from allowable operating conditions may be determined. Sufficient observations shall be recorded to prove that steady state conditions existed during the test where this is a requirement. A sufficient number of observations shall be taken to reduce the random component of uncertainty to an acceptable level.

3-6 OPERATING CONDITIONS

3-6.1 Operating Philosophy

The tests should be conducted as closely as possible to specified operating conditions; this reduces and minimizes the magnitude and number of corrections for deviations from specified conditions.

3-6.2 Permissible Deviations

The equipment tested should be operated to ensure its performance is bounded by the permissible fluctuations and permissible deviations specified.

3-6.3 Inconsistent Measurements

If any measurement influencing the result of a test is inconsistent with some other like measurement even though either or both of them may have been made strictly in accordance with the rules of the individual test code, the cause of the inconsistency shall be identified and eliminated.

3-7 RECORDS

3-7.1 Data Records and the Test Log

For all acceptance and other official tests, a complete set of data and a complete copy of the test log shall become the property of each of the parties to the test. The original log, data sheets, files, disks, recorder charts, and tapes, being the only evidence of actual test conditions, must permit clear and legible reproduction. Copying by hand is not permitted. The completed data records shall include the date and time of day the observation was recorded. The observations shall be the actual readings without application of any instrument corrections. The test log should constitute a complete record of events including details that at the time may seem trivial or irrelevant. Erasure on or destruction or deletion of any data record, page of the test log, or any recorded observation is not permitted. If a correction is made, the alteration shall be entered so that the original entry remains legible and an explanation is included.

For manual data collection, the test observations shall be entered on carefully prepared forms that constitute original data sheets authenticated by the observers' signatures. For automatic data collection, printed output or electronic files shall be authenticated by the engineer in charge and other representatives of the parties to the test. When no paper copy is generated, the parties to the test must agree in advance to the method used for authenticating, reproducing, and distributing the data. Copies of the electronic data files must be copied onto tape or disks and distributed to each of the parties to the test. The data files shall be in a format that is easily accessible to all. Data residing on a machine should not remain there unless a backup, permanent copy is made.

3-8 TESTING TECHNIQUE

3-8.1 Technical Considerations

Technical aspects of carrying out tests of equipment and the making of measurements should be considered so computed results may be reliable and acceptable. Such considerations require a working knowledge of

(a) theory, precision, and accuracy of methods and measurements

(b) practical limitations imposed by the testing of equipment

3-8.2 Precision and Accuracy

In all scientific and engineering testing, results may be precise and/or accurate. The former is a relative quantity, whereas the latter is an absolute quantity. A high degree of precision does not necessarily imply a high degree of accuracy. A given object may be measured for length with a specific measuring scale. Several measurements may show but slight deviation from one another and from the mean. Individual deviations show the degree of precision of measurement. This degree of precision, however, bears no relationship to the exactness of the chosen scale for measuring standard units of length. The specific scale may fail to agree with the official legal unit of length. This deviation is of an absolute nature. The readings obtained on the given object when referred to this absolute standard are said to show error or degree of accuracy. A thorough discussion of accuracy and uncertainty in test measurements is given in ASME PTC 19.1. Therefore, precision and accuracy in scientific work must be clearly distinguished. Extreme care must prevail in the use of the terms and in their application to testing methods and techniques. ASME PTC 2 is the reference for interpreting such terms.

3-9 ERRORS

3-9.1 Sources of Errors

Among the sources of error that influence the test uncertainty are the following:

(a) instrument errors

(b) errors of observation

(c) errors resulting from failure to obtain representative samples

(d) errors resulting from misplaced instruments that then do not respond to conditions at the required point of measurement

(e) errors resulting from instruments having insufficient sensitivity to respond to changes of conditions during a test

(f) errors resulting from local disturbance in connection to instruments from unpredictable or unexplained causes even though the instruments are located and attached in accordance with code or contract requirements

(g) calibration errors

(h) mistakes in unit conversions

(i) mistakes in correcting readings, e.g., water legs

3-9.2 Proper Identification and Propagation of Errors

Instrumentation errors are discussed in the ASME PTC 19 Supplements. ASME PTC 19.1 provides guidance and direction on the propagation of the estimates of those errors. Each PTC shall quantify the expected uncertainties associated with the test measurements on that specific component or system.

3-10 COMPUTATION OF RESULTS

3-10.1 Data Reduction

Following each test, when all test logs and records have been completed and assembled they should be examined critically to determine whether or not the limits of permissible deviations from specified operating conditions have exceeded those prescribed by the individual test code. Adjustments of any kind should be agreed upon and explained in the test report. If adjustments cannot be agreed upon, the test run(s) may have to be repeated. Inconsistencies in the test record or test result may require tests to be repeated in whole or in part to attain test objectives. Corrections resulting from deviations of any of the test operating conditions from those specified are applied when computing test results.

3-10.2 Inconsistencies in Test Results

(a) Recorded Data. Some data recorded from instruments may not be consistent with observed data recorded from other instruments when both have been acquired in accordance with the rules of an individual code. In such cases, it shall be the duty of the test coordinator to assess the data sources, evaluate the conditions leading to the inconsistencies, and determine which set of observed data is correct, if any.

(b) Analysis and Interpretation. During the conduct of a test or during the subsequent analysis or interpretation of the observed data, an obvious inconsistency may be found. If so, reasonable effort should be made to adjust or eliminate the inconsistency. Failing this, test runs should be repeated.

3-10.3 Data Presentation

Test data should be plotted or tabulated as determined by the code calculation procedure. Additional calculations shall be made to establish the test uncertainty in accordance with ASME PTC 19.1. For additional guidance, refer to para. 1-5 of this Code. All test results should be reported from the test observations.

3-10.4 Graphical Presentation and Scales

Graphical presentation of test data and results is useful in engineering analysis. Standard graphical formats prevail for many specific types of machinery, and these forms should be used wherever practical. In the absence of standard forms, the independent variable should be plotted horizontally (abscissa) and the dependent variable should be plotted on the vertical axis (ordinate). Scales should be selected to reflect the precision of measurements encountered and to avoid distortion of the results. Scales chosen should be easily readable by making the smallest division of the graph represent 1, 2, 5, or 10 units of data or one of these units multiplied by 10 to the nth power, where n is an integer. Logarithmic scales are useful for certain analyses. Other scales should be avoided.

3-10.5 Analysis Requirements

The complete analysis of the results of a performance test requires a working knowledge of

(a) the concepts of statistics including averages, means, standard deviations, variances, probability distributions, and uncertainties

(b) the theory, application, and acceptability of significant figures and numerical standards

(c) the specific computational method(s) applicable to the equipment

3-10.6 Data Reduction and Averaging

Each PTC shall specify the method to be used for reducing and averaging test data. These methods shall be the most appropriate engineering practices available. Guidance should be provided to ensure correct unit conversions.

3-10.7 Curve Construction

In constructing graphs from test data, individual test points should be retained and clearly identified by specific symbols. This facilitates the understanding of the deviations between the plotted curve shape and the actual test points. Test points plotted can be raw data, corrected data, or calculated results and must be described clearly.

3-11 TEST REPORT

3-11.1 Completion and Approval

The report of an ASME code test should be complete in all respects and approved by all appropriate parties to the test. The best criterion for determining completeness is the status the report might have in a court of law. Some states and parties to the test may require a registered professional engineer competent in the field to approve the test report.

3-11.2 Test Report Contents

The report should include the following distinctive sections:

(a) an executive summary containing

(1) a brief description of the object, result, and conclusions reached

(2) signature of the test director(s)

(3) signature of the reviewer(s)

(4) approval signature(s)

(b) a detailed report of

(1) authorization for the tests, their object, contractual obligations and guarantees, stipulated agreements, by whom the test is directed, and the representative parties to the test if it is a commercial test

(2) description of the equipment tested and any other auxiliary apparatus, the operation of which may influence the test result

(3) method of test, giving arrangement of testing equipment, instruments used and their location, operating conditions, and a complete description of methods of measurement not prescribed by the individual code

(4) summary of measurements and observations

(5) methods of calculation from observed data and calculation of probable uncertainty

(6) correction factors to be applied because of deviations, if any, of test conditions from those specified

(7) primary measurement uncertainties, including method of application

(8) the test performances stated under the following headings:

(a) test results computed on the basis of the test operating conditions, instrument calibrations only having been applied

(b) test results corrected to specified conditions if test operating conditions have deviated from those specified

(9) tabular and graphical presentation of the test results

(10) discussion and details of the test results uncertainties

(11) discussion of the test, its results and conclusions

(c) appendices and figures to clarify description of the circumstances, equipment, and methodology of the test; a description of methods of calibrations of instruments; an outline of details of calculations including a sample set of computations, descriptions, and statements depicting special testing apparatus; a result of preliminary inspections and trials; and any supporting information required to make the report a complete, self-contained document of the entire undertaking

Section 4
Acceptance Tests: Responsibilities, Purchase Contracts, and Arbitration

An acceptance test is the evaluation conducted to determine if a new or modified piece of equipment satisfactorily meets its performance criteria, permitting the purchaser to accept it from the supplier. ASME PTCs specify the technical and not the commercial details of tests that can be used as acceptance tests. The following paragraphs represent common practice and are recommended for equipment acceptance tests.

4-1 Cost of Acceptance Tests

Apportionment of costs or division of responsibility for acceptance tests should be stated in the purchase contract. Failing this, the contracting parties should agree upon cost and responsibility in writing. Acceptance test location should be specified to be either at the manufacturer's facilities, a test laboratory, or after installation in the field.

4-2 Test at a Manufacturer's Facilities

The cost of tests conducted in the manufacturer's facilities may be included in the price of the equipment or may be a separate item in the purchase contract. If tests are conducted in the manufacturer's facilities, the manufacturer usually supplies all necessary instruments, test apparatus, operators, observers, and data loggers. The manufacturer also provides to the purchaser a complete authenticated log of the tests, computations, and results. The purchaser should be invited, at his expense, to witness the tests and instrument calibrations. The purchaser may also furnish instruments at his expense to check the accuracy of those furnished by the manufacturer. All instruments should be calibrated by an accredited party. If ASME code acceptance tests are conducted in the manufacturer's facilities, preliminary tests are for the satisfaction of the manufacturer and should be conducted at his expense.

4-3 Field Tests

If tests are conducted after installation of the equipment, their costs are usually included in the price of the equipment. That charge may be a separate item in the purchase contract if a decision to conduct an acceptance test is to be made at a later date. The contract should stipulate which party to the test is to supply the test instrumentation and delineate a clear division of responsibilities, which includes all tasks required to successfully prepare and conduct a test in accordance with the code. If field tests show that the equipment has failed to fulfill one or more of the contract guarantees and the parties to the contract have agreed that the manufacturer may make certain changes or adjustments to the equipment, the cost of further tests is usually the responsibility of the manufacturer.

4-4 Arbitration Procedure

Sometimes a dispute or claim between the parties to the purchase contract agreement cannot be resolved. In such cases, the dispute or claim shall be settled by arbitration in accordance with the prevailing rules of the American Arbitration Association, and a judgment or decree upon the award rendered may be entered in any court having jurisdiction thereof.

4-5 Suggested Clause for Incorporating ASME PTCs in Equipment Purchase Contracts

Insertion of the following clause or equivalent statement in an equipment purchase contract will incorporate the ASME PTCs as part of the contract. "If an acceptance test is performed, the performance guarantees on the equipment covered herein shall be verified according to the provisions of the current edition (in effect at the time of contract signing) of the ASME Performance Test Code for ________ (dated _____). All the conditions of that Code shall be binding on all parties, excepting contrary stipulations in the contract."

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