

The new ISO 14253-5:2015 and the Measurement Uncertainty associated in verification testing of indicating measuring instruments

Oelof Kruger

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Learning objective

- Introduction to the ISO 14253 series of standards
- Significance of ISO 14253-1
- Newly published ISO 14253-5
- Examples of use of this ISO standard, part 5 in dimensional metrology
- The impact of part 5 in calibration/conformance testing



Drawings of Products

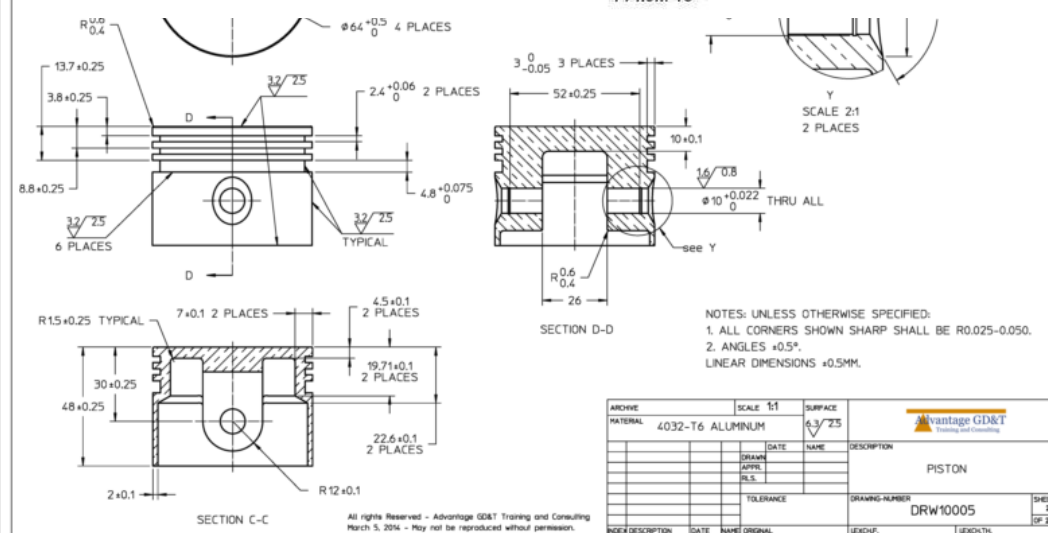
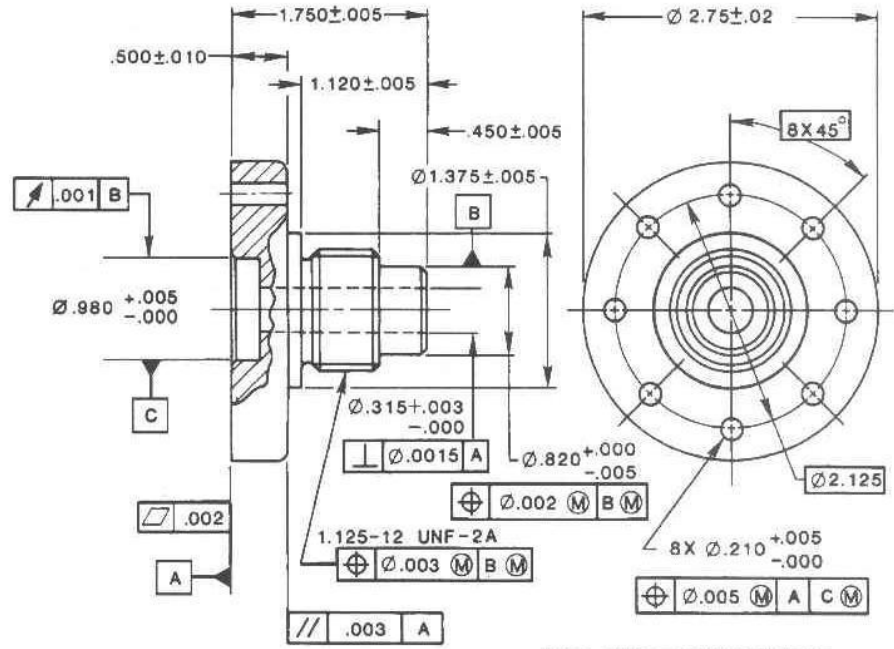
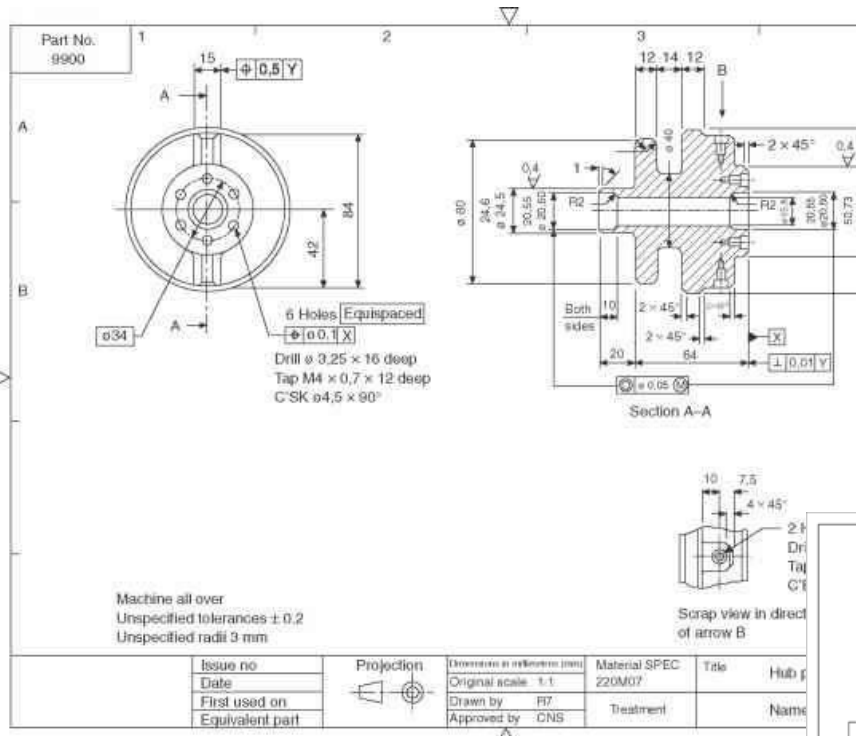


Fig. 31.1



ISO/IEC 17025

ISO/IEC 17025 clause

5.10.4.2:

– *“When statements of conformance are made, the uncertainty of measurement shall be taken into account.”*

This was to make up for the past rule where it was accepted ratio was 10:1 for uncertainty versus instrument to be tested.

Nowadays a ratio of 4:1 is acceptable



ISO 14638 & 14253

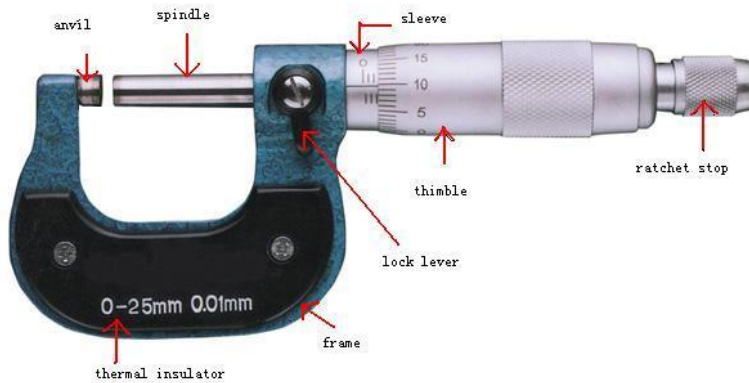
- Geometrical product specification (GPS) -- Masterplan
- Part 1: Decision rules for proving conformity or nonconformity with specifications
- Part 2: Guidance for the estimation of uncertainty in GPS measurement, in calibration of measuring equipment and in product verification
- Part 3: Guidelines for achieving agreements on measurement uncertainty statements
- Part 4: Background on functional limits and specification limits in decision rules
- Part 5: Uncertainty in verification testing of indicating measuring instruments
- Part 6: Generalized decision rules for the acceptance and rejection of instruments and workpieces



Hand measuring equipment Vernier, dial and digital caliper



Hand measuring equipment ISO and BS specifications



Geometrical Product Specifications (GPS) — Inspection by measurement of workpieces and measuring equipment —

Part 1:

Decision rules for proving conformance or non-conformance with specifications

Spécification géométrique des produits (GPS) — Vérification par la mesure des pièces et des équipements de mesure —

Partie 1: Règles de décision pour prouver la conformité ou la non-conformité à la spécification



ISO/IEC 17025

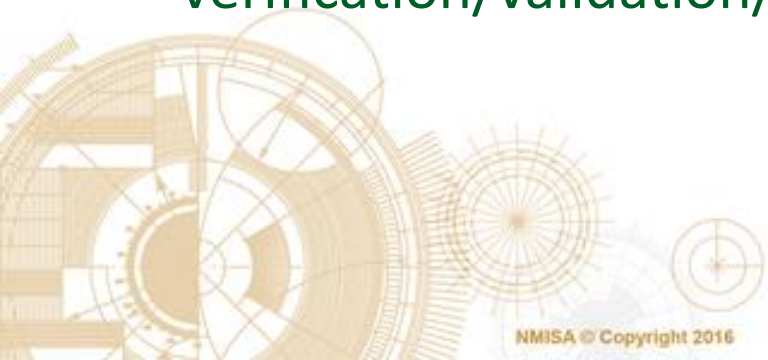
ISO/IEC 17025 accredited calibration labs started not making statements of conformance.

The implementation of the requirement that “...*uncertainty of measurement shall be taken into account*” has had unintended negative results.
(Salsbury)



“Calibration” versus “Adjustment of a measuring system”

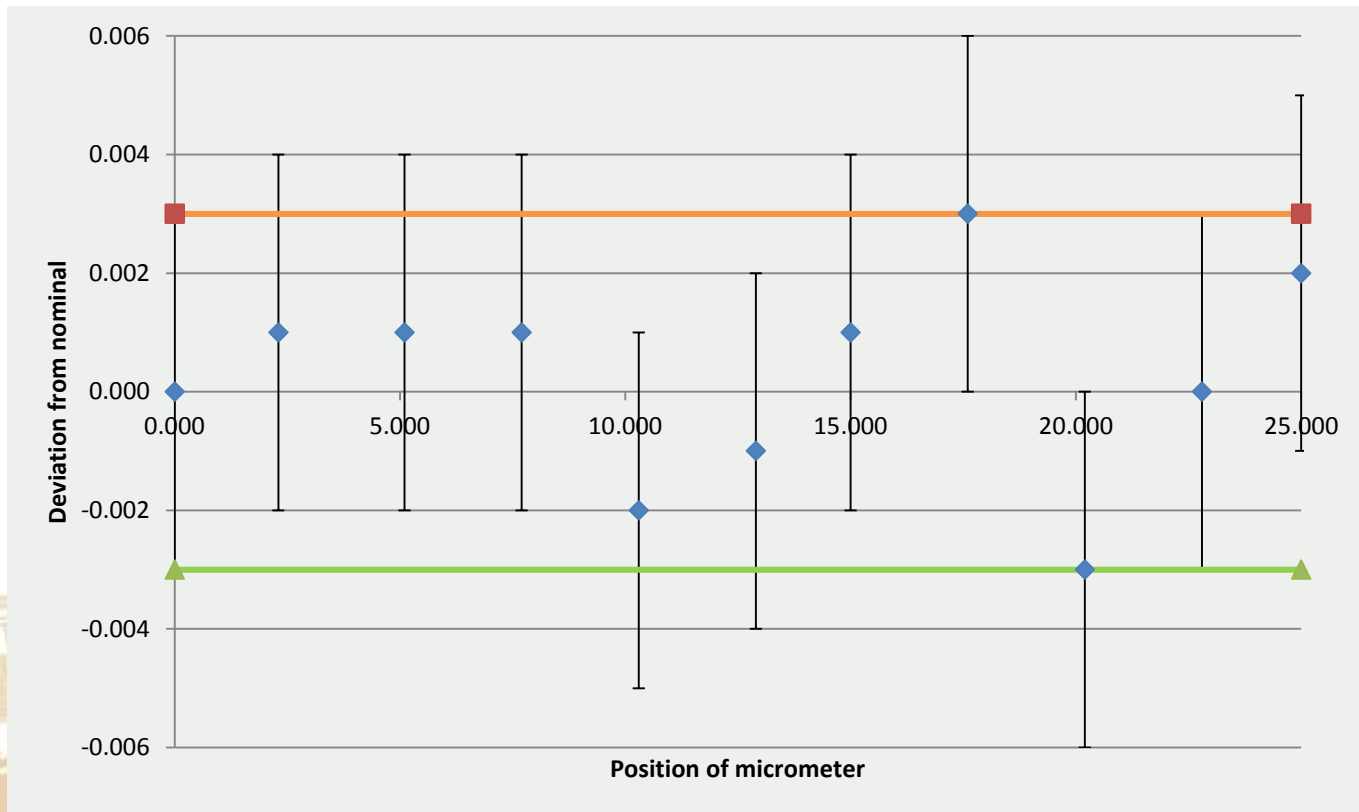
- The concept of calibration when taken over years ago by VIM and ISO17025 and does requires to includes adjustments.
- Inclusion of adjustments is an important contractual issue for calibration services.
- A calibration without adjustment is still a calibration, but it may not be what you want or expect.
- Some industries call this a verification/validation/evaluation. (ISO 10360- CMM)



Micrometer example

Using specifications eg: ISO 3611 and BS 870

These two specifications prescribed the tolerance for external micrometers to be $\pm 4 \mu\text{m}$ and $\pm 3 \mu\text{m}$ respectively.



Micrometer uncertainty budget

Original

Symbol	Description	Uncertainty Estimate (\pm)	Type	Probability Distribution	Divisor	Standard Uncertainty	units	Sensitivity coefficient	units	Uncertainty contributor	Reliability	Degrees of Freedom	Significance
				N,R,T		$u(x_i)$		c_i		$u(y_i)$	%	ν_i	
Std	Std Gauge Block	0.15	B	Normal	2	0.0750	um	1	um	0.0750	100%	infinite	0.35%
	Resolution	0.5	B	Rectangular	1.7321	0.2887	um	1	um	0.2887	100%	infinite	5.24%
	Exp coeff	0.025	B	triangular	2.4495	0.0102	um	1	um	0.0102	100%	infinite	0.01%
Rep	Repeatability	1.2	A	Normal	1	1.2000	um	1	um	1.2000	-	9	90.51%
	Difference in temp	0.431	B	Rectangular	1.7321	0.2488	um	1	um	0.2488	80%	12.5	3.89%
								$u_c(y)$		1.26134168			100.00%
								ν_{eff}		1.E+01			
								Level of Confidence		95.45%			
								Coverage factor		2.283681613			
								U		2.880502802			



TUR (Test uncertainty ratio): Micrometer measuring instruments

- In dimensional metrology, a TUR of around 1:1 is not uncommon, e.g. micrometers and calipers.
- This should create a massive quality problem.
- But why don't we see this quality problem?
 - If the uncertainty is really this bad, we should see a large percentage of hand measuring equipment failing calibration or parts being measured falling, but we don't.
 - Maybe the uncertainty is not being estimated correctly?
 - Maybe we are looking at the wrong measurand?



Micrometer calibration

Define the Measurand:

- Workpiece measurement: errors in the micrometer are sources of measurement uncertainty
- Calibration: testing for errors in the micrometer is the purpose of this measurement.



Micrometer uncertainty budget

Without UUT included

Symbol	Description	Uncertainty Estimate (\pm)	Type	Probability Distribution	Divisor	Standard Uncertainty	units	Sensitivity coefficient	units	Uncertainty contributor	Reliability	Degrees of Freedom	Significance
				N,R,T		$u(x_i)$		c_i		$u(y_i)$	%	ν_i	
Std	Std Gauge Block	0.15	B	Normal	2	0.0750	um	1	um	0.0750	100%	infinite	8.31%
	Resolution	0	B	Rectangular	1.7321	0.0000	um	1	um	0.0000	100%	infinite	0.00%
	Exp coeff	0.025	B	triangular	2.4495	0.0102	um	1	um	0.0102	100%	infinite	0.15%
Rep	Repeatability	0	A	Normal	1	0.0000	um	1	um	0.0000	-	9	0.00%
	Difference in temp	0.431	B	Rectangular	1.7321	0.2488	um	1	um	0.2488	80%	12.5	91.53%
										$u_c(y)$			100.00%
										ν_{eff}			
										Level of Confidence			
										Coverage factor			
										U			



Gauge blocks and gauge block comparator

- Calibration of Comparators according to EAL-G21
- Use 6 pairs of gauge blocks over the full range of the probe

Pair	Nominal Length (mm)	Nominal Length (mm)
	A	B
1	0,5	0,5
2	1,0	1,005
3	1,0	1,01
4	4,0	4,0
5	100,0	100,0
6	6,0	6,0



Gauge block comparator

- Prescribed tolerance limits:

- $\pm 0,015 \mu\text{m}$ (EAL)
- $\pm 0,057 \mu\text{m}$ (UKAS)
- $\pm 0,0025 \mu\text{m}$ (NRC)
- $\pm 0,030 \mu\text{m}$ (NMISA)

- Uncertainty in calibrating of gauge blocks by interferometry which are used to calibrate these comparators is only $\pm 20 \text{ nm}$ ($0,02 \mu\text{m}$)



Line scale- Steel rules

- To take to the extreme;
- What is the resolution of a line scale?
- Uncertainty?



Conclusion

- The new ISO 14253-5 changed the way we use uncertainty statements in proofing conformance.
- This is something we must investigate further with many more examples.
- NLA is planning a few dimensional ILCs and one is for external micrometers. Will investigate how this will change the calculation of uncertainties from the participants.
- Question: When calibrating an instrument; do we calculate uncertainty for when the instrument is used or when calibrated?



Measurement is fabulous. Unless
you're busy measuring what's easy
to measure as opposed to what's
important

— Seth Godin —

