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GUIDELINES FOR DECISION RULES: CONSIDERING MEASUREMENT UNCERTAINTY IN DETERMINING CONFORMANCE TO SPECIFICATIONS

AN AMERICAN NATIONAL STANDARD

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FOREWORD

The intent of these guidelines is to facilitate the development of understanding between suppliers and customers regarding measurement uncertainty in the decision to accept or to reject a product. Metrologists are continuously faced with the task of making decisions in the presence of measurement uncertainty. To formalize this task, procedures known as decision rules have been developed. A decision rule is a prescription for the acceptance or rejection of products based on the measurement result of a characteristic of the product, the permissible variation associated with that characteristic, and the uncertainty of the measurement result. For workpieces, the permissible variation is commonly called the tolerance; for instruments it is often given by the specification limits or maximum permissible error (MPE). The terminology of ISO 14253-1 has been adopted and the permitted variation of a product's characteristic is referred to as the specification zone. This document is intended to provide guidance on decision rules and their implementation.

A related document, ASME B89.7.2-1999, Dimensional Measurement Planning, specifies requirements for preparation and approval of dimensional measurement plans and for the use of approved plans in making dimensional measurements. The dimensional measurement plan must contain or reference all information for making measurements, including specification of a decision rule. ASME B89.7.3.1 serves as a resource to the dimensional measurement planner by providing terminology and specifying the requirements for decision rules for use in dimensional measurement plans.

The Guide to the Expression of Uncertainty in Measurement, (GUM), NCSL Z540-2-1997 provides a unified means of evaluating and expressing the uncertainty of a measurement result; consequently the calculational details of evaluating the uncertainty of a measurement result will not be discussed. Unless otherwise stated, the term "measurement uncertainty" will be used to mean the expanded uncertainty, U, with a coverage factor of two, which is the most common coverage factor used nationally and internationally.

Although all traceable measurement results include an uncertainty statement not all measurement results involve decision rules. (See ISO International Vocabulary of Basic and General Terms in Metrology.) Many calibrations, particularly at National Measurement Institutes (NMIs), typically state a description of the measurement, its result, and its uncertainty; decision rules are not involved since there are no specifications. Most products, however, have stated specifications and a decision must be reached regarding the product's characteristic relative to its stated specifications.

The decision rule in use should be well documented to prevent ambiguity in the acceptance or rejection of product. The selection of a particular decision rule is ultimately a business decision; some of the factors to be considered are outlined in nonmandatory Appendices A and D.

The concept of a decision rule has a long history and over the years has developed many variations including "gauge maker's rule," "test accuracy ratio (TAR)," "test uncertainty ratio (TUR)," "four-to-one rule," "gauging ratio," "guard bands," "gauging limit," and many more. Most of these terms were defined before the development of the GUM and hence concepts such as "accuracy" or "uncertainty" were nebulously defined. One of the motivations of these guidelines is to explicitly define the decision rule concept and have some well-documented decision rules that can be referenced. Consequently, these guidelines have encapsulated some of the commonly used procedures and their specifically-named decision rules.

The terminology used in these guidelines is consistent with national and international standards whenever possible. Descriptors such as “stringent” and “relaxed,” used in describing conformance and nonconformance, have been carefully chosen. For example, stringent acceptance is meant to imply both a *decrease* in the acceptance zone width and an *increase* in confidence that a measurement result in this zone is associated with an in-specification product. Similarly, stringent rejection results in a decreased size of the rejection zone while increasing the confidence that a measurement result in this zone is associated with an out-of-specification product. The converse situation applies to relaxed acceptance and rejection.

The decision rules formulated using these guidelines ensure a self-consistent procedure for an organization to accept or to reject products. The situation becomes more complicated when two or more parties are involved, commonly a supplier and a customer, each of which is using a different measurement system with a different uncertainty and possibly using a different decision rule (this topic is very briefly discussed in nonmandatory Appendix A). Such a situation has the potential for conflicting decisions by the different parties, and conflict resolution is outside the scope of this document. When using decision rules in multi-party commerce, it is prudent to anticipate the potential conflicts that can arise (which depend on the details of the decision rules and the measurement systems involved) and agree upon a conflict resolution procedure prior to performing measurements.

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

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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 provide a concise description.
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.

Requests that are not in this format may be rewritten in the appropriate format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

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ABSTRACT

These guidelines provide suggestions for decision rules when considering measurement uncertainty in determining conformance to specifications. Applying these guidelines can assist businesses in avoiding disagreements with customers and suppliers about conformance to specifications and in managing costs associated with conformance decisions.

GUIDELINES FOR DECISION RULES: CONSIDERING MEASUREMENT UNCERTAINTY IN DETERMINING CONFORMANCE TO SPECIFICATIONS

1 SCOPE

These guidelines provide terminology and specify the content that must be addressed when stating a decision rule used for deciding the acceptance or rejection of a product according to specification.

2 DEFINITIONS

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

binary decision rule: a decision rule with only two possible outcomes, either acceptance or rejection.[1]

specification zone (of an instrument or workpiece): the set of values of a characteristic between, and including, the specification limits.[2, 3, 4]

measurand: particular quantity subject to measurement. See VIM, 2.6.[5]

expanded uncertainty: quantity defining 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.

uncertainty interval (of a measurement): the set of values of a characteristic 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.[6, 7]

N:1 decision rule: a situation where the width of the specification zone is at least *N* times larger than the uncertainty interval for the measurement result.[8]

acceptance zone: the set of values of a characteristic, for a specified measurement process and decision rule, that results in product acceptance when a measurement result is within this zone.[9]

rejection zone: the set of values of a characteristic, for a specified measurement process and decision rule, that results in product rejection when a measurement result is within this zone.[10]

transition zone: the set of values of a characteristic, for a specified measurement process and decision rule, that is neither in the acceptance zone nor rejection zone.[11]

[1] A binary decision rule does not have any transition zones (see 2.10).

[2] The width of the specification zone is a positive number.

[3] In the case of workpieces, the width of the specification zone is identical to the tolerance.

[4] Specification zone is equivalent to "tolerance interval" or "tolerance zone" defined in ISO 3534-2.

[5] The specification of a measurand may require statements about such quantities as time, temperature, and pressure.

[6] The width of the uncertainty interval is typically twice the expanded uncertainty.

[7] The uncertainty interval for the mean of repeated measurements may decrease with increasing numbers of measurements.

[8] A common example is the 4:1 ratio.

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

[10] When claiming product rejection, it is important to state the decision rule; e.g., "rejection using the XX rule."

[11] There may be more than one transition zone; each should be separately labeled.