



# NSAI

National Metrology Laboratory



## **Euramet 1057 Tri-Lateral Comparison**

### **Calibration of XXX Pin Gauge by Mechanical Probing**

#### **Final Report**

**September 2011**

## 1. Introduction

The National Metrology Laboratory (NML), Ireland approached NPL (UK) and METAS (CH) with a request to organise a tri-lateral inter-comparison on the external measurement of two XXX pin gauges. The purpose of this inter-comparison was to enable NML to validate its uncertainty budgets and better formulate its CMC's in this area. NML acted as the pilot for this intercomparison. The technical protocol was drafted by agreement between the three participants.

Participants in this inter-comparison agreed to use the same apparatus and methods as routinely applied to client artefacts.

## 2. Organisation

This Tri-Lateral comparison was organised between NML (IE), NPL (UK) and METAS (CH).

### 2.1 Participants

Laboratory	Address	Contact Person
NML	NSAI National Metrology Laboratory Glasnevin Dublin 9 Ireland	Paul Turner +353 1 8082611 +353 1 8082603 paul.turner@nml.ie
METAS	METAS Lindenweg 50 CH-3003 Bern Wabern Switzerland	Dr. Rudolf Thalmann +41 31 32 33 385 +41 31 32 33 210 rudolf.thalmann@metas.ch
NPL	National Physics Laboratory Hampton Road, Teddington Middlesex TW 11 OLW United Kingdom	Dr. Andrew Lewis + 44 20 8943 6074 +44 20 8614 0533 andrew.lewis@npl.co.uk

**Table 1** List of Participants

### 2.2 Time Schedule

Table 2 indicates the proposed time schedule for performing the measurements. The pin gauges were calibrated by the NML prior to delivery to METAS. The pin gauges were re-calibrated on their return from the NPL.



Laboratory	Country	Date
NML	IE	9 <sup>th</sup> June 2008
METAS	CH	Late June – July 2008
NPL	UK	Late Aug – Sept 2008
NML	IE	Oct 2008

**Table 2** Measurement Schedule

### 2.3 Standards

The pin gauges that were used in the intercomparison are listed below in table 3.

Identification	Nominal Diameter (mm)
Serial No. 23857	1.5
Serial No. 23856	5.0

**Table 3** Standards

### 3. Measurement Instructions

Before calibration, the measuring cylinders have to be inspected for damage to the measurement surfaces. Any scratches or other damages have to be documented and further actions agreed between the two participants.

The pin gauges should be in the laboratory environment for an adequate period to allow temperature stabilisation.

The pin gauges should be measured by mechanical probing using a suitable measuring device. Five repeat measurements in different directions are made at three positions (P1, P2 & P3) on each pin gauge. The same approximate position is used for each of the repeat measurements.

Position 1 (P1) is the top of the pin (designated by a black mark), Position 2 (P2) is the midpoint of the pin and Position 3 (P3) is the bottom of the pin. Position 1 and Position 3 are three millimetres from the respective ends of the pin gauge.

The mean measured diameter at the each position is determined for each pin gauge.

All measurements are to be corrected to zero force and 20°C.

#### 4. Measurement methods and instruments used by the participants

The methods and instruments used by the participating laboratories for the measurement of the pin gauges are listed in table 4.

<b>Laboratory</b>	<b>Equipment</b>	<b>Probe</b>	<b>Probe Force</b>
NML	OKM ULM OPAL 600D	2mm Knife Edge Contact Tip	1.5N
NPL	Movotelit Display, Bridge Unit & Transducer	Flat Parallel Tungsten carbide measuring faces: width 0.5mm & 2mm	1.5N
METAS	Movotelit with incremental scale	Knife edge probes from tungsten carbide, probe width 1 mm	0.25N

**Table 4** Participating Laboratories Equipment

#### 5. Measurement Uncertainty

The uncertainty of measurement shall be estimated and reported according to the ISO Guide for the Expression of Uncertainty in Measurement.



## 6. Measurement Results

### 6.1 METAS Results

	Repeat Diameter Measurements					Mean	Uncert. (1 $\sigma$ )
	1	2	3	4	5		
Position	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	$u_c$ ( $\mu\text{m}$ )
<b>P1,</b> h = 3 mm	1.50074	1.50072	1.50078	1.50075	1.50077	<b>1.50075</b>	<b>0.15</b>
<b>P2,</b> h = 25.4 mm	1.50061	1.50065	1.50069	1.50066	1.50066	<b>1.50065</b>	<b>0.15</b>
<b>P3,</b> h = 47.7 mm	1.50107	1.50104	1.50103	1.50104	1.50107	<b>1.50105</b>	<b>0.15</b>

Table 5 METAS 1.5mm Results

	Repeat Diameter Measurements					Mean	Uncert. (1 $\sigma$ )
	1	2	3	4	5		
Position	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	$u_c$ ( $\mu\text{m}$ )
<b>P1,</b> h = 3 mm	5.00062	5.00069	5.00059	5.00075	5.00070	<b>5.00067</b>	<b>0.2</b>
<b>P2,</b> h = 25.5 mm	5.00065	5.00071	5.00073	5.00070	5.00075	<b>5.00071</b>	<b>0.15</b>
<b>P3,</b> h = 48 mm	5.00067	5.00062	5.00066	5.00064	5.00076	<b>5.00067</b>	<b>0.25</b>

Table 6 METAS 5.0mm Results



## 6.2 NPL Results

	Repeat Diameter Measurements					Mean	Uncert. (1 $\sigma$ )
	1	2	3	4	5		
Position	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	$u_c$ ( $\mu\text{m}$ )
P1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
P2	1.50058	1.50056	1.50060	1.50057	1.50055	1.50057	0.045
P3	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 7 NPL 1.5mm Results

	Repeat Diameter Measurements					Mean	Uncert. (1 $\sigma$ )
	1	2	3	4	5		
Position	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	$u_c$ ( $\mu\text{m}$ )
P1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
P2	5.00062	5.00065	5.00068	5.00063	5.00066	5.00065	0.045
P3	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 8 NPL 5.0mm Results

**NSAI**

National Metrology Laboratory

Euramet 1057

Final Report

Page 6 of 9

### 6.3 NML Results

#### 6.3.1 June 2008 Results

Repeat Diameter Measurements							
	1	2	3	4	5	Mean	Uncert. (1 $\sigma$ )
Position	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	$u_c$ ( $\mu\text{m}$ )
P1	N/A	N/A	N/A	N/A	N/A	1.50065	0.076
P2	N/A	N/A	N/A	N/A	N/A	1.50044	0.076
P3	N/A	N/A	N/A	N/A	N/A	1.50088	0.076

Table 9 NML 1.5mm Results

Repeat Diameter Measurements							
	1	2	3	4	5	Mean	Uncert. (1 $\sigma$ )
Position	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	$u_c$ ( $\mu\text{m}$ )
P1	N/A	N/A	N/A	N/A	N/A	5.00067	0.078
P2	N/A	N/A	N/A	N/A	N/A	5.00069	0.078
P3	N/A	N/A	N/A	N/A	N/A	5.00066	0.078

Table 10 NML 5.0mm Results



### 6.3.2 NML October 2008 Results

Position	Repeat Diameter Measurements					Mean (mm)	Uncert. (1 $\sigma$ ) $u_c$ ( $\mu\text{m}$ )
	1	2	3	4	5		
	(mm)	(mm)	(mm)	(mm)	(mm)		
P1	N/A	N/A	N/A	N/A	N/A	1.50066	0.076
P2	N/A	N/A	N/A	N/A	N/A	1.50050	0.076
P3	N/A	N/A	N/A	N/A	N/A	1.50092	0.076

Table 11 NML 1.5mm Results

Position	Repeat Diameter Measurements					Mean (mm)	Uncert. (1 $\sigma$ ) $u_c$ ( $\mu\text{m}$ )
	1	2	3	4	5		
	(mm)	(mm)	(mm)	(mm)	(mm)		
P1	N/A	N/A	N/A	N/A	N/A	5.00069	0.078
P2	N/A	N/A	N/A	N/A	N/A	5.00072	0.078
P3	N/A	N/A	N/A	N/A	N/A	5.00070	0.078

Table 12 NML 5.0mm Results

#### 6.4 En Calculations

Pin Gauge Nominal Size  (mm)	NSAI NML Measured Value		NPL Measured Value		$X_{LAB} - X_{REF}$ (mm)	$U_{LAB} - U_{REF}$ (mm)	Normalised Error  $E_n$
	$X_{REF}$ (mm)	$U_{REF}$ (mm)	$X_{LAB}$ (mm)	$U_{LAB}$ (mm)			
1.5 (Pos 2)	0.0005	0.000152	0.00057	0.00009	0.00007	-0.000062	0.40
5.0 (Pos 2)	0.00072	0.000156	0.00065	0.00009	-0.00007	-0.000066	-0.39

**Table 13** NML Vs NPL for Position 2 Measurement

Pin Gauge Nominal Size  (mm)	NSAI NML Measured Value		METAS Measured Value		$X_{LAB} - X_{REF}$ (mm)	$U_{LAB} - U_{REF}$ (mm)	Normalised Error  $E_n$
	$X_{REF}$ (mm)	$U_{REF}$ (mm)	$X_{LAB}$ (mm)	$U_{LAB}$ (mm)			
1.5 (Pos 1)	0.00066	0.000152	0.00075	0.0003	0.00009	0.000148	0.27
1.5 (Pos 2)	0.0005	0.000152	0.00065	0.0003	0.00015	0.000148	0.45
1.5 (Pos 3)	0.00092	0.000152	0.00105	0.0003	0.00013	0.000148	0.39
5.0 (Pos 1)	0.00069	0.000156	0.00067	0.0004	-0.00002	0.000244	-0.05
5.0 (Pos 2)	0.00072	0.000156	0.00071	0.0003	-0.00001	0.000144	-0.03
5.0 (Pos 3)	0.0007	0.000156	0.00067	0.0005	-0.00003	0.000344	-0.06

**Table 14** NML Vs METAS for Position 1-3 Measurement

Pin Gauge Nominal Size  (mm)	NSAI NML Measured Value		NPL & METAS Weighted Mean Measured Value		$X_{LAB} - X_{REF}$ (mm)	$U_{LAB} - U_{REF}$ (mm)	Normalised Error  $E_n$
	$X_{REF}$ (mm)	$U_{REF}$ (mm)	$X_{LAB}$ (mm)	$U_{LAB}$ (mm)			
1.5 (Pos 2)	0.0005	0.000152	0.00058	0.00009	0.00008	-0.000062	0.45
5.0 (Pos 2)	0.00072	0.000156	0.00065	0.00009	-0.00007	-0.000066	-0.39

**Table 15** NML Vs Weighted Mean of NPL & METAS for Position 2 Measurement

**NSAI**

National Metrology Laboratory

Euramet 1057

Final Report

Page 9 of 9

Pin Gauge Nominal Size  (mm)	METAS Measured Value		NPL Measured Value		$X_{LAB} - X_{REF}$ (mm)	$U_{LAB} - U_{REF}$ (mm)	Normalised Error  $E_n$
	$X_{REF}$ (mm)	$U_{REF}$ (mm)	$X_{LAB}$ (mm)	$U_{LAB}$ (mm)			
1.5 (Pos 2)	0.00065	0.0003	0.00057	0.00009	-0.00008	-0.00021	-0.26
5.0 (Pos 2)	0.00071	0.0003	0.00065	0.00009	-0.00006	-0.00021	-0.19

**Table 16** METAS Vs NPL for Position 2 Measurement

$X_{REF}$  : The error of indication as determined by NML

$U_{REF}$  : The expanded uncertainty of measurement associated with  $X_{REF}$  (expressed with a confidence level of 95%).

$X_{LAB}$  : The error of indication as determined by the participating laboratory.

$U_{LAB}$  : The expanded uncertainty of measurement associated with  $X_{LAB}$  (expressed at the 95% confidence level).

$E_n$  value: The normalised error of the result reported by the participating laboratory, defined as:

$$E_n = \frac{(X_{LAB} - X_{REF})}{(U_{LAB}^2 + U_{REF}^2)^{1/2}}$$

## 7. Discussion

For the purpose of calculating the  $E_n$  values the NML October 2008 results were used.

The NPL pin gauge procedure only calibrates the pin gauge in the central position (position 2). Therefore, NPL did not submit results for position 1 and 3.

## 8. Conclusion

All the normalised error ( $E_n$ ) values for the measurement at each position on the 1.5mm and 5mm pin gauges were found to be less than unity, indicating that the results were satisfactory.