ASME PTC 19.1-2005

(Revision of ASME PTC 19.1-1998)

Test Uncertainty

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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The 2005 edition of ASME PTC 19.1 will be revised when the Society approves the issuance of the next edition. There will be no Addenda issued to ASME PTC 19.1-2005.

ASME issues written replies to inquiries as code cases and interpretations of technical aspects of this document. Code cases and interpretations are published on the ASME website under the Committee Pages at http://www.asme.org/codes/ as they are issued.

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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 which 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. This 2005 revision is notable for the following significant departures from the 1998 text:

(a) Nomenclature adopted for this revision is more consistent with the ISO Guide. Uncertainties remain 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). The new aspect is that both types of uncertainty are defined at the standard-deviation level as "standard uncertainties." The determination of an uncertainty at some level of confidence is 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 is expected to render PTC 19.1-2005 more acceptable at the international level.

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

(c) There is new text on a simplified approach to determine the uncertainty of straight-line regression.

ASME PTC 19.1-2005 was approved by the PTC Standards Committee on September 13, 2005, and was approved as an American National Standard by the ANSI Board of Standards Review on November 3, 2005.

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Section 1
Introduction

1-1 GENERAL

This Supplement has significant additions and Sections that have been 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 Supplement that can be utilized easily by engineers and scientists whose interest is the objective assessment of data quality, using test uncertainty analysis.

1-2 HARMONIZATION WITH INTERNATIONAL STANDARDS

It is recognized that this Supplement and promulgated international uncertainty standards and/or guides must be in harmony. In rewriting this Supplement, great care was taken to assure continued harmony with the International Organization for Standardization (ISO) *Guide to the Expression of Uncertainty in Measurement* (GUM) [1]. For the practicing engineer, this harmonization means the elimination of such ambiguous terms as bias, precision, bias limit, and precision index. In addition, careful attention was paid to discriminating between errors, the effects of errors, and the estimation of their limits, which is the uncertainty.

The term "bias" is not used in this Supplement. Instead, the combined terms of "systematic error" and "systematic uncertainty" are used. The former describes an error source whose effect is systematic or constant for the duration of a test. The latter describes the limits to which a systematic error may be expected to go with some confidence.

The term "precision" also is not used in this Supplement. Instead the combined terms of "random error" and "random uncertainty" are used. The former describes an error source that causes scatter in test data. The latter describes the limits to which a random error may be expected to reach with some confidence.

Throughout the Supplement, the term "standard" uncertainty has been introduced to improve harmony with international guidelines and standards. In this Supplement, "standard" uncertainties are always equivalent to a single standard deviation of the average.

The most common confidence level used in this Supplement is 95% although methods for employing alternate confidences are also given. The confidence level of 95% is applied to "expanded" uncertainty. This term, too, was included in this Supplement for improved harmony with international guidelines and standards.

While this Supplement is in harmony with the ISO GUM, this Supplement emphasizes the effects of errors rather than the basis of the information utilized in the estimation of their limits. The ISO GUM utilizes two major classifications for errors and uncertainties. They are "Type A" and "Type B." Type A uncertainties have data with which to calculate a standard deviation. Type B uncertainties do not have data to calculate a standard deviation and must be estimated by other means.

This Supplement 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.

Harmonization of this Supplement with the ISO GUM is achieved by encouraging subscripts with each uncertainty estimate to denote the ISO Type, i.e., using subscripts of either "A" or "B."

1-3 APPLICATIONS

This Supplement is intended to serve as a reference to the various 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.

The paramater values and uncertainty levels used throughout the examples are for illustrative purposes only and are not intended to be typical of standard tests.

Section 2
Object and Scope

2-1 OBJECT

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

Analysis of test measurement and result uncertainty is useful because it

(a) facilitates communication regarding measurement and test results;

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

(c) guides the decision-making process for selecting appropriate and cost-effective measurement systems and methodologies;

(d) reduces the risk of making erroneous decisions; and

(e) documents uncertainty for assessing compliance with agreements.

2-2 SCOPE

The scope of this Supplement is to specify procedures for evaluation of uncertainties in test parameters and methods, and for 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 (Type A or Type B). The various statistical terms involved are defined in the Nomenclature (subsection 3-1) or Glossary (subsection 3-2).

The end result of an uncertainty analysis is a numerical estimate of the test uncertainty with an appropriate confidence level.