ASME
PTC 1-1999
(Revision of ASME PTC 1-1991)

General Instructions

PERFORMANCE
TEST CODES

AN AMERICAN NATIONAL STANDARD

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PTC 1-1999
(Revision of ASME PTC 1-1991)

General Instructions

The American Society of Mechanical Engineers

PERFORMANCE
TEST CODES

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This Standard will be revised when the Society approves the issuance of a new edition. There will be no Addenda issued to ASME PTC 1-1999.

Please Note: ASME issues written replies to inquiries concerning interpretation of technical aspects of this document. PTC 1-1999 is being issued with an automatic subscription service to the interpretations that will be issued to it up to the publication of the next edition.

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

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 standard practice of the Society in January 1924.

During the years 1920 to 1970, the functions 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 to 1985, the scope of the Power Test Codes, now known as the Performance Test Codes, was further broadened as a result of (1) their designation as American National Standards by the American National Standards Institute (ANSI); (2) an increased awareness of the relationships between U.S. domestic standards and their international counterparts and a related need to reconcile substantially conflicting requirements between U.S. and international documents; and (3) clarification on the use of uncertainty in test codes. These developments resulted in several additional revisions to the Code on General Instructions which were approved by the Board on Performance Test Codes on May 13, 1970 (with an October 1971 Addenda), October 29, 1979, June 18, 1986, and June 12, 1991.

This Code was first approved as an American National Standard by the ANSI Board of Standards Review on May 15, 1980. A revision of PTC 1 was approved as an American National Standard on November 27, 1991. Work on the current revision was started in mid 1998. A Project Team was appointed by the BPTC to develop this revision under the ASME Redesign Process. It was approved and adopted by the Council as a standard practice of the Society by action of the BPTC on November 19, 1998. It was also approved as an American National Standard by the ANSI Board of Standards Review on August 16, 1999.

PERSONNEL OF PERFORMANCE TEST CODE COMMITTEE NO. 1 ON GENERAL INSTRUCTIONS

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

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SECTION 0 — INTRODUCTION

This Code provides direction to committees writing Performance Test Codes and to users of Performance Test Codes. It shall be considered by code users as part of each test.

The objectives of this document are:

(a) Define the purpose and scope of ASME Performance Test Codes;

(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;

(e) Provide direction on the use of equipment Performance Test Codes concerning the planning, preparation, implementation, and reporting of test results.

SECTION 1 — PURPOSE, SCOPE, AND ORGANIZATION

1.1 DEFINITION AND PURPOSE

Performance Test Codes (PTCs) provide uniform rules and procedures for the planning, preparation, execution, and reporting of performance test results. Performance test results indicate how well the thermodynamic or the mechanical functions of equipment, systems, or plants are being effected. Throughout 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 PERFORMANCE TEXT CODES

Most ASME Performance Test Codes are applicable to a specific type of equipment defined by the 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:

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

The quantities, which characterize performance, are defined in each code for the equipment within its scope. 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. Reference material codes can be divided into three types. The first type addresses the measurement of phenomena closely associated with the equipment, such as emissions. The second type covers instrumentation used in the measurement of thermodynamic or process fluid parameters, such as pressure, temperature, flow, and steam quality, and how to analyze the uncertainties associated with measurement of all primary parameters to develop overall test uncertainty is included in this type. 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 can supersede the information given in these supplements, or these supplements may be referenced by an equipment Test Code where deemed appropriate by the committee. The third type covers miscellaneous general information, and 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.

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

1.3 PHILOSOPHY

The codes provide guidelines for test procedures which 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 Performance Test Code, consistent with economic considerations as judged appropriate by each technical committee and 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:

(a) Determine if equipment meets design or expected performance criteria;

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

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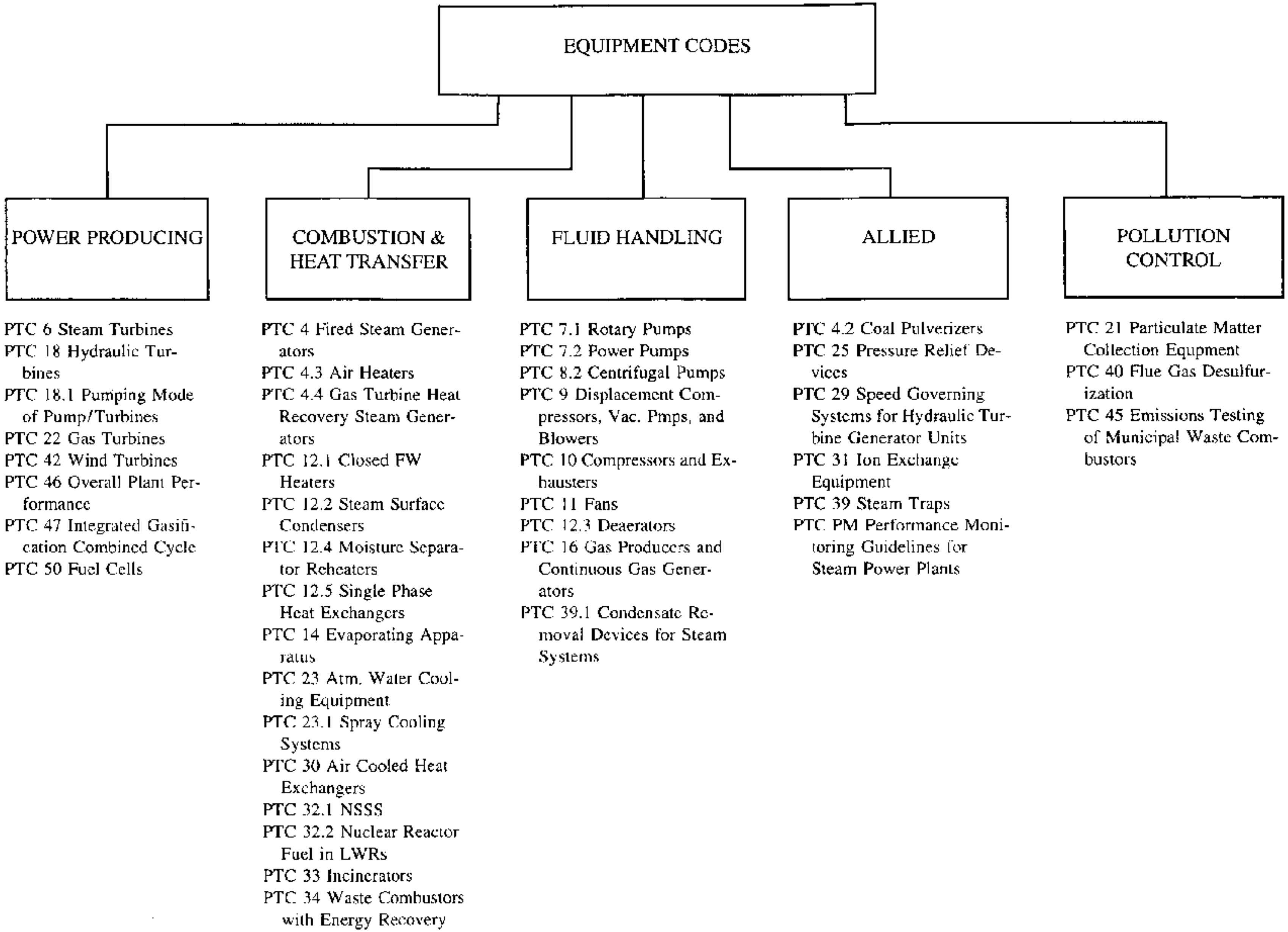

FIG. 1 ORGANIZATION OF ASME PERFORMANCE TEST CODES FOR INDUSTRIAL EQUIPMENT

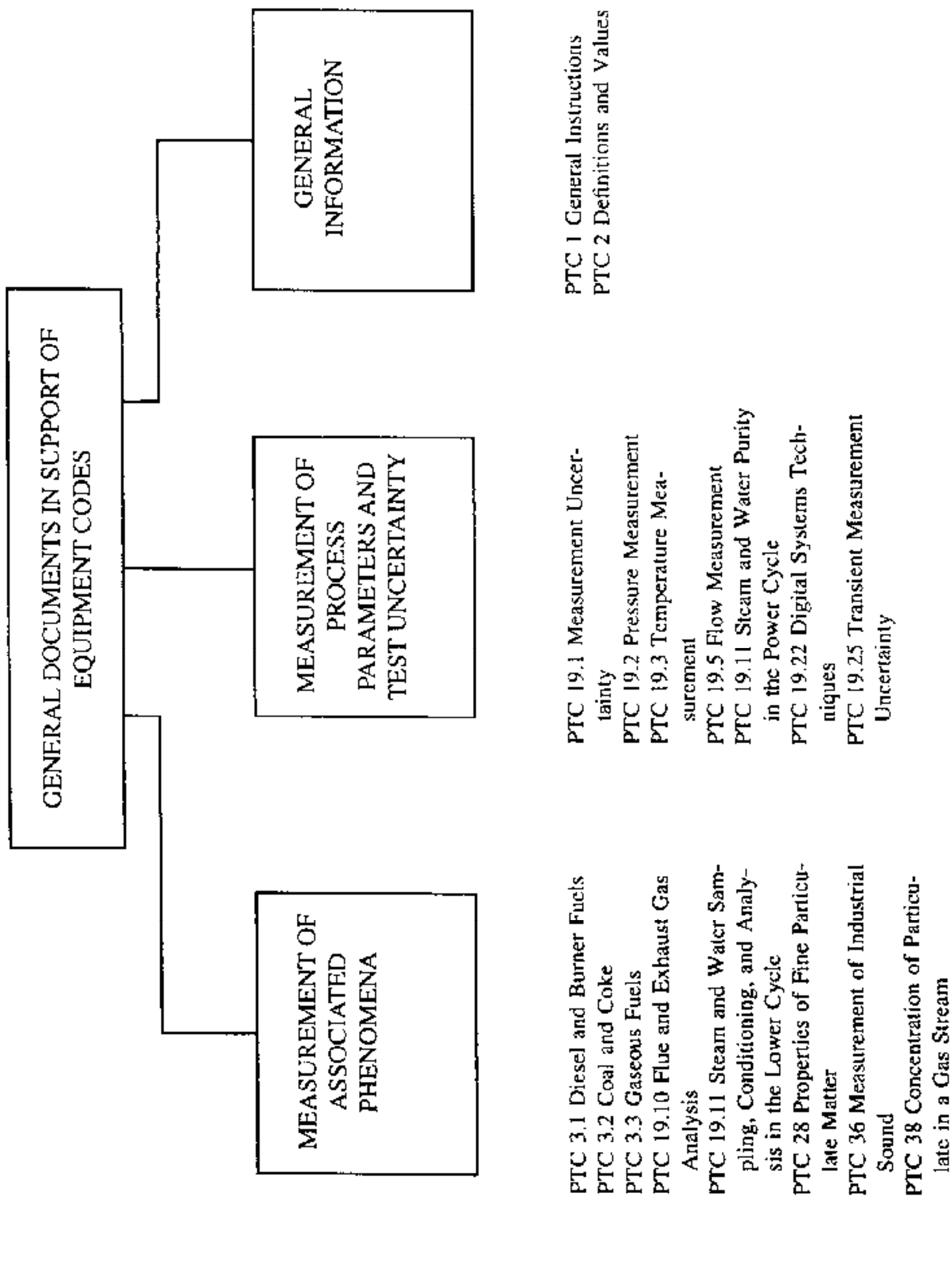

FIG. 2 ORGANIZATION OF GENERAL DOCUMENTS

(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 the equipment, system, or plant;

(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 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. 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 utilizing probability theory, instrumentation information, calculation procedure, and actual test data. PTC 19.1 is the Performance Test Code Supplement that covers general procedures for calculation of test uncertainty. 95% is Performance Test Codes standard level of confidence for which uncertainty is calculated.

1.5.2 Applications of Test Uncertainty Analysis — General. Test uncertainty analysis is useful because it:

- Identifies dominant sources of error, their effects on a test result, and estimates of their limits
- Serves to validate quality of test results
- Facilitates communication regarding results
- Facilitates the choice of appropriate and cost effective measurement devices and procedures
- Reduces the risk of making erroneous decisions
- Demonstrates compliance with test requirements
- Facilitates interpretation of test results

(a) 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. During a test, uncertainty analysis is useful in determining if the number of observations is adequate.

(b) 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 Performance Test Code 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 complete post-test uncertainty analysis, based on PTC 19.1, should be included as a non mandatory appendix. This should 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 utilize test uncertainty analysis in ASME PTCs. The following uses of test uncertainty to prepare for and to validate the acceptability of a test are permissible. One or more may 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, 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, indicates that something is amiss. For example, if a "typical test uncertainty" of 1.0% is 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 it is desirable to treat uncertainty per item (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) 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:

- Non-homogenous fuels, and
- Unusually high and variable sensitivity factors

It should then 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 utilizing 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 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.

(f) For some tests, it may not be feasible to satisfy all Code specified requirements. The post-test uncertainty may therefore exceed the expected uncertainty value. Test uncertainties exceeding the expected uncertainty by amounts on the order of 50% can be acceptable, if the committee does not disallow such excess and if agreed in advance by the parties to a test.

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

First, the minimum achievable test uncertainty cannot be given exclusively without reference to a range, a typical, or a maximum allowable test uncertainty per (a) through (e), 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.

Further, reference to any commercial issues contained in contracts should 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 Performance Test Codes. Assigning or suggesting values for commercial "tolerance" or any other discussion of commercial issues is not permitted in a PTC.

1.6 OTHER CODES AND STANDARDS

Performance Test Codes 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 Standards Organization (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 ASTM, IEEE, AIChE, and the EPA, may be referenced by PTCs.

1.7 STANDARDS COMMITTEES

ASME Performance Test Codes are developed by Standards Committees organized and appointed by the ASME Board on Performance Test Codes. Each code writing committee is organized to include representatives of three interest groups:

(a) users, operators or buyers of the equipment;

(b) suppliers or manufacturers of the equipment, and;

(c) general interest, which may include, for example, members of the academic community or consulting engineers.

The qualifications of each member of a code writing committee are subject to examination and approval by the Board. Members of code writing committees are highly qualified, technically competent professionals, generally members of the 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.

Committees that develop Instrument and Apparatus Supplements (PTC 19 Series) need not be balanced among the three interest groups, although it is expected that each interest group will be represented. All other requirements for the code writing Committees are applicable.

1.8 NEW CODES, REVISIONS, RE-AFFIRMATIONS, OR WITHDRAWALS

Development of a new code is initiated by action of the BPTC. Members of the ASME, the public, industry, academia, or government representatives may propose new areas of activity to the Board. The Board evaluates the proposal and determines if formation of a new committee is appropriate. When a new committee is formed, a Board member will be assigned as liaison to that committee.

Action should be taken every five years to reaffirm, withdraw, or initiate revision of each existing Code, by the Standards Committee. Action to either withdraw or revise may be initiated at an earlier date in response to industry needs or requests. Board members will be appointed as liaisons to Code writing committees to review and recommend appropriate action.

1.9 CODE DEVELOPMENT AND REVISION PROCEDURES

There are separate procedures developed by the Board on Performance Test Codes that must be followed in the development or revision of a Code. When a committee is formed, an ASME staff member is assigned to the committee as its Secretary and these procedures are distributed to all members of the committee.

1.10 INTERIM CODES

Standard Committees may publish Interim Codes in exceptional instances, such as new testing techniques with newly developed equipment. They are limited to 5 years from date of approval. At the end of this period, the Board must withdraw the Interim Code or modify it as dictated by experience and reissue it as a new Code.

1.11 PERFORMANCE MONITORING (PM)

It is recognized that performance monitoring systems for continual trending are generally less accurate in determination of equipment performance than are tests conducted in rigorous accordance with the applicable PTC (see para. 1.4(f). The numbered PTCs are designed for the uses outlined in para. 1.4, and are not meant for continuous, long term trending.

Calculation procedures in Performance Test Codes can be applied in developing performance monitoring systems. Also, comparison of PTC required instrumentation and actual instrumentation is useful in developing such systems.

There is considerable value in performance monitoring systems for determining performance trends. The ASME BPTC commissioned ASME PTC-PM, "Performance Monitoring Guidelines for Steam Power Plants," for this reason. While not suitable for any testing requiring high precision, it does establish procedures for monitoring steam cycle performance parameters in a routine, continuous, and practical manner.

SECTION 2 — STANDARD FORM OF INDIVIDUAL TEST CODES

2.1 INTRODUCTION

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

2.2 OBJECT AND SCOPE

Under this section the individual codes shall define the scope of the test, size and types of equipment, and processes embraced by, or excluded from, the Code and outline the test objectives.

The Object must clearly state:

- The type(s) of equipment being covered.
- The physical results that can be determined regarding the performance of the covered equipment. Examples include capacity, efficiency, power output or input, specific process results such as temperatures, sulfur capture, etc. It should be stated that not all results which can be determined by application of the Code need be included in the objectives of a specific test.
- 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 parameters held fixed.

The Scope must clearly state:

- A specific definition of the types of equipment to which the Code may be applied
- Identification of any similar equipment to which the Code does not apply
- Other minimum conditions that must be met for the Code to be applied
- Similar tests that can be performed on the equipment within the Scope of the Code, but which are not part of the Code, such as pre-operational or start-up tests, are discussed to avoid misapplication of the Code

This section shall also address the uncertainty of tests performed using the Code. The following shall be included:

- A statement of the expected test uncertainty per one or more of the approaches tabulated in para. 1.5.3, of each performance parameter of the test results. 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 values of several representative configurations shall be shown in tabular form with appropriate identification.
- Acceptable ways to use post-test uncertainty analysis to define the validity of a test

2.3 DEFINITIONS AND DESCRIPTION OF TERMS

This section shall contain a list of terms employed with definitions for those not given in the Code on Definitions and Values (PTC 2). Symbols and abbreviations shall be specified for equations and formulas. These should conform to the Code on Definitions and Values (PTC 2). Illustrations or diagrams desirable for clarification of terms or symbols may also be included.

2.4 GUIDING PRINCIPLES

This section shall discuss in detail items on which agreement between the parties to the test should be reached prior to the test, rules covering test preparations, arrangements of test apparatus, starting and stopping procedures, selection and qualifications of test personnel including chief of tests, methods of operation during test, provisions for equipment inspection, provisions for preliminary tests, permissible and nonpermissible adjustments during test, degree of constancy of test conditions, duration of tests, causes for rejection of inconsistent test readings or results, methods of comparing results with specified performance, and rules as to permissible limits of uncertainty.

2.5 INSTRUMENTS AND METHODS OF MEASUREMENT

This section 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 Supplements on Instruments and Apparatus (PTC 19 Series). 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 ALTERNATIVE METHODS

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 and;

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

2.7 COMPUTATION OF RESULTS

This section 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. This section shall also contain formulas and directions for calculating uncertainty of test results. The details of computations and data assembled shall be included in an appendix, along with the derivations of pertinent equations.

2.8 REPORT OF RESULTS

This section 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 by the parties to the test; methods to be 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, this section shall require that the report document such validity.

2.9 ADDITIONAL SECTIONS (NON-MANDATORY)

Additional sections may be included to present detailed background information which illustrates or supports methods or formulas included in the mandatory sections or present additional data and guidance to the user. Illustrations of subjects included in non-mandatory 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 PTC 19 Series, list of references, sample calculations, alternative test methods, etc. It should be noted that it is not mandatory that Codes have additional sections. However, additional sections, such as Section 7, 8, etc., and/or Appendix 1, 2 etc, may be defined as mandatory, if the Committee deems it necessary. Note that lettered appendices are generally considered non-mandatory.

SECTION 3 — INFORMATION FOR ASME PERFORMANCE TEST CODE USERS

3.1 INTRODUCTION

This section contains rules for carrying out tests common to most equipment. They are not made mandatory herein, but, where pertinent, they should be included by quotation in individual test codes and therein be made mandatory.

3.2 OBJECT OF TEST

The object of the test shall be agreed by the parties to the test and shall be defined in writing before the test(s) commence.

3.3 PREPARATIONS FOR TESTING

3.3.1 General Precaution. Every reasonable precaution should be employed in making preparations for conducting any Code test. Indisputable records shall be made 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, agreed by the parties to the test, and described in detail in test records.

3.3.2 Agreements. Prior to any tests there shall be agreement on the exact method of testing and the methods of measurement. Among such items are:

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

3.3.3 Acceptability of Equipment and Instruments. Equipment and instruments should be examined thoroughly 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.

3.3.4 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 preliminary test run complies with all the necessary requirements of the appropriate test code, it may be agreed to be an official test run within the meaning of the applicable code.

3.4 TESTS

3.4.1 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.

3.4.2 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 and should be specified in respective individual Codes. Agreement on procedures and time should be reached before commencing the test.

3.4.3 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.

3.4.4 Conduct of Test. The parties to the test shall designate a person to direct the test. Intercommunication arrangements between observers 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. 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 with the test code and prior agreement.

3.5 INSTRUMENTS

3.5.1 Use of Supplements on Instrumentation and Apparatus. The Supplements on Instruments and Apparatus (PTC 19 Series) 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 assure that:

(a) the requisite degree of accuracy of measurement is attainable, and;

(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 so that they are unaffected by ambient conditions, e.g., temperature or temperature variations, or be placed in environmentally controlled cabinets. 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 of 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 and thus reduce and minimize the magnitude and number of corrections for deviations from specified conditions.

3.6.2 Permissible Deviations. The individual code should specify permissible fluctuation in operating conditions from the average during a test run and permissible deviation of the average operating conditions from those specified.

3.6.3 Inconsistent Measurements. If any measurement influencing the result of a test is inconsistent with some other like measurement, although 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, and disks; recorder charts; tapes; etc., being the only evidence of actual test conditions, must permit clear and legible reproduction. Copying by hand is not permitted. All duplicate copies shall be signed by the test director and other representatives to the parties of the test certifying the accuracy of reproduction. 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 corrected, 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 to be 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 copied onto tape or disks and distributed to each of the parties of 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.

3.7.2 Preliminary Data Presentation. Graphical logs and preliminary graphical representation of computed results during the test runs are generally helpful in the conduct of a test. See paras. 3.4.3 and 3.4.4, for additional information.

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 in order that computed results may be reliable and acceptable. Such considerations require a working knowledge of the following:

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

(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 discussion of accuracy and uncertainty in test measurements is given in PTC 19.1. Precision and accuracy in scientific work must therefore 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 of assistance in interpreting such terms.

3.9 ERRORS

3.9.1 Sources of Errors. Among the sources of error which influence the accuracy of a test are:

(a) instrument errors;

(b) errors of observation;

(c) errors resulting from failure to obtain representative samples;

(d) errors resulting from failure to place instruments for response 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 due to unpredictable or unexplained causes even though instruments are located and attached in accordance with code or contract requirements;
(g) calibration errors;
(h) errors in unit conversions;
(i) errors 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 estimate of those errors. Each Performance Test Code should 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. Although approximate computations made during the course of a test are useful for indicating errors, omissions, and irregularities, they should not be included in the test report. 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 and explained in the test report. If adjustments, which are to be mutually acceptable, cannot be agreed, the tests 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. Numerical values of any corrections, if not contractually specified, should be agreed upon prior to starting tests.

3.10.2 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 para. 1.5 of this Code. All test results should be reported from the test observations. The data should be reported in the same units of measure as recorded during the test. Publications that contain examples and information on methods of computing and presenting data are listed in a bibliography at the end of this Code.

3.10.3 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 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. A running plot of recorded data should be kept during the test to help identify outliers, discontinuities, and anomalies.

3.10.4 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.

3.10.5 Data Reduction and Averaging. Each Performance Test Code 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.

3.10.6 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 relationship between the plotted curve shape and the actual test points and the relative placement of the individual test data. Test points plotted can be raw data, corrected data, or calculated results, and must be clearly described as such in a legend.

3.11 TEST REPORT

3.11.1 Completion and Approval. The report of an ASME Code Test should be complete in all respects and should be signed by the test director(s). 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 test director(s);

(3) signature of reviewer(s);

(4) approval signature(s).

(b) The 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;

(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 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 of the test, its results and conclusions;

(11) discussion and details of the errors and test measurement uncertainties.

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

MANDATORY APPENDIX I — RESPECTIVE RESPONSIBILITIES FOR CONDUCT OF ASME CODE ACCEPTANCE TESTS - RELATION OF TESTS TO PURCHASE CONTRACTS - ADJUSTMENT OF CONTROVERSIES AND ARBITRATION

The following paragraphs discuss the subjects under the above heading and represent common practice. They are recommended for acceptance tests.

A.1 COST OF ACCEPTANCE TESTS

Apportionment of costs or division of responsibility for acceptance tests should be stated in the purchase contract. Failing this, cost and responsibility should be agreed upon in writing by the contracting parties. In absence of such agreements, the burden of proof for determining the performance of the equipment rests with the purchaser. Acceptance-test location, i.e., manufacturer's facilities, or after installation in the field should be specified.

A.1.1 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. In either case, the purchaser bears the cost.

A.1.2 Field Tests. If tests are carried out after installation of the equipment, it is usual for the purchaser to assume responsibility for the test. 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. During such changes or adjustments, the manufacturer should be accorded the privilege of using the instruments and test apparatus that have been supplied by the purchaser.

A.2. PRELIMINARY TESTS AND ADJUSTMENTS

Before conducting an ASME Code acceptance test, all parties have the right to examine the equipment to ascertain that it is in the condition contractually agreed upon, to run a preliminary test to ascertain that the equipment is capable of reliable and continuous operation within the scope of the contract; and to satisfy themselves that it is in condition to undergo acceptance tests.

A.3 TESTING IN MANUFACTURER'S FACILITIES

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, if he elects, furnish instruments, at his expense, to check the accuracy of those furnished by the manufacturer, which should be calibrated by an accredited party.

A.3.1 Adjustments and Preliminary Testing. 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.

A.4 TESTING IN THE FIELD

The purchaser should furnish all necessary instruments, test apparatus, observers, operators, and computers and supply to the manufacturer a complete authenti-

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cated log of the tests, computations and results. The manufacturer should be invited, at his expense, to witness the tests and all instrument calibrations. He should also be accorded the privilege to direct operation of the equipment during the test to the extent of ensuring proper functioning. Either party may, by agreement, use the other party's instruments.

A.4.1 Readjustments. Once acceptance tests have been started, readjustments to the equipment that can influence the results of the test should require repetition of any tests conducted prior to the readjustments. No adjustments should be permissible for the purpose of a test that are inappropriate for reliable and continuous commercial operation following a test under any and all of the specified outputs and operating conditions.

A.4.2 Time Limits. The purchase contract should specify the time limit following first dependable commercial operation, within which a field acceptance test should be undertaken. Failing this, the acceptance test should be undertaken within the period stated in the test code but not over six months from the time the equipment is first put into operation, except that 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 the 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.

A.5 INCONSISTENCIES IN THE TEST RESULTS

A.5.1 Observed Data. Because of local conditions, observed data recorded from instruments, applied in accordance with the rules of an individual code or with provisions of a contract may not be consistent with observed data recorded from other instruments also applied in accordance with the rules. In such cases, it shall be the duty of the engineer in charge to determine which set of observed data is more correct, and these data shall be used for calculating performance regardless of any requirement of the individual code or the contract.

A.5.2 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, the parties to the test should make every reasonable effort to adjust or eliminate the inconsistency by mutual agreement. Failure to reach agreement requires repetition of the test, or, upon the demand of either party, recourse may be had to arbitration as provided in para. A.6.

A.6 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.

A.7 SUGGESTED CLAUSE FOR INCORPORATING ASME PERFORMANCE TEST CODES IN EQUIPMENT PURCHASE CONTRACTS

Insertion of the following clause or equivalent statement in an equipment purchase contract will incorporate the ASME Performance Test Codes as part of the contract.

A.7.1 Clause. "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."

PERFORMANCE TEST CODES

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