ASME PTC 19.1-2018

(Revision of ASME PTC 19.1-2013)

Test Uncertainty

Performance Test Codes

AN AMERICAN NATIONAL STANDARD

The American Society of
Mechanical Engineers

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The next edition of this Standard is scheduled for publication in 2023.

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The American Society of Mechanical Engineers
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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 Supplement. 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 Supplement.

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 with 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 with 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 the document PTC 19.1, General Considerations. The PTC 19.1 Committee proceeded to develop a Performance Test Code Instruments and Apparatus Supplement published in 1985 as PTC 19.1-1985, Measurement Uncertainty. This, along with its subsequent editions, was intended to provide a means to standardize nomenclature, symbols, and methodology of measurement uncertainty in ASME Performance Test Codes.

Work on the revision of the original 1985 edition began in 1991 with the two-fold objective of improving its usefulness to the reader through greater clarity, conciseness, and technical treatment of the evolving subject matter and harmonizing with ISO/IEC Guide 98-3, Guide to the Expression of Uncertainty in Measurement (GUM). ASME published PTC 19.1-1998 as 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) ASME PTC 19.1-2005 adopted nomenclature more consistent with ISO/IEC Guide 98-3. 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 by 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 ASME PTC 19.1-2005 and subsequent revisions more acceptable to an international audience.

(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.

For this 2018 revision, the significant changes are the addition of the Monte Carlo method for propagating uncertainties and the use of multiple test results to obtain an estimate of the random uncertainty of the result. A detailed example that illustrates all aspects of uncertainty analysis is included as a separate section in the document. This section shows both the Taylor series method and the Monte Carlo method for propagating uncertainties. This new section replaces the examples section that was included in previous versions of the document.

This Standard is available for public review on a continuing basis. This provides an opportunity for additional public-review input from industry, academia, regulatory agencies, and the public-at-large.

ASME PTC 19.1-2018 was approved by the PTC Standards Committee on March 28, 2018, and was approved as an American National Standard by the ANSI Board of Standards Review on September 20, 2018.

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Performance Test Codes

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

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General. ASME Standards 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 to provide 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.

Requests for interpretation should preferably be submitted through the online Interpretation Submittal Form. The form is accessible at http://go.asme.org/InterpretationRequest. Upon submittal of the form, the Inquirer will receive an automatic e-mail confirming receipt.

If the Inquirer is unable to use the online form, he/she may mail the request to the Secretary of the PTC Standards Committee at the above address. 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 in one or two words.
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. Please provide a condensed and precise question, composed in such a way that a "yes" or "no" reply is acceptable.
Proposed Reply(ies):	Provide a proposed reply(ies) in the form of "Yes" or "No," with explanation as needed. If entering replies to more than one question, please number the questions and replies.
Background Information:	Provide the Committee with any background information that will assist the Committee in understanding the inquiry. 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 the format described above may be rewritten in the appropriate format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

Moreover, ASME does not act as a consultant for specific engineering problems or for the general application or understanding of the Code requirements. If, based on the inquiry information submitted, it is the opinion of the Committee that the Inquirer should seek assistance, the inquiry will be returned with the recommendation that such assistance be obtained.

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 http://go.asme.org/PTCcommittee.

INTRODUCTION

Most sections in this revision of ASME PTC 19.1-2013 [1] have been rewritten to add to the available technology for uncertainty analysis and to make it easier for the practicing engineer to use. The intent is to provide a standard that can be used easily by engineers and scientists with interest in the objective assessment of measured-parameter data quality using test uncertainty analysis.

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Section 1
Object and Scope

1-1 OBJECT

The object of this Standard is to define, describe, and illustrate the 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.

1-1.1 Objectives

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%.

1-2 SCOPE

The scope of this Standard is to specify procedures for

(a) evaluation of uncertainties in test measurements, parameters, and methods

(b) 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).

1-2.1 Uncertainty Propagation Methods

This Standard incorporates two internationally accepted methods of propagating uncertainties in measured parameters to a derived test result.

1-2.1.1 Taylor Series Method (TSM). This method of propagation is consistent with ISO/IEC Guide 98-3 (GUM) [2]. The TSM requires the determination of sensitivity coefficients for each input variable (how the result is affected by variations in the input variables) and standard uncertainties for each error source.

1-2.1.2 The Monte Carlo Method (MCM). This method of propagation is consistent with JCGM 101 [3]. The MCM requires estimation of probability distributions and standard uncertainties (standard deviations) for each error source.

The distribution determined as the output of an MCM analysis allows direct determination of the lower and upper limits of a coverage interval that contains a specified percentage of the distribution. Thus there are no additional assumptions required to arrive at an "expansion factor," as is necessary in the TSM approach, to obtain a confidence interval estimate.

1-2.2 Uncertainty Propagation Classifications

This Standard uses two major classifications for errors and uncertainties: systematic and random. The ISO GUM uses a different classification for uncertainties: Type A and Type B.

1-2.2.1 Systematic. Systematic errors, whose effects are estimated with "systematic standard uncertainties," do not cause scatter in test data.

1-2.2.2 Random. Random errors, whose effects are estimated with "random standard uncertainties," cause scatter in test data.

1-2.2.3 ISO GUM Classification. The ISO GUM uses a different classification: Type A uncertainties are evaluated with statistical methods and Type B uncertainties are evaluated using other means, such as models or judgment. The 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