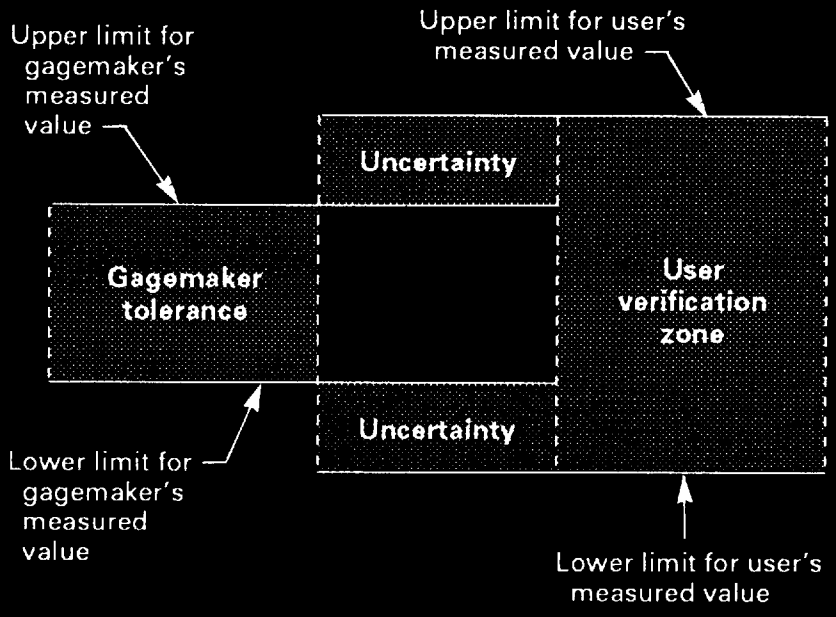
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ASME B1
TECHNICAL REPORT

Measurement Uncertainty for 60 deg. Screw Thread Gage Element Measurement (Inch and Metric)



AN ASME TECHNICAL REPORT

The American Society of Mechanical Engineers

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ASME B1 TECHNICAL REPORT

Measurement Uncertainty for 60 deg. Screw Thread Gage Element Measurement (Inch and Metric)

The American Society of Mechanical Engineers

345 East 47th Street, New York, N.Y. 10017

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FOREWORD

(This Foreword is not part of the B1 Technical Report.)

Every measurement has a degree of uncertainty. This problem surfaces when screw threads had to assemble and be interchangable. Early standards writers provided safeguards by establishing a common basic size where the products limits were not permitted to cross. All forms variations which result in a functional size had to meet this requirement.

As time progressed screw thread writers simplified the concept by placing Class 3 maximum—material pitch diameter of both product and gage for internal and external threads at basic, assuming both gage and product have no form variations. By doing this, it became difficult to manufacture gages with close tolerances to gage marginal product with certainty.

This Report does not solve the screw thread standard's concept. It recognizes that gages shall be made to specified tolerances by the gagemaker, but may be outside the tolerance by a second party's uncertainty.

At the October 1987 meeting of the ASME B1 Committee in New York City, a working group was created to address uncertainty. After several meetings, a scope and tentative measurement uncertainty values were proposed at the April 1989 meeting in Orlando, Florida.

This Report represents the best estimates for measurement uncertainty for gage sizes through 12 inches (300 millimeters). A gage is acceptable when a second party's measurement exceeds the tolerance by the tabulated value.

The uncertainty value may be changed at a future date if statistical data justify such a change.

Suggestions for the improvement of this Report will be welcome. They should be sent to Secretary, ASME B1 Main Committee, 345 East 47th Street, New York, NY 10017.

This Technical Report was approved by the ASME Board on Standardization on October 19, 1992.

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Standardization and Unification of Screw Threads

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ASME B1 TECHNICAL REPORT

MEASUREMENT UNCERTAINTY FOR 60 DEG. SCREW THREAD GAGE ELEMENT MEASUREMENT (INCH AND METRIC)

1 INTRODUCTION

Measurement uncertainty is inherent in all types of measurement. A better understanding and definition of this factor is necessary to promote its acceptance within the screw thread industry. Uncertainty in measurement is documented in many dimensional measurement areas. (See references at the end of this Report.) However, no current standards are available to direct the screw thread industry.

This Report is intended to provide:

(a) an explanation of measurement uncertainty;

(b) a tabulation of uncertainty estimates for the calibration of screw thread gage elements; and

(c) a guide in the resolution of disputes arising from difference in screw thread measurement.

2 SCOPE

This Report provides estimates of uncertainty associated with the measurement of pitch diameter, lead and flank angle only for screw thread gages. It is intended that these estimates will be used as a guide to resolve measurement disputes arising between any two parties calibrating the same gage.

3 DEFINITIONS

The following definitions are based upon ANSI/ASQC M1–1987, Calibration Systems.

3.1 Uncertainty (Measurement)

An estimate of the range of values about the measured value in which the accepted value is believed to lie. A total uncertainty represents the combination of a measure of the random error (e.g., some multiple of the standard deviation) and the estimated bounds to the systematic error. The term is inversely related to the term *accuracy* in that an instrument or measurement with the greater uncertainty is said to have the lesser accuracy and vice versa. If one figure is given as the total uncertainty, this figure is the sum of the limits due to random and systematic errors unless other means of combining such limits are specified.

3.2 Random Error

The limits of variation in measured value of unpredictable sign and magnitude occurring when measurements of the same quantity are made under effectively identical conditions.

3.3 Systematic Error

A contribution to the total uncertainty comprised of the combined effects of all nonrandom sources of uncertainty, known or unknown, which cannot be replicated during the calibration or measurement of a characteristic which tends to offset uniformly or predictably all results of repeated applications of the same measurement process at the time of the measurement. Such an error may be reduced or eliminated by adjustments or application of a correction factor.

3.4 Measured Value

The stated or recorded value after all adjustments and corrections, if any, have been incorporated into the observed value.

3.5 Accuracy

The extent to which the measured value of a quantity agrees with the accepted value for that quantity.

3.6 Precision

The degree of agreement among independent measurements of a quantity under specified conditions.

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TABLE 1 ESTIMATED UNCERTAINTY VALUES FOR SCREW THREAD GAGES (All Dimensions in Inches Except Where Noted)

Nominal Thread Size	0.060 Through 0.190		Above 0.190 Through 1.500		Above 1.500 Through 6.000		Above 6.000 Through 12.000	
	Ext.	Int.	Ext.	Int.	Ext.	Int.	Ext.	Int.
Pitch diameter	±0.00008	[Note (1)]	±0.0001	±0.0002	±0.00015	±0.0003	±0.0002	±0.0003
Lead	±0.00008	[Note (1)]	±0.0001	±0.0002	±0.00015	±0.0002	±0.0002	±0.0002
Flank angle [Note (2)]								
1 through 12 TPI	...	...	±0°3'	±0°5'	±0°3'	±0°5'	±0°3'	±0°5'
13 through 32 TPI	±0°5'	...	±0°5'	±0°7'	±0°5'	±0°7'	±0°5'	±0°7'
33 through 80 TPI	±0°10'	...	±0°10'	±0°15'	±0°10'	±0°15'	...	...

TABLE 2 ESTIMATED UNCERTAINTY VALUES FOR SCREW THREAD GAGES (All Dimensions in Millimeters Except Where Noted)

Nominal Thread Size, mm	1.5 Through 5.00		Above 5.00 Through 38.00		Above 38.00 Through 150.00		Above 150.00 Through 300.00	
	Ext.	Int.	Ext.	Int.	Ext.	Int.	Ext.	Int.
Pitch diameter	±0.0020	[Note (1)]	±0.0025	±0.0051	±0.0038	±0.0076	±0.0051	±0.0076
Lead	±0.0020	[Note (1)]	±0.0025	±0.0051	±0.0038	±0.0051	±0.0051	±0.0051
Flank angle [Note (2)]								
P = 2.2 through 25	...	...	±0°3'	±0°5'	±0°3'	±0°5'	±0°3'	±0°5'
P = 0.8 through 2	±0°5'	...	±0°5'	±0°7'	±0°5'	±0°7'	±0°5'	±0°7'
P = 0.3 through 0.75	±0°10'	...	±0°10'	±0°15'	±0°10'	±0°15'	...	...

GENERAL NOTES TO TABLES 1 AND 2:

(a) External pitch diameter measurements made over thread wires require consideration of the influencing factors of measuring wires and the gage blocks. Uncertainty values for pitch diameter include variation of the best wire size. These wires are normally calibrated to within 0.000020 of an inch (0.00051 mm). The method by which this measurement is made and coupled with the geometrical characteristics of the thread form easily increases the resulting uncertainty to 0.000060 of inch (0.00151 mm). Consideration has also been given to the gage block variations. The variation of the block combination is transferred direct to the measuring device (measuring machine) during initial set up.

(b) Diametrical equivalent for lead measurement uncertainty is obtained by multiplying the uncertainty value by 1.7321. Lead is measured between any two threads over the length of engagement.

(c) To determine diametrical equivalent for flank angle measurement uncertainty, use the formula: $\Delta\, d_2\alpha = 1.5P(\tan \Delta MU\alpha)$ where $\Delta MU\alpha$ is the measurement uncertainty value in Table 1 or 2.

NOTES TO TABLES 1 AND 2:

(1) Measurement uncertainty values are not estimated for internal thread ring gages below 0.190 in. (5 mm) since measurement is not practical.

(2) Flank angle measurements on internal threads are made on casts or with tracing instruments.

4 ESTIMATES OF MEASUREMENT UNCERTAINTY

In any measurement process, one normally compares the characteristics of an artifact or product to the results of a measurement instrument or a device. This comparison inevitably produces errors, and so one cannot determine with complete certainty the exact value of the characteristic even if the measurement instrument's or device's readout value is known exactly (which it is not). Furthermore, most instruments or devices are not perfectly stable; that is, they may change with time and use. For this reason, one of the most important aspects of any measurement process is the specification of the extent to which the value or values determined during the process may be in error, i.e., the development of a valid uncertainty statement.

The errors associated with any measurement process

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MEASUREMENT UNCERTAINTY FOR 60 DEG. SCREW THREAD GAGE ELEMENT MEASUREMENT (INCH AND METRIC)

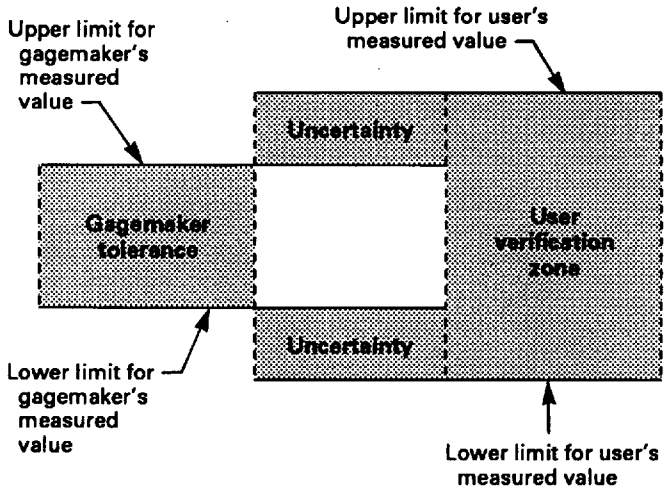


FIG. 1 GAGE ACCEPTANCE USING MEASUREMENT UNCERTAINTY (NEW AND USED GAGES)

fall into one of two categories: *random errors* and *systematic errors*. Random error is related to the precision or degree of reproducibility of a measurement process. Systematic error is simply an unwanted offset or bias, the sign and magnitude of which may be unknown, that is present in the measurement process. The total uncertainty must reflect both kinds of errors, and thus it is obtained from an appropriate combination of the best estimates of these two types of errors.

The measurement uncertainty values presented in Tables 1 and 2 are the best estimates currently available for the variation in the dimensions of thread gages when the gage characteristics are measured. These variations are inherent in the gage measuring techniques and equipment. Measurement uncertainty values for lead and flank angle apply to measurements of variables gage segments or rolls as well as to fixed limit gages. The translation of these variations in gage sizes to the actual product thread evaluated by the respective gages is not addressed by these paragraphs. No attempt has been made to address the impact of gage size variables on product thread evaluations for either attribute gaging or variable gaging. Intuitively, it can be assumed that at each transfer of the measured characteristic (i.e., from setting plug or ring gage to gage contact), additional uncertainty will be accumulated.

The measurement uncertainty values are based on the use of laboratory grade instruments, accepted measurement techniques, and a temperature span of 66°F to 70°F (18.9°C to 21.1°C).

5 APPLICATION

The application of measurement uncertainty is illustrated in Fig. 1. Measurement uncertainty values are provided for pitch diameter, lead and flank angles.

The gage manufacturer shall make the gage within the applicable tabulated GAGEMAKER'S TOLERANCE. However, if the customer measures the gage outside of the gagemaker's tolerance but within the USER'S VERIFICATION ZONE, then the gage shall be accepted.

When disputes arise between two parties and the average measured value is not acceptable, a third party may be used as agreed upon.

Examples:

(a) The two disputing parties agree to make a decision based upon the value determined by a third selected party.

(b) The parties agree to make a decision on the average of the measurements of the disputed parties and a third party.

(c) Each party picks an outside calibration laboratory to measure the item and the two outside laboratories pick a third calibration laboratory. The average of the three independent measurements is used.

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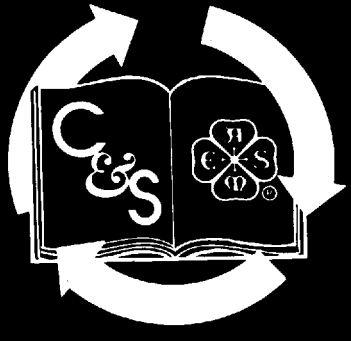
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