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GUIDELINES FOR ASSESSING THE RELIABILITY OF DIMENSIONAL MEASUREMENT UNCERTAINTY STATEMENTS

AN AMERICAN NATIONAL STANDARD

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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 this edition.

ASME will issue written replies to inquiries concerning interpretation of technical aspects of this Standard.

The American Society of Mechanical Engineers
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FOREWORD

The ISO Guide to the Expression of Uncertainty in Measurement (GUM) is now the internationally-accepted method of expressing measurement uncertainty. The U.S. has adopted the GUM as a national standard. (See ANSI/NCSL Z540-2.) The evaluation of measurement uncertainty has been applied for some time at national measurement institutes but more recently issues such as measurement traceability and laboratory accreditation are resulting in its widespread use in calibration laboratories.

Given the potential impact to business practices, national and international standards committees are working to publish new standards and technical reports that will facilitate the integration of the GUM approach and the consideration of measurement uncertainty. In support of this effort, ASME B89 Committee for Dimensional Metrology has formed Division 7, Measurement Uncertainty.

Measurement uncertainty has important economic consequences for calibration and measurement activities. In calibration reports, the magnitude of the uncertainty is often taken as an indication of the quality of the laboratory, and smaller uncertainty values generally are of higher value and of higher cost. In the sorting of artifacts into classes or grades, uncertainty has an economic impact through the use of decision rules. ASME B89.7.3.1, Guidelines to Decision Rules in Determining Conformance to Specif cations, addresses the role of measurement uncertainty when accepting or rejecting products based on a measurement result and a product specif cation.

With increasing use of measurements from laboratories that are accredited, and subsequent measurement uncertainty statements, signif cant economic interests are at stake, so it is not surprising that metrologists might disagree over the magnitude of the measurement uncertainty statements. While the selection of a decision rule is a business decision, the evaluation of the measurement uncertainty is a technical activity. This report provides guidance for resolving disagreements involving measurement uncertainty statements.

This report was approved by the American National Standards Institute on April 22, 2002.

Comments and suggestions for improvement of this Technical Report are welcomed. They should be addressed to: ASME, Secretary, B89 Committee, Three Park Avenue, New York, NY 10016-5990

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General. ASME Codes and Standards are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Standard may interact with the Committee by requesting interpretations, proposing revisions, and attending Committee meetings. Correspondence should be addressed to:

Secretary, B89 Main Committee
The American Society of Mechanical Engineers
Three Park Avenue
New York, NY 10016

Proposing Revisions. Revisions are made periodically to the Standard to incorporate changes that appear necessary or desirable, as demonstrated by the experience gained from the application of the Standard. Approved revisions will be published periodically.

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.

Interpretations. Upon request, the B89 Committee will render an interpretation of any requirement of the Standard. Interpretations can only be rendered in response to a written request sent to the Secretary of the B89 Main Committee.

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 Standard 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 which 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 B89 Main Committee regularly holds meetings, which are open to the public. Persons wishing to attend any meeting should contact the Secretary of the B89 Main Committee.

GUIDELINES FOR ASSESSING THE RELIABILITY OF DIMENSIONAL MEASUREMENT UNCERTAINTY STATEMENTS

ABSTRACT

The primary purpose of this technical report is to provide guidelines for assessing the reliability of measurement uncertainty statements. Applying these guidelines can assist businesses in avoiding disagreements about measurement uncertainty statements and in resolving such disagreements should they occur. Disagreements over uncertainty statements involving both single measurement systems and multiple measurement systems (each having their own uncertainty statement) are considered. Guidance is provided for examining uncertainty budgets as the primary method of assessing their reliability. Additionally, resolution by direct measurement of the measurand is also discussed.

1 SCOPE

1.1 Objective

This technical report provides guidance in assessing the reliability of a statement of measurement uncertainty in question, that is, in judging whether that stated uncertainty can be trusted to include the values that could reasonably be attributed to the measured quantity (measurand) with which that stated uncertainty is associated.

1.2 Applicability

This report is most applicable to statements of uncertainty in the results of dimensional measurements based upon the ISO Guide to Expression of Uncertainty in Measurement (GUM). (Also called ANSI/NCSL Z540-2.)

1.3 Purpose

This technical report helps parties to avoid potential, or resolve actual, disagreements over the magnitude of a stated measurement uncertainty, particularly when that uncertainty is part of a determination of conformity of a manufactured product to a dimensional specifi cation.

2 DEFINITIONS[1]

acceptance zone: the set of values of a characteristic, for a specifie measurement process and decision rule, that results in product acceptance when a measurement result is within this zone.[2]

decision rule: a documented rule, meeting the requirements of section 3 of ASME B89.7.3.1, that describes how measurement uncertainty will be allocated with regard to accepting or rejecting a product according to its specificatio and the result of a measurement.

expanded uncertainty: quantity definin an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand. See GUM, 2.3.5.

guard band: the magnitude of the offset from the specificatio limit to the acceptance or rejection zone boundary.[3, 4, 5, 6, 7, 8]

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[1] Many of these definition are selected from ASME B89.7.3.1. The figure from that document are omitted here for brevity.

[2] When claiming product acceptance, it is important to state the decision rule; e.g., “acceptance using the XX rule.”

[3] The symbol g is deliberately used for the guard band, instead of the symbol U employed in ISO 14253-1 since U is reserved for the expanded uncertainty which is associated with a measurement result and hence it is confusing to attach U to a specificatio limit. The evaluation of U is a technical issue, while the evaluation of g is a business decision.

[4] The guard band is usually expressed as a percentage of the expanded uncertainty, i.e., a 100% guard band has the magnitude of the expanded uncertainty U.

[5] Two-sided guard banding occurs when a guard band is applied to both the upper and lower specificatio limits. (In some exceptional situations the guard band applied within the specificatio zone, g_{In}, could be different at the upper specificatio limit and at the lower specificatio limit. This would reflec a different risk assessment associated with an upper or lower out-of-specificatio condition depending on whether the characteristic was larger or smaller than allowed by the specificatio zone.) If both the upper and lower guard bands are the same size then this is called symmetric two-sided guard banding.

[6] A guard band is sometimes distinguished as the upper or lower guard band, associated with the upper or lower specificatio limit. Subscripts are sometimes attached to the guard band notation, g, to provide clarity, e.g., g_{Up} and g_{Lo}. See ASME B89.7.3.1, Fig. 1.