ASME PTC 1-2015

(Revision of ASME PTC 1-2011)

General Instructions

Performance Test Codes

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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Two Park Avenue • New York, NY • 10016 USA

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The American Society of Mechanical Engineers
Two Park Avenue, New York, NY 10016-5990

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FOREWORD

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

During the years 1920 through 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 June 17, 1945 and May 7, 1970, respectively.

During the years 1970 through 1985, the scope of the Power Test Codes, now known as Performance Test Codes (PTCs), was further broadened as a result of

(a) their designation as American National Standards by the American National Standards Institute (ANSI)

(b) an increased awareness of the relationship between U.S. domestic standards and their international counterpart and a related need to reconcile substantially conflicting requirements between U.S. and international documents

(c) clarification on the use of uncertainty in test codes

These developments resulted in several additional revisions to the Code on General Instructions that were approved by the Board on Performance Test Code (BPTC) on May 13, 1970 (with the October 1971 Addenda), October 29, 1979, June 18, 1986, and June 12, 1991.

The subsequent revision of the Code was initiated in mid-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 next revision was a major updating of PTC 1. The existing information contained in PTC 1 was divided into two separate documents. One is the code writer's guide, the PTC 1 Template. The other, PTC 1, contains 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.

The 2011 revision contained modifications to the 2004 version where by some new committees were added and others discontinued. The template was not updated at this time. The 2011 revision was approved by the PTC Standards Committee on May 24, 2011 and approved and adopted as a Standard practice of the Society by action of the Board on Standardization and Testing on August 8, 2011. It was also approved as an American National Standard, by the ANSI Board of Standards Review, on November 14, 2011.

The current revision of PTC 1 modifies para. 1-6.3.1 to add another permissible use of test uncertainty to prepare for and validate the acceptability of a test. This method strictly specifies each measurement's systematic uncertainty along with its permissible variation (data fluctuation) or a total measurement uncertainty, including both systematic and random effects for each measured parameter and/or variable or each type of measured parameter or variable. A pretest and post-test uncertainty analysis is always required. It is limited to demonstrating the achievement of uncertainty limits placed upon each individual measurement without having to calculate a total test uncertainty for the result. However, if the user of the Code wishes to exceed any of the specified uncertainty limits of any parameter or variable, a complete test uncertainty analysis is required to establish that the Code's limit level of uncertainty for the test result has been met. This requires utilizing the systematic, random, and/or total measurement's uncertainty limits of each parameter and variable in accordance with PTC 19.1. Once the Code Limit Uncertainty is determined for the result, exceeding the upper limit of any individual parameter's or variable's specified uncertainty is allowable only if it is demonstrated that the selection of all instrumentation used will result in an overall test uncertainty equal to or less than what it would have been had all parameter's uncertainty requirements been met. This recognizes the industrial need for an acceptable method that allows flexibility in the determination of total test uncertainty while ensuring that the specified overall test uncertainty is achieved. Also, the template is no longer required by PTC 1, but it is recommended and is available on the PTC Web site (go.asme.org/PTCcommittee) for use as a reference.

This edition of the Code was approved as an American National Standard, by the ANSI Board of Standards Review, on September 9, 2015.

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Performance Test Codes

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CORRESPONDENCE WITH THE PTC COMMITTEE

General. ASME Codes are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Code may interact with the Committee by requesting interpretations, proposing revisions or a Case, and attending Committee meetings. Correspondence should be addressed to:

Secretary, PTC Standards Committee
The American Society of Mechanical Engineers
Two Park Avenue
New York, NY 10016-5990
http://go.asme.org/Inquiry

Proposing Revisions. Revisions are made periodically to the Code to incorporate changes that appear necessary or desirable, as demonstrated by the experience gained from the application of the Code. Approved revisions will be published periodically.

The Committee welcomes proposals for revisions to this Code. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

Proposing a Case. Cases may be issued 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. 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 at go.asme.org/Inquiry.

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.
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 may be rewritten in the appropriate 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 or Subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

Attending Committee Meetings. The PTC Standards Committee regularly holds meetings and/or telephone conferences that are open to the public. Persons wishing to attend any meeting and/or telephone conference should contact the Secretary of the PTC Standards Committee. Future Committee meeting dates and locations can be found on the Committee Page at go.asme.org/PTCcommittee.

INTRODUCTION

This document provides direction to 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) to define the purpose and scope of ASME PTCs

(b) to list major industry applications where PTCs can be used

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

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 STANDARDS COMMITTEES

ASME PTCs are developed by technical committees that are governed, organized, and appointed by the Performance Test Codes Supervisory Committee under the auspices of the Board on Standardization and Testing. 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 Supervisory Committee. Members of the 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, not as representatives of employers or special interest groups.

1-3 SCOPE AND ORGANIZATION OF PTCs

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

(a) power production
(b) combustion and heat transfer
(c) fluid handling
(d) emission
(e) instruments, apparatus, and other supplemental documents

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 as 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 as 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 shaft power. Such individual codes referring to process or thermodynamic quantities are known as Performance Test Code 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 guidance and reference information. It currently consists of PTC 1, General Instructions, and PTC 2, Definitions and Values. PTC 2 contains standards for terms, units, values of constants, and technical nomenclature.

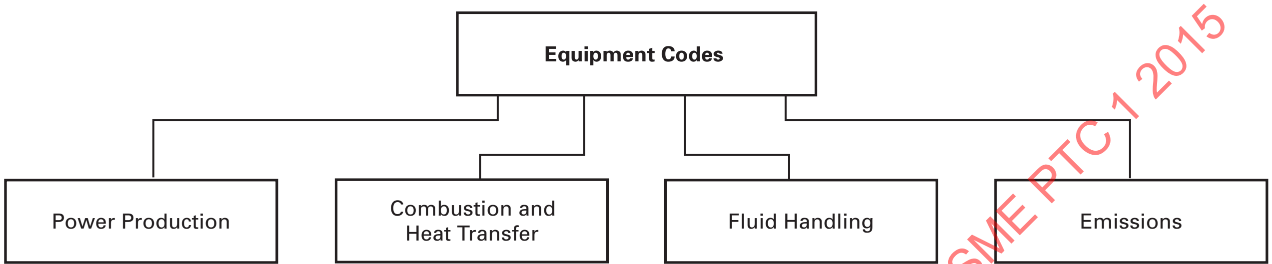
The third type addresses how to analyze the uncertainties associated with measurement of all primary parameters to develop overall test uncertainty. It currently consists of PTC 19.1, Test Uncertainty.

Figures 1-3-1 and 1-3-2 show the organization of ASME Performance Test Code categories.

1-4 PHILOSOPHY

PTCs 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

Fig. 1-3-1 Organization of Equipment Performance Test Codes



Power Production

- PTC 6, Steam Turbines
- PTC 6.2, Steam Turbines in Combined Cycles
- PTC 17, Reciprocating Internal-Combustion Engines
- PTC 18, Hydraulic Turbines and Pump-Turbines
- PTC 22, Gas Turbines
- PTC 29, Speed-Governing Systems for Hydraulic Turbine-Generator Units
- PTC 42, Wind Turbines
- PTC 46, Overall Plant Performance
- PTC 47, Integrated Gasification Combined Cycle Power Generation Plants
- PTC 50, Fuel Cell Power Systems Performance
- PTC 52, Concentrated Solar Power Plants
- PTC 55, Gas Turbine Aircraft Engines
- PTC 70, Ramp Rates

Combustion and Heat Transfer

- PTC 4, Fired Steam Generators
- PTC 4.2, Coal Pulverizers
- PTC 4.3, Air Heaters
- PTC 4.4, Gas Turbine Heat Recovery Steam Generators
- PTC 12.1, Closed Feedwater Heaters
- PTC 12.2, Steam Surface Condensers
- PTC 12.4, Moisture Separator Reheaters
- PTC 12.5, Single Phase Heat Exchangers
- PTC 23, Atmospheric Water Cooling Equipment
- PTC 30, Air-Cooled Heat Exchangers
- PTC 30.1, Air-Cooled Steam Condensers
- PTC 33, Large Incinerators [Note (1)]
- PTC 34, Waste Combustors With Energy Recovery
- PTC 48, Overall Plant Performance With Carbon Capture [Note (1)]
- PTC 51, Gas Turbine Inlet Air-Conditioning Equipment

Fluid Handling

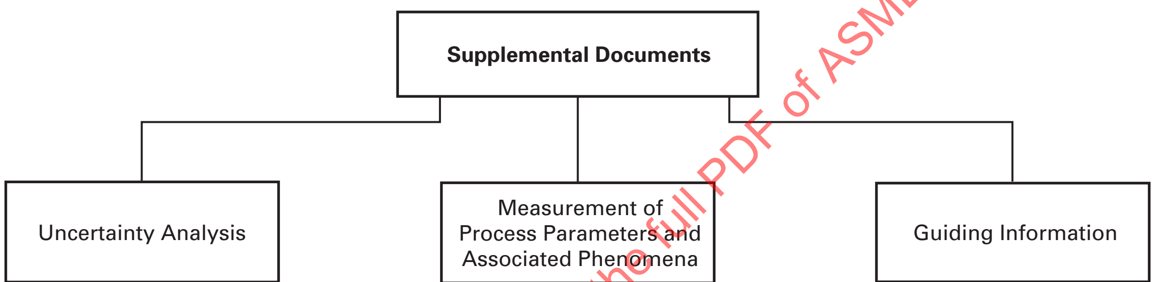
- PTC 8.2, Centrifugal Pumps
- PTC 10, Compressors and Exhausters
- PTC 11, Fans
- PTC 12.3, Deaerators
- PTC 13, Blowers [Note (1)]
- PTC 19.11, Steam and Water Sampling, Conditioning, and Analysis in the Power Cycle
- PTC 24, Ejectors
- PTC 25, Pressure Relief Devices
- PTC 31, High-Purity Water Treatment Systems
- PTC 39, Steam Traps

Emissions

- PTC 19.10, Flue and Exhaust Gas Analyses
- PTC 38, Determining the Concentration of Particulate Matter in a Gas Stream
- PTC 40, Flue Gas Desulfurization Units

NOTE:
(1) PTC 13, PTC 33, and PTC 48 are in the course of preparation.

Fig. 1-3-2 Organization of Supplemental Documents



Uncertainty Analysis

PTC 19.1, Test Uncertainty

Measurement of Process Parameters and Associated Phenomena

PTC 19.2, Pressure Measurement
PTC 19.3, Temperature Measurement
PTC 19.5, Flow Measurement
PTC 19.6, Electrical Power Measurement [Note (1)]
PTC 19.7, Measurement of Shaft Power
PTC 19.22, Data Acquisition Systems
PTC 36, Measurement of Industrial Sound

Guiding Information

PTC 1, General Instructions
PTC 2, Definitions and Values

NOTE:
(1) PTC 19.6 is in the course of preparation.

considerations in the development of an ASME Performance Test Code, consistent with economic considerations as judged appropriate by each technical committee and in keeping with the philosophy of the ASME Performance Test Codes Supervisory Committee.

1-5 APPLICATIONS OF PTCs

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

(a) determining if the equipment meets design or expected performance criteria.

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

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

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

(e) benchmarking performance, sometimes to help determine the necessity for specific preventive maintenance, or possible upgrade or modification.

(f) trending performance in time by scheduling performance tests at regular intervals. Such trends are also used to help determine necessity for specific preventive maintenance, or possible upgrade or modification.

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

PTCs 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 preventive maintenance or modification.

1-6 TEST UNCERTAINTY

1-6.1 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 utilizing 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. This confidence level therefore represents a 95% chance that the uncertainty interval contains the true value.

1-6.2 Applications of Test Uncertainty Analysis — General

Analysis of test uncertainty is useful because it

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

(b) validates 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

1-6.2.1 Pretest Uncertainty Analysis. PTCs require a pretest uncertainty analysis in order to effectively plan the 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.

1-6.2.2 Post-Test Uncertainty Analysis. PTCs require a post-test uncertainty analysis to determine the uncertainty intervals for the actual test. This analysis should confirm the pretest systematic and random uncertainty estimates. It serves to either validate the quality of the test results or to expose problems.

1-6.3 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 PTC 19.1 shall be included. This shall include typical random 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 utilize test uncertainty analysis in ASME PTCs (see paras. 1-6.3.1 and 1-6.3.2).

1-6.3.1 Permissible Uses of Test Uncertainty. The following uses of test uncertainty to prepare for and to validate the acceptability of a test are permissible. One or more shall be used in a single code.

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

(b) Specify the typical test result uncertainty of a test for each type or configuration of equipment. This can

be done only if the range of acceptable test result uncertainties is small — 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 test result uncertainty — in either direction — indicate that something is amiss. For example, if a "typical test result 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) Specify a typical range of acceptable uncertainties for each type or configuration of equipment. This approach is preferable 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 (b) above, in order 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) Specify the total uncertainty for each measurement parameter/variable (e.g., main steam throttle pressure, compressor inlet temperature, fan inlet air flow, etc.) or measurement parameter/variable type (e.g., flow, temperature, pressure, etc.). The total uncertainty can be specified directly or by specifying the systematic and random uncertainty. The random uncertainty may be specified directly or as a variation or data fluctuation. This is equivalent to establishing an upper limit on the test result uncertainty per (a) above since the test result uncertainty is calculated from the total uncertainty and sensitivity of the individual parameter/variable upon the test result. A pretest and post-test uncertainty is still required, however is limited to demonstrating the uncertainty limits placed upon each individual measurement parameter/variable have been met. In this case, the sensitivity coefficients must be very nearly linear so that the total test result uncertainty is not affected by the magnitude of any corrections.

(e) Specify the instrumentation requirements and uncertainty limits as per (d) along with the additional allowance for the total test result uncertainty to be determined pretest from those requirements to establish a code limit for the test result uncertainty. Once this limit is established, any of the specified parameter/variable limits set can be exceeded if the total test result uncertainty is lesser than or equal to the established code limit total test result uncertainty. This requires that total test result uncertainty for the actual pretest and post-test be determined using the same uncertainty analysis approach (e.g., same assumptions, same sources, same mathematical steps, etc.) as was done to establish the code limit for the total test result uncertainty. 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) inhomogeneous fuels

(2) 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 acceptable methods [(a), (b), (c), (d), and (e)] of utilizing the test uncertainty principles listed above, or a combination of them, to prepare for and validate a test shall be used.

1-6.3.2 Nonpermissible Uses of Test Uncertainty. 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 or a typical or maximum allowable test uncertainty per (a) through (d) above. 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) PTCs specify test methods to determine the performance of the equipment. Commercial issues are wholly outside the scope of PTCs. Reference to any commercial issues typically contained in contracts, such as the method of comparing a test result to a contract guarantee by offsets or deadbands related to test uncertainty, is not permissible.

1-7 OTHER CODES AND STANDARDS

PTCs must be developed in strict accordance with the philosophy stated in subection 1-4. Related codes and standards or additional measuring procedures developed by other organizations, such as ASTM, IEEE, AIChE, and the EPA, may be referenced by PTCs. Consideration should be given to techniques and rules published in other international codes and standards, such as those of the International Standards Organization (ISO). Some equations and techniques are referenced as joint ASME/ISO equations or techniques in the professional literature.

Section 2
Standard Form of Individual Equipment 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

Under 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, and 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 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) identification 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, but which are not part of the Code

2-2.3 Uncertainty

This Section 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 tabulated in para. 1-6.3. 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 AND DESCRIPTIONS OF TERMS

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 those items that 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 (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 PTC 19 Supplement(s). Specific references may be made to a PTC 19 Supplement by particular paragraph number and date of Supplement. General references to a PTC 19 Supplement are also permitted. All required instruments, not covered by the Supplements on Instruments and Apparatus, are to have any further rules and precautions described completely in this Section.

2-6 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.

2-7 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; 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 documents such validity.

2-8 SECTION 7, TEST UNCERTAINTY

This Section shall contain formulas and directions for calculating uncertainty of test results. PTC 19.1, Test Uncertainty, is the primary reference for uncertainty calculations, and any uncertainty analysis that conforms to PTC 19.1 shall be acceptable. Any deviations from the methods described in PTC 19.1 shall be noted and explained in detail. Additionally, this Section should provide guidance for estimating the systematic component(s) of uncertainty. This Section, taken together with 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. 1-6.3 of this Code.

2-9 ADDITIONAL SECTIONS AND APPENDICES

Additional sections may be included to present detailed background information that illustrates or supports methods or formulas included in the Code or present additional data and guidance to the user. Subjects that may be included in additional sections are, for example, rationale and derivation of expected uncertainty, derivation of formulae, derivation of figures, examples of the proper use of figures or curves, detailed description of methods of measurement or techniques not covered in the PTC 19 Series, a list of references, sample calculations, alternative test method, detailed requirements for use of a Performance Model for test calculations, etc. It should be noted that it is not mandatory that codes have additional sections. However, additional sections (in the body of the Code, such as Sections 7 and 8, etc., and/or Appendices 1 and 2, etc.) are mandatory if the Committee deems it necessary. Lettered appendices are not mandatory; they provide expository information explaining rationale of the body of the Code or additional useful information to the code user.

The number of such expository sections shall be minimized to maintain the clarity of the Code.

2-10 ALTERNATIVE METHOD

If an individual code provides for an alternative testing method, 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 their effect on test uncertainty

Section 3
Information for ASME Performance Test Code 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, it may include the owner(s), supplier(s), equipment manufacturers, architect, engineer, firms hired to conduct the tests, engineering analysts, financiers, and any of their representatives. In other noncommercial tests, the parties to a test may all be from the same company but represent 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, test measurement forms, or photographs 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 tabulation of preparatory items, which must be completed, understood, and agreed to among 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 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 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 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 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. Redundant instruments should also be considered for the measurement of key parameters that have a large effect on test results or the test uncertainty.

3-3.7 Preliminary Test Runs

Preliminary test runs with records serve to determine if equipment is in suitable condition

(a) to test

(b) to check instruments and methods of measurement

(c) to check adequacy of organization and procedures

(d) 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.

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 test coordinator. Intercommunication arrangements between all test personnel/test parties and the person in charge 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. If a commercial test, then accredited representatives of the purchaser 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 specific 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. Care shall be used in placement of transmitters and relay stations for wireless applications to avoid interference that results in erroneous readings. 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 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, which may include data sheets, files, disks, and recorder charts, 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. Erasures on or destruction or deletion of any data record, page of the test log, or of 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 observer's 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 distributed as soon as possible to each of the parties to the test. The data files shall be in a format that is easily accessible to all. A backup, permanent copy should be made for any data residing on a single machine.

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 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. The Code on Definitions and Values (PTC 2) is the reference for interpreting such terms.

3-9 ERRORS

3-9.1 Sources of Errors

The following sources of errors may influence the test uncertainty:

(a) instrument errors

(b) errors of observation

(c) errors resulting from failure to obtain representative samples

(d) errors resulting from misplaced instruments that 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) errors in correcting readings, e.g., water legs

3-9.2 Proper Identification and Propagation of Errors

Instrumentation errors are discussed in the Supplements on Instrumentation and Apparatus, the PTC 19 Series. 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 in order 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

3-10.2.1 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.

3-10.2.2 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 PTC 19.1. For additional guidance, refer to subsection 1-6 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.

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.