Compliance Statements

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Purpose

Often the biggest question when performing any kind of measurement that has a tolerance is simply “is it in spec?”. In some cases it is very clear that the measurement is either inside or outside of tolerance and in other cases, particularly when the measurand is close to the tolerance limit, it is not so clear and cannot be stated with any kind of confidence. Measurements that are close to the tolerance limit can randomly fall on either side of it due to measurement repeatability. Measurement uncertainty widens up the grey area around the measurement tolerance beyond what can easily be seen from measurement repeatability.

This article is about compliance statements and the accepted practice for expressing compliance to a specification. When expressing an opinion of compliance from the performance tests on a coordinate measuring machines following ASME B89.4.10360 or ISO/IEC 10360, it is necessary to do this with a suitable level of confidence particularly if traceability is a requirement.

Requirements for Expressing Compliance to Specifications

As a requirement of ISO/IEC 17025 the compliance statement must have the measurement uncertainty taken into account in order to express an opinion of the results. The statement of compliance must be stated with a specific confidence level.

Traditionally measurements were simply compared to the specification without any consideration of the uncertainty so results were either reported as inside or outside of tolerance. This method is referred to as *simple acceptance* or *shared risk*. This method of expressing compliance to a specification is not allowed by ISO/IEC 17025.

Additional information related to decisions rules can be found in ISO/IEC 14253-1; Decision rules for proving conformity or nonconformity with specifications and *ASME B89.7.3.1;Considering Measurement Uncertainty in Determining Confirmation to Specifications.*

Measurement Uncertainty

The measurement uncertainty is the sum of all recognized contributing error sources back to the definition of the international system of units (SI) primary reference standard and from all additional sources of error introduced by the actual measurement. The measurement uncertainty on a coordinate measuring machine is from a variety of factors including, but not limited to, the following:

- Type and capability of the equipment used.
- Environmental conditions during the measurement (particularly true when measuring anything of length where material expansion is a factor).
- Measurement variability or repeatability. The effect of 'noise' in the measurement.

The measurement uncertainty represents the range of results similar to how a standard deviation represents the range of values from a normally distributed data set. The uncertainty level chosen (indicated as k=1,2, or 3 where K=1 is the standard uncertainty) indicates the necessary range for the desired confidence level. For example, to represent 95% (k=2) of the data a coverage of two standard deviations of the uncertainty is required.

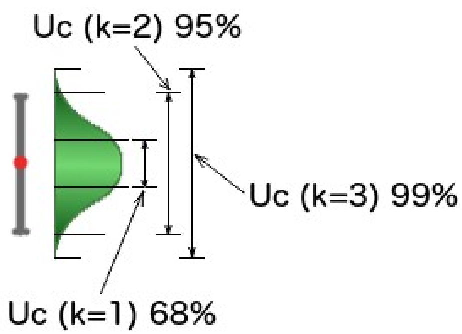

Illustration 1: Distribution of uncertainty around the measured value. Uncertainty 'bar' drawn at 95% confidence (k=2).

The measurement uncertainty that is calculated for each measurand is essential for determining compliance to a specification with any degree of confidence.

Interpretation of Measurement To Specification

In the example shown in illustration 2 four sets of measured values are displayed relative to a nominal and tolerance. Each measurand includes the expanded uncertainty drawn around the value to show the relative range of the expanded uncertainty for each item.

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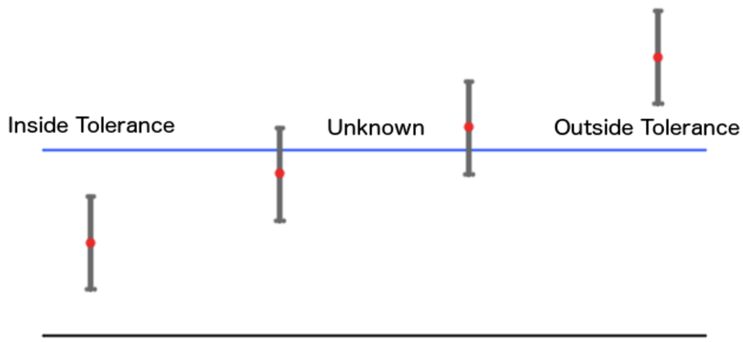

Illustration 2: Examples of measurements shown with the expanded uncertainty for each.

As shown in illustration 2 only the first and last value can be described as being inside or outside of tolerance. The two middle results could be either inside or outside of tolerance but cannot be stated with confidence in either case to the two middle results should only be described as *compliance unknown*.

Compliance Statements For 10360-2 El Results

The compliance statement to a machine specification when performing the ASME B89.4.10360-2 or ISO/IEC 10360-2 performance test is based on all of the data measured for any given test position.

The El measurement positions described in 10360-2 consists of five measurement lengths repeated three times for a total of fifteen unique measured values. Each of the fifteen measured length values are compared to the specification limit that is both reduced and increased by the expanded measurement uncertainty (the uncertainty guard band around the specification).

In order to state the opinion that the measurement is inside tolerance all fifteen results must have a deviation that falls completely within the specification limit reduced by the expanded uncertainty.

If one or more individual measurements exceed the specification by more than the expanded measurement uncertainty then the result is out of tolerance.

For all other cases the compliance statement will report the result as unknown.

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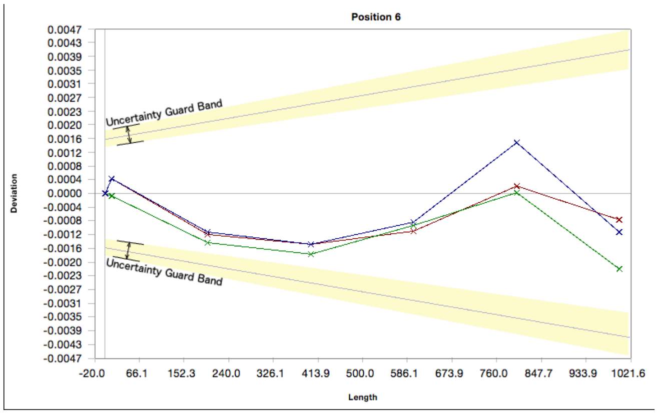
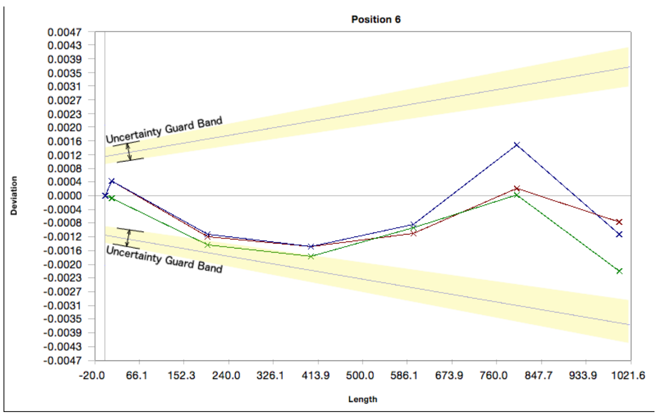
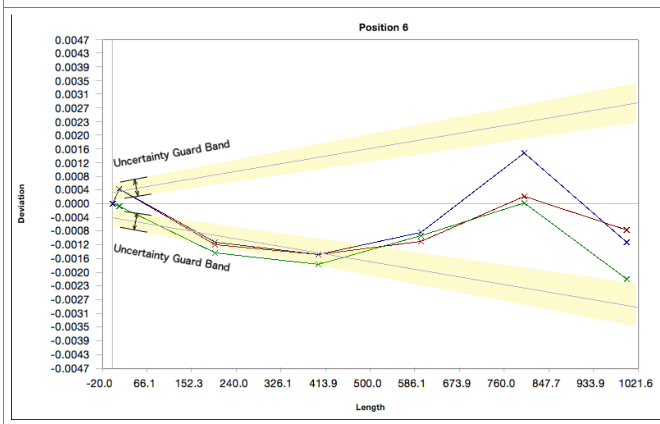
Image	*Comment*
	All measurement lengths are within specification reduced by the expanded uncertainty. Compliance statement would indicate the measurement is within tolerance. This statement would have a confidence level of 95% or higher.
	One or more measurement lengths are greater than the reduced specification. No measurement exceeds the expanded specification. Compliance statement would indicate the measurement is unknown. *The individual lengths are considered and not the average.*
	One or more measurement lengths exceed the specification increased by the expanded uncertainty. Compliance statement would indicate the measurement is outside of tolerance. This statement would have a confidence level of 95% or higher. *The individual lengths are considered and not the average.*

Coordinate Measuring Machine Measurement Uncertainty

For an ISO/IEC 17025 inspection laboratory that uses a coordinate measuring machine the same rules apply as described above.

Calibration certificates contain some of the information necessary to allow the user to determine the strict acceptance specification of a CMM machine. This limit is where all deviations and their expanded uncertainties are fully contained. Additional sources of error based on the use of the equipment should be included to form a complete picture.

As an example using only the calibration data the graph in illustration 3 shows all measurement deviations from the seven E0, and two E150 test measurements relative to the machine specification. Each measurement deviation shown on the graph is increased by the expanded uncertainty. The specification is not sufficient to provide the necessary level of confidence for strict acceptance as the measured values, increased by the expanded uncertainty, is not completely contained inside the specification.

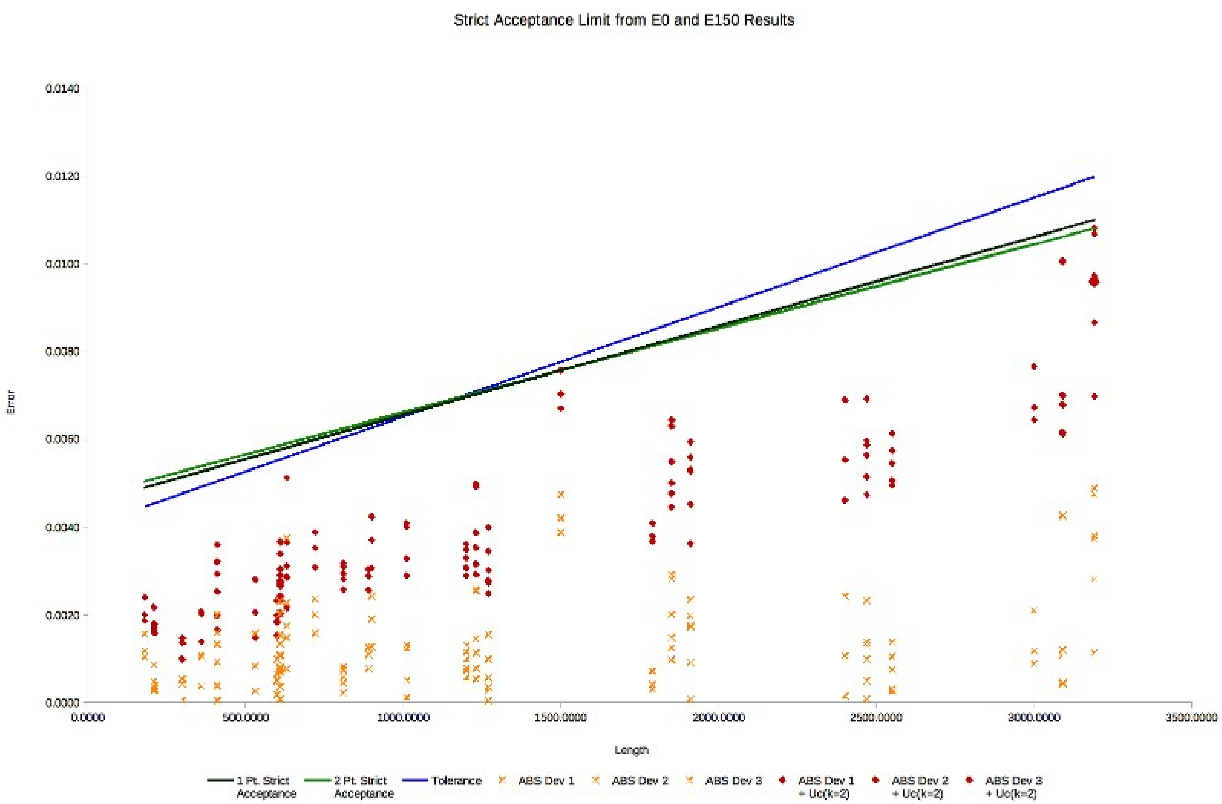


Illustration 3: Example of minimum specification suitable to meet ISO/IEC strict acceptance requirements.

It should be mentioned that the calibration report data, on its own, does not represent the true measurement uncertainty of a coordinate measuring machine as this is specific to the type of measurements performed. A complete uncertainty would include error sources such as probing, articulating head errors, errors from feature approximation, errors related to approximations of requirements from ASME Y14.5, and many other sources. The calibration data is usually just a small part of the entire uncertainty budget.

Reducing Measurement Uncertainty

In cases where the calculated measurement uncertainty is high it may not be possible to report any results as being inside specification with any kind of confidence. In these cases some or all the results will simply show as compliance unknown.

The most common source of a large uncertainty value for a length dependent performance test is the environment of the coordinate measuring machine. For example, a machine environment that is 23 °C (a temperature that is typically outside of specifications for most coordinate measuring machines) the uncertainty will increase by approximately 0.003 mm/m from what it would have been at the ideal temperature of 20 °C. At this temperature the measurement uncertainty can become comparable to the specification of some of the more accurate machines.

The most common and effective way to reduce the measurement uncertainty is to ensure the coordinate measuring machine is in an environment suitable for inspection purposes.

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Revision History

Revision	*Date*	*Reason*
1	Sept 5, 2015	Initial Release
2	Sept 9, 2015	Clarification of ISO/IEC 17025 regarding simple acceptance.
3	Feb 8, 2020	Document review and update.

