ASME B1.25-2019

REAFFIRMED 2024

Measurement Uncertainty Factors in the Calibration of Screw Thread Gages

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 24, 2019

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FOREWORD

The increasing demand for regular calibration of equipment used to ensure dimensional conformity in manufacturing has created corresponding growth in the number of calibration facilities to meet it. This in turn has brought more stringent requirements for those doing such work, including a requirement for a statement of measurement uncertainty applicable for each measurement reported.

Publications such as the ASME B1 Technical Report Measurement Uncertainty for 60 deg. Screw Thread Gage Element Measurement were produced to assist in evaluating the impact of uncertainty for gage calibration. Unfortunately, the values shown in ASME B1 were often adopted as generic in nature even though equipment and procedures being used did not match those on which the indicated values were based. This led to wide variations in reported uncertainties and disagreements over measurements. This Standard replaces the B1 Technical Report by providing a generic base that can be used for uncertainty calculations.

While the calculations used to produce uncertainty values are well documented, the elements that have to be considered require knowledge of metrology in keeping with the specialized nature of precision gage calibrations and the standards to which precision gage calibration devices are made. This is particularly critical with respect to the calibration of thread gages. This Standard has been prepared to assist in the calculation of related uncertainty values by noting unique details of the calibration procedures and the various elements that have to be considered.

Following the approvals of the ASME B1 Standards Committee and ASME, approval for this edition was granted by ANSI on March 15, 2019.

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Screw Threads

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The Committee welcomes proposals for revisions to this Standard. 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.

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MEASUREMENT UNCERTAINTY FACTORS IN THE CALIBRATION OF SCREW THREAD GAGES

1 INTRODUCTION

Every measurement contains an element of uncertainty with respect to the values obtained compared to the true value of the measured feature. This Standard has been prepared as a guide to the factors that contribute to uncertainty in the calibration of screw thread gaging devices. The reference section at the end of this Standard provides sources on how to compute uncertainty values.

This Standard is intended to provide the following:

(a) an explanation of measurement uncertainty and the factors that contribute to it

(b) characteristics of the equipment required for thread gage calibration

(c) guidance in the application of measurement uncertainty

(d) methods to resolve measurement disputes

NOTE: The metric values shown in parentheses are not conversions. They represent the closest typical metric values for the inch values shown.

2 SCOPE

(a) This Standard notes technical factors that can explain measurement differences between two parties calibrating the same gage. It is directed to the metrology involved, not acceptance rules or other quality considerations.

(b) While measurement uncertainty applies to the calibration of gages to any standard, this Standard focuses on gages made to ASME standards only. The calibration of gages necessitates a thorough understanding of the standards they were made to because the standards often include required conditions for and corrections to the calibration.

(c) Users of this Standard should be aware that while a number of elements for each gage type are listed, independent calibration laboratories may not include them all in their reports. Agreement should be reached with outside calibration providers as to what elements are included in their various levels of calibration.

3 DEFINITIONS

3.1 General Definitions

measurement uncertainty: the amount that a measurement of size may differ from the true value of that feature. Every measurement contains an element of uncertainty expressed as plus or minus from the reading of a size obtained. Uncertainty values determined by this Standard indicate the true measurement is included within the uncertainty band with 95% confidence. With an expansion of the uncertainty value, the confidence of the true measurement being included could be raised to 99%.

It is important to understand that there is no generic uncertainty for a given process. Two laboratories having identical principal equipment will have different uncertainties due to variations in the factors noted in section 5.

Often several laboratories report the same or similar values for uncertainty due to rounding of the actual values to the nearest convenient value. For example, 12 μin. may be rounded to 15 μin. in a conservative budget.

uncertainty budget: a listing of all of the factors affecting a particular measurement and the mathematical method used to process each one to arrive at a total expanded uncertainty. Each factor is processed to show its common dimensional effect even though it may not be of dimensional origins, such as temperature or measurement force. Also called uncertainty statement.

3.2 Dimensional Calibration Definitions

The following terminology is commonly used in dimensional calibration; however, some terms may refer to thread gages and related devices only:

accuracy: an indication of the performance of an instrument, the dimensional state of a master, or the outcome of a process when compared to specified values. Per JCGM 200:2012, “accuracy” is not a quantity and is not given a numerical quantity value.

comparison: a dimensional measurement process in which the unknown size of a gage is compared to the known size of a master, such as a gage-block build-up. Some instruments, usually referred to as comparators, are designed for this type of short-range measurement only. Other devices with a long measurement range may be set up in a similar manner for improved precision. The performance of all devices used in this manner is limited by the uncertainty in the calibration of the dimensional master(s) used.

cosine error: an error that results when the feature being measured, such as a diameter, is not normal (square) to the axis of measurement. This error may be encountered when plug gages rest on a worktable that cannot be adjusted to offset it. It may also appear in the direct measurement of solid thread ring gages. In both cases, it occurs because either the face or table the gage is