ASME PTC 19.1-2013
(Revision of ASME PTC 19.1-2005)

Test Uncertainty

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

Date of Issuance: May 30, 2014

This Code will be revised when the Society approves the issuance of a new edition.

ASME issues written replies to inquiries concerning interpretations of technical aspects of this Code. Interpretations are published on the Committee Web page under go.asme.org/InterpsDatabase. Periodically certain actions of the ASME PTC Committee may be published as Cases. Cases are published on the ASME Web site under the PTC Committee Pages at go.asme.org/PTCcommittee as they are issued.

Errata to codes and standards may be posted on the ASME Web site under the Committee Pages to provide corrections to incorrectly published items, or to correct typographical or grammatical errors in codes and standards. Such errata shall be used on the date posted.

The PTC Committee Page can be found at go.asme.org/PTCcommittee. There is an option available to automatically receive an e-mail notification when errata are posted to a particular code or standard. This option can be found on the appropriate Committee Page after selecting "Errata" in the "Publication Information" section.

The American Society of Mechanical Engineers
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Nonmandatory Appendices

NOTICE

All Performance Test Codes must adhere to the requirements of ASME PTC 1, General Instructions. The following information is based on that document and is included here for emphasis and for the convenience of the user of the Code. It is expected that the Code user is fully cognizant of Sections 1 and 3 of ASME PTC 1 and has read them prior to applying this Code.

ASME Performance Test Codes provide test procedures that yield results of the highest level of accuracy consistent with the best engineering knowledge and practice currently available. They were developed by balanced committees representing all concerned interests and specify procedures, instrumentation, equipment-operating requirements, calculation methods, and uncertainty analysis.

When tests are run in accordance with a Code, the test results themselves, without adjustment for uncertainty, yield the best available indication of the actual performance of the tested equipment. ASME Performance Test Codes do not specify means to compare those results to contractual guarantees. Therefore, it is recommended that the parties to a commercial test agree before starting the test and preferably before signing the contract on the method to be used for comparing the test results to the contractual guarantees. It is beyond the scope of any Code to determine or interpret how such comparisons shall be made.

FOREWORD

In March 1979 the Performance Test Codes Supervisory Committee activated the PTC 19.1 Committee to revise a 1969 draft of a document entitled PTC 19.1 "General Considerations." The PTC 19.1 Committee proceeded to develop a Performance Test Code Instruments and Apparatus Supplement which was published in 1985 as PTC 19.1-1985, "Measurement Uncertainty," and which was intended, along with its subsequent editions, to provide a means of eventual standardization of nomenclature, symbols, and methodology of measurement uncertainty in ASME Performance Test Codes.

Work on the revision of the original 1985 edition began in 1991. The two-fold objective was to improve the usefulness to the reader regarding clarity, conciseness, and technical treatment of the evolving subject matter, as well as harmonization with the ISO "Guide to the Expression of Uncertainty in Measurement." That revision was published as PTC 19.1-1998, "Test Uncertainty," the new title reflecting the appropriate orientation of the document.

The effort to update the 1998 revision began immediately upon completion of that document. The 2005 revision was notable for the following significant departures from the 1998 text:

(a) Nomenclature adopted was more consistent with the ISO Guide. Uncertainties remained conceptualized as "systematic" (estimate of the effects of fixed error not observed in the data), and "random" (estimate of the limits of the error observed from the scatter of the test data). Both types of uncertainty were defined at the standard-deviation level as "standard uncertainties." The determination of an uncertainty at some level of confidence was based on the root-sum-square of the systematic and random standard uncertainties multiplied times the appropriate expansion factor for the desired level of confidence (usually "2" for 95%). This same approach was used in the 1998 revision but the characterization of uncertainties at the standard-uncertainty level ("standard deviation") was not as explicitly stated. The new nomenclature was expected to render PTC 19.1-2005 and subsequent revisions more acceptable at the international level.

(b) There was greater discussion of the determination of systematic uncertainties.

(c) Text was added on a simplified approach to determine the uncertainty of straight-line regression.

The preparation of this 2013 revision began immediately upon publication of PTC 19.1-2005. The main distinguishing characteristics of this revision compared to its immediate predecessor are the following:

- The most significant new feature of this revision is the inclusion of several new examples in Section 10; these were presented in a simplified format.
- The methodology is given, in subsection 8-1, for including the effects of correlated random errors in the uncertainty determination.
- Subsection 8-2 on nonsymmetric systematic uncertainty has been updated to include distributions other than Gaussian.
- A simplified uncertainty analysis for calibrations is presented in subsection 8-7.
- A new Nonmandatory Appendix E is included covering general regression uncertainty. It is much more comprehensive than the treatment of this subject in the earlier versions of this Code.

ASME PTC 19.1-2013 was approved by the PTC Standards Committee on October 15, 2013, and was approved as an American National Standard by the ANSI Board of Standards Review on November 26, 2013.

ASME PTC COMMITTEE
Performance Test Codes

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

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, 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 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 will be rewritten in this format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME Committee or Subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

Attending Committee Meetings. The PTC Standards Committee and PTC Committees regularly hold 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 Committee. Future Committee meeting dates and locations can be found on the Committee Page at go.asme.org/PTCcommittee.

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TEST UNCERTAINTY

Section 1
Introduction

1-1 GENERAL

Most Sections in this revision of ASME PTC 19.1-2005 [1] are rewritten to both add to the available technology for uncertainty analysis and to make it easier for the practicing engineer. Throughout, the intent is to provide a Code that can be utilized easily by engineers and scientists whose interests are the objective assessment of measured-parameter data quality, using test uncertainty analysis.

1-2 UNCERTAINTY CLASSIFICATIONS

This Code utilizes two major classifications for errors and uncertainties. They are "systematic" and "random." Random errors, whose effects are estimated with "Random Standard Uncertainties," cause scatter in test data. Systematic errors, whose effects are estimated with "Systematic Standard Uncertainties," do not. Random and systematic terms illustrate the effects of error sources.

While this Code uses the uncertainty-propagation methodology consistent with the International Organization for Standardization (ISO), Guide to the Expression of Uncertainty in Measurement (GUM) [2], this Code emphasizes the effects of errors rather than the basis of the information utilized in the estimation of their limits. The ISO GUM utilizes a different classifications for uncertainties, "Type A" and "Type B." Type A uncertainties are evaluated with statistical methods while Type B uncertainties are evaluated using other means, such as models or judgment. Types A and B terms identify the pedigree of the error sources.

The uncertainty of a test result is independent of whether the elemental uncertainties are classified as systematic or random, or as Type A or Type B. Regardless of the uncertainty classification used, the calculated uncertainty of the result will be the same. While this Code utilizes systematic and random terms, there may be situations where it is useful to classify elemental uncertainties by effect, source, or both. This dual classification is illustrated in the examples presented in this Code.

1-3 ADVANTAGES OF USING THIS CODE

This Code includes procedures and techniques that are needed for proper uncertainty analysis. These include

(a) proper handling of both systematic and random uncertainty sources

(b) allowance for identification of the pedigree of each uncertainty source

(c) simplified method for estimating the uncertainties from nonsymmetrical error sources

(d) estimating uncertainties resulting from partially or fully correlated errors

(e) computing uncertainties for test measurements including the uncertainties of calibration processes

(f) enhancement of understanding through the inclusion of illustrative simple examples, within the body of the Code

(g) presentation of additional topics of interest for estimating test uncertainty including

(1) sensitivity evaluation

(2) fossilization of calibration uncertainties

(3) handling spatial variation

(4) analyzing redundant means

(5) detailed analysis of regression uncertainty

In addition, Section 10 and several Appendices of this Code include advanced, more comprehensive examples of uncertainty applications.

The inclusion of the above is intended to improve the understanding of engineers engaged in the estimation of their test data quality and of their test measurement uncertainty in a practical setting.

1-4 APPLICATIONS

This Code is intended to serve as a reference to other ASME Instruments and Apparatus Supplements (PTC 19 Series) and to ASME Performance Test Codes and Standards in general. In addition, it is applicable for all known measurement and test-uncertainty analyses.

1-5 DISCLAIMER

The measurand, parameter, and uncertainty levels used throughout this Code are for illustrative purposes only and are not intended to be typical of standard tests. Values and uncertainty levels must be evaluated for the specific test and measurement system used.

Section 2
Object and Scope

2-1 OBJECT

The object of this Code is to define, describe, and illustrate the various terms and methods used to provide meaningful estimates of the uncertainty in test measurements, parameters, and methods, and the effects of those uncertainties on derived test results.

An uncertainty analysis of test measurements, parameters, and methods is useful because it

(a) provides an objective estimate of the quality of test data and results

(b) facilitates communication regarding measurement and test results

(c) fosters an understanding of potential error sources in a measurement system and the effects of those potential error sources on test results

(d) guides the decision-making process for selecting appropriate and cost-effective measurement systems and methods

(e) reduces the risk of making erroneous decisions based on test results

(f) documents uncertainty for assessing compliance with test requirements

(g) substantiates the test uncertainty budget

When an uncertainty analysis is completed, a numerical characterization of the quality of test results is available with an appropriate level of confidence, typically 95%.

2-2 SCOPE

The scope of this Code is to specify procedures for evaluation of uncertainties in test measurements, parameters, and methods, and propagation of those uncertainties into the uncertainty of a test result. Depending on the application, uncertainty sources may be classified either by the presumed effect (systematic or random) on the measurement or test result, or by the process in which they may be quantified or their pedigree (Type A or Type B). The various statistical terms involved are defined in the Nomenclature (subsection 3-1) or Glossary (subsection 3-2).