Asia-Pacific Metrology Programme

APMP Key Comparison

APMP.L-K1

Calibration of gauge blocks by interferometry

Final Report - Results

Contents

1. Introduction

The Asia Pacific Metrology Programme's Technical Committee for Length (APMP/TCL), held its second meeting at SIRIM Berhad (Malaysia) in August 1998, where it was decided to carry out a regional key comparison on gauge block measurements to be coordinated by the National Metrology Institute of Japan (NMIJ/AIST) with this laboratory acting as the pilot laboratory. The technical protocol was modelled on the protocol for CCL-K1 which was drawn up by Dr. Rudolf Thalmann (CCL Pilot –Metrology and Accreditation Switzerland (METAS)).

A goal of dimensional metrology key comparisons is to compare routine calibration services offered by NMIs to clients. Uncertainty claims should match those listed in Appendix C of the Mutual Recognition Agreement (MRA) [BIPM, 1999]. To this end, participants in this comparison agree to use the same apparatus and methods as routinely applied to client artefacts.

The participant's replies have been collated into an Excel spreadsheet and are shown in Appendix B in an Excel workbook. These results are identified in the text with a B pre-fix.

2. Organization

2.1 Participants

APMP member laboratories were invited to join the comparison by the pilot laboratory. The final participant list was then circulated within the APMP TCL. The service tested in this comparison is the measurement of central length of gauge blocks covering the range 0.5 mm to 100 mm to a standard uncertainty of less than approximately 50 nm.

2.2 Participants' details

INTERFEROMETRIC MEASUREMENTS		
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Table 1. Participant's details at the start of the comparison

During the comparison some changes were made: Chinese Taipei was unable to participate due to instrument failure. Two gauge blocks were damaged during the international comparison. NMIJ, the pilot laboratory of APMP.L-K1, decided not to use these two gauges in the rest of the circulation.

2.3 Comparison Schedule

The original idea was to have some participants in a first loop and the other participants in a second loop. Some changes had to be made to suit participant's requirements. Table B1 shows the original schedule and the actual schedule of participants. The first change occurred for MSL/IR, the measurement schedule of MSL/IR was postponed after the second loop. The second change was the exchange between SPRING Singapore and NIM. The third change occurred for CMS/ITRI, CMS/ITRI was unable to participate in APMP.L-K1 comparison although the schedule arrangement had been tried.

2.4 Handling and transport

Two gauge blocks were damaged during the international comparison. The damaged gauge blocks are "Steel 8mm" and "Steel 80mm" in nominal length. The damages look so significant. Therefore, NMIJ, the pilot laboratory of APMP.L-K1, decided not to use these two gauges in the rest of the circulation because additional damages for gauge block platens would be caused by using the damaged gauges.

NPLI was unable to measure "Steel 0.5 mm" , "Steel 1.1 mm" and the left side of "Steel 1.01 mm" in nominal length due to some surface damages.
The other standards showed some damage in the form of scratches and low level corrosion, but were still in an acceptable condition for interferometric measurements.

3. Reported results

The Technical Protocol asked the participants to report the followings with the specified form:

A1: The central length measured in two orientations and the uncertainty for the average of these measurements , see Form A1 (Measurement results) .

A2: The observed condition of the measurement surfaces, see Form A2 (Inspection of the measurement surfaces, steel gauge blocks)

A3: The observed condition of the measurement surfaces, see Form A3 (Inspection of the measurement surfaces, ceramic gauge blocks)

A4: A description of the type of interferometer, the light sources, the method of fringe fraction determination, the method used for determination of refractive index of the air, the range of gauge block temperature during measurement and phase correction, see Form A4 (Description of the measurement instrument).

A5: The Uncertainty budget, see Form A5 (Uncertainty of measurement)

4. Analysis of the results

4.1 Discussion

The aim of this analysis is to find a key reference value which can be used to determine the deviations of the results of each laboratory. Two different approaches could be used, that is a simple average value and a weighted mean as a key reference value. However, it seems more appropriate that the weighted mean values are used as key reference values after excluding the measured value which corresponded to an absolute En number larger than one based on one-by-one procedure. Very similar key comparisons have been completed for Gauge blocks (CCL-K1) and for Long Gauge blocks (CCL-K2, APMP.L-K2). The policy of using a weighted mean as a key reference value has been agreed by all the participants of APMP.L-K1 before the Draft B becomes open to the public. On the other hand, the values of MSL are also excluded for key reference values because MSL reported their values without phase corrections. MSL’s values without phase corrections are shown in Figures 1 to 20. The phase correction values of -32 nm for steel gauges and -29 nm for ceramic gauges had been reported properly as shown in Table 24. MSL’s situation is explained in their comments in Table 28. The proper phase correction would improve MSL’s En values.

CCL –K1 chose to use a simple average value taken from the participant results after removing measurements that had not complied with the Technical Protocol. This was justified because all participants used the same method of measurement. CCL-K2 chose to use a weighted mean, where the weighting factor was derived from the uncertainties reported by participants. In this case the gauges were much more sensitive to environmental conditions, such as gauge temperature, and the participant’s uncertainties had a larger range than was the case for gauge blocks.

The statistical background for determining a weighted mean is given below, and is based on the discussion in CCL-K2. This approach requires that the participants have made correct estimates of their uncertainty of measurements, otherwise a too low uncertainty will place undue emphasis on the result of that particular laboratory

4.2 Weighting Factors and the Reference Value

Let the measured deviation from nominal size reported by each participant be $x_{i,}$, where the number of laboratories is given by I. Since the gauge blocks have different lengths, thermal expansion coefficients, material properties *etc*, it is reasonable to expect that the data comes from separate populations (one per gauge block) and so analysis should be on a gauge-by-gauge basis.

Thus, for a particular gauge block:
Each laboratory reports a measured value, x_i, and its associated standard uncertainty $u(x_i)$.
The normalised weight, w_i , for the result x_i is given by:

$$w_i = C \cdot \frac{1}{[u(x_i)]^2} \tag{1}$$

where the normalising factor, C, is given by:

$$C = \frac{1}{\sum_{i=1}^{I} \left(\frac{1}{u(x_i)} \right)^2} \tag{2}$$

Then the weighted mean, $\bar{x}_w$, is given by:

$$\bar{x}_w = \sum_{i=1}^{I} w_i \cdot x_i \tag{3}$$

The simple mean uses a weighting factor of one and is given by:

$$\bar{x}_a = \sum_{i=1}^{I} \frac{x_i}{I} \tag{4}$$

Each participant, including the pilot, should only contribute once to any determination of a reference value. The comparison reference value $\bar{x}_{RV}$ can be set equal to the simple mean ($\bar{x}_a$ - Equation 4) or the weighted mean ($\bar{x}_w$ - Equation 3), and these options are discussed below.

4.3 Uncertainties

If the artefact uncertainty is ignored, the uncertainty of the reference value can be calculated as either the internal $u_{\text{int}}(\bar{x}_{RV})$ or external $u_{ext}(\bar{x}_{RV})$ standard deviation. The internal standard deviation is based on the estimated uncertainties $u(x_i)$ as reported by the participants:

$$u_{\text{int}}(\bar{x}) = \sqrt{\frac{1}{\sum_{i=1}^{I} \left(\frac{1}{u(x_i)} \right)^2}} = \sqrt{C} \tag{5}$$

The external standard deviation is the standard deviation of the spread of the residuals $x_i - \bar{x}_{RV}$, weighted by the uncertainties $u(x_i)$:

$$u_{ext}(\bar{x}) = \sqrt{\frac{1}{(I-1)} \cdot \frac{\sum_{i=1}^{I} w_i (x_i - \bar{x}_{RV})^2}{\sum_{i=1}^{I} w_i}} \tag{6}$$

The residuals have an uncertainty which results from the measured value ($x_i \pm u(x_i)$) and the reference value ($\bar{x}_{RV} \pm u(\bar{x}_{RV})$) . The uncertainty of the reference value is taken to be the internal uncertainty and the uncertainty of the artefact $u_{art}(\bar{x}_{RV})$. The internal uncertainty can be viewed as setting a limit to the knowable accuracy of any artefact length, given the uncertainty of each measurement. The artefact uncertainty sets a limit on the stability of the artefact during the comparison. The Pilot's measurements provide the best information on artefact changes, given that the same instrument and method were used each time. The uncertainty of the artefact is obtained by repeating the method used to determine the reference value, but only using the Pilot's data. The standard deviation of the mean for just the pilot's measurements, J, then gives the uncertainty for the artefact.

$$u_{art}\left(\overline{x}_{pilot}\right) = \sqrt{\cdot \frac{\sum_{j=1}^{J}\left(x_j - \overline{x}_{pilot}\right)^2}{J(J-1)}} \tag{7}$$

The uncertainty for each participant's residual is therefore given by:

$$u\left(x_i - \overline{x}_{RV}\right) = \sqrt{\left[u\left(x_i\right)\right]^2 - \left[u_{\text{int}}\left(\overline{x}_w\right)\right]^2 + \left[u_{art}\left(\overline{x}_{pilot}\right)\right]^2} \tag{8}$$

The internal uncertainty is subtracted from the participant's uncertainty because their result has already pulled the reference value in their direction (it has a negative correlation). This could be avoided by excluding them from the reference value they are compared with, but this approach is not used here.

4.4 Analysis using $\mathbf{E_n}$ *values*

A check for statistical consistency of the results with their associated uncertainties can be made by calculating the E_n value for each laboratory, where E_n is defined as the ratio of the deviation from the weighted mean, divided by the uncertainty of this deviation, taken for a coverage factor of k=2:

$$E_n = \frac{x_i - \overline{x}_{RV}}{2 \cdot u\left(x_i - \overline{x}_{RV}\right)} \tag{9}$$

E_n values should be less than 1, if the participant's result and uncertainty are consistent with the reference value. These values are shown in Table B22 and Fig B19 for steel gauges and Table B23 and Fig B20 for ceramic gauges.

4.5 Birge ratios tests

The statistical consistency of a comparison can also be investigated by the Birge ratio R_B, which compares the observed spread of the results with the spread expected from the individual reported uncertainties.
The application of least squares algorithms and the χ^2-test leads to the Birge ratio:

$$R_B = \frac{u_{ext}\left(\overline{x}_w\right)}{u_{int}\left(\overline{x}_w\right)} \tag{10}$$

The Birge ratio has an expectation value of R_B = 1, when considering standard uncertainties. For a coverage factor of k = 2, the expectation value is increased and the data in a comparison are consistent provided that

$$R_B < \sqrt{1 + \sqrt{8/(I-1)}} \tag{11}$$

where I is the number of laboratories. For the case I = 10, a value of R_B < 1.39 indicates consistency.

Only one measurement from the pilot is used. The pilot's value JP2 of NMIJ is used because this is towards the middle of the comparison.
The Birge ratios are shown in Table B26 and summarised below in Table 2 and Table 3 .
The Birge ratio should be less than 1.4 and this is roughly the case for all gauges.

Gauge Length [mm]	0.5	1.01	1.1	6	7	8	15	80	90	100
Birge ratios	0.74	0.90	1.22	1.39	1.10	---	0.64	---	0.79	0.63

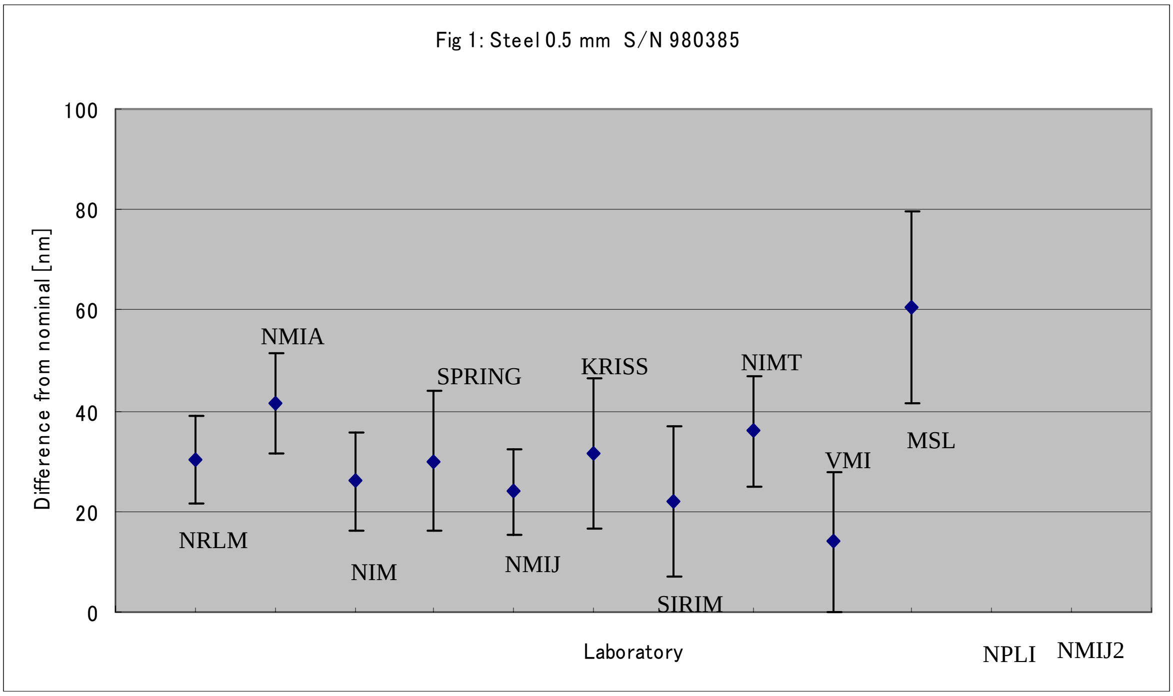
Table 2. Birge ratios for steel gauges.

Gauge Length [mm]	0.5	1	1.01	1.1	6	7	8	80	90	100
Birge ratios	0.93	0.62	0.27	0.49	0.69	0.94	0.88	0.84	0.59	0.72

Table 3. Birge ratios for ceramic gauges.

CRITICAL FIGURES FROM APPENDIX B

Figure 1 to 18: Measurement data from participants.



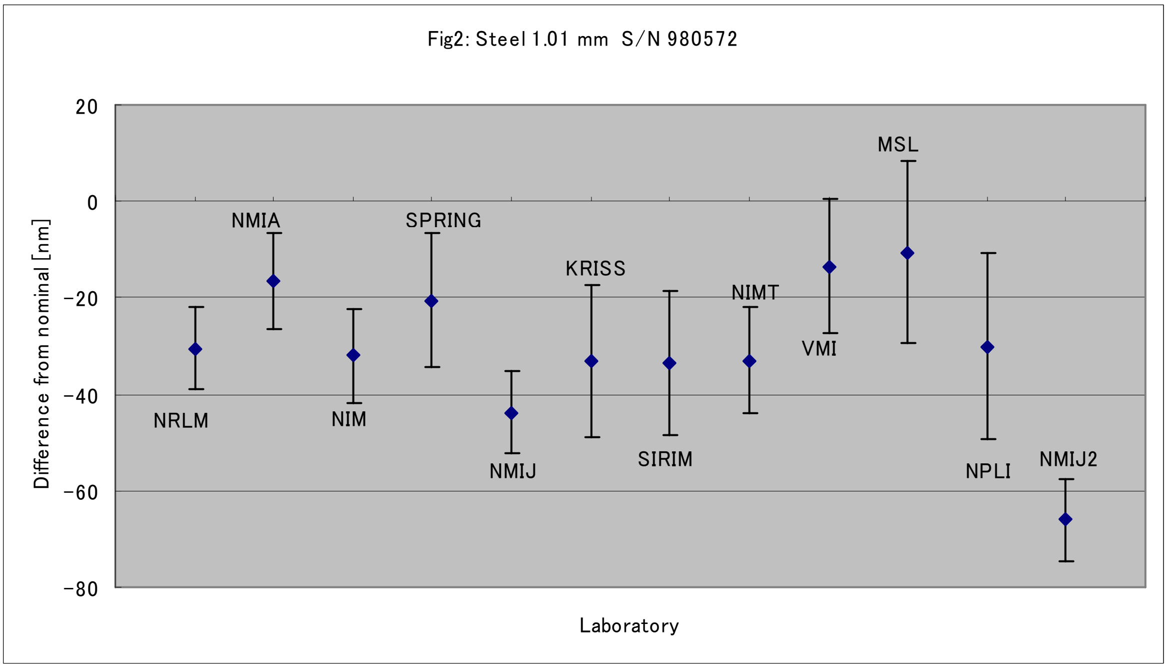


Fig.1, 2

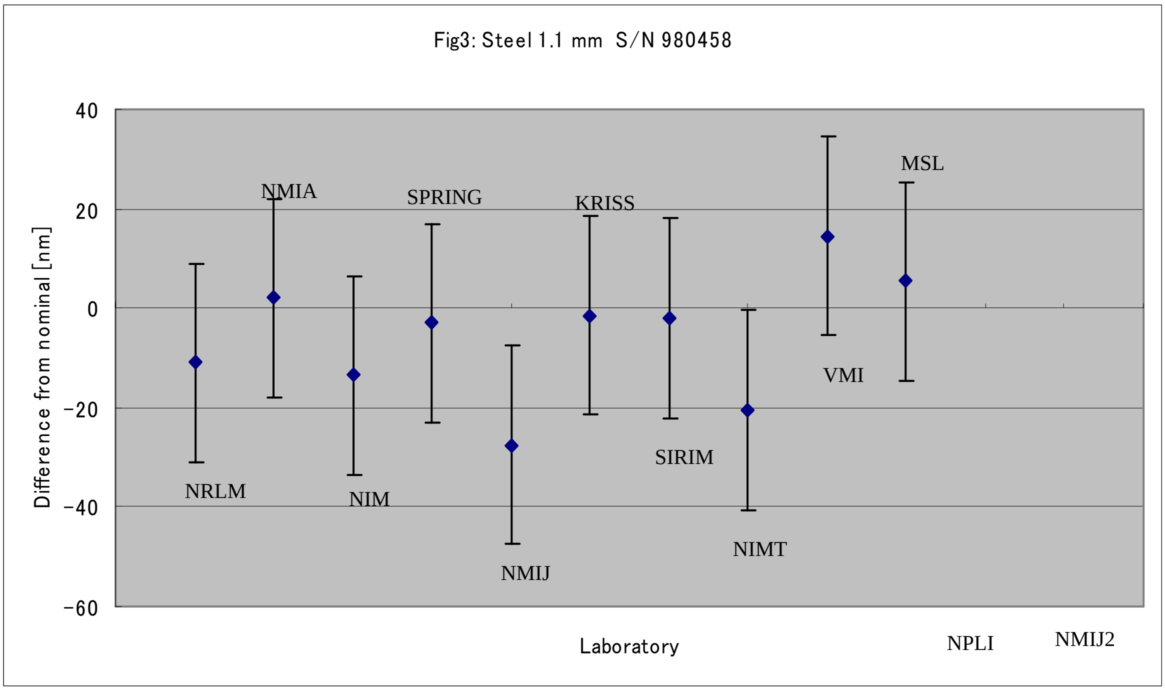


Fig3: Steel 1.1 mm S/N 980458
40
20
0
-20
-40
-60
Difference from nominal [nm]
NRLM
NMIA
NIM
SPRING
NMIJ
KRISS
SIRIM
NIMT
VMI
MSL
NPLI
NMIJ2
Laboratory

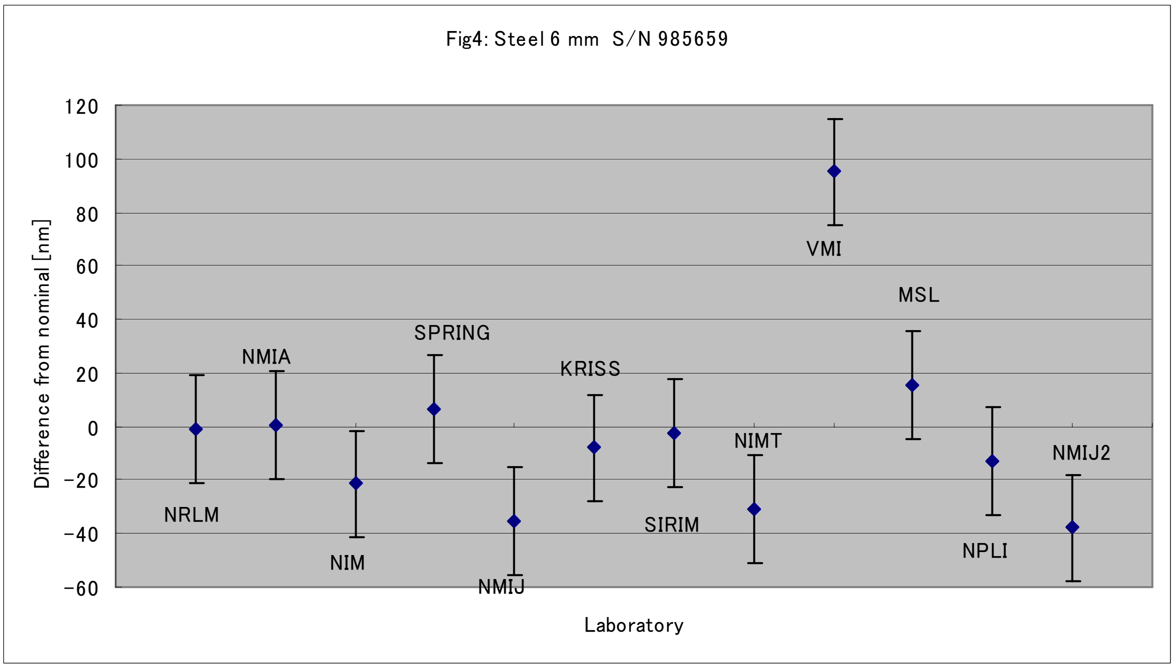


Fig4: Steel 6 mm S/N 985659
120
100
80
60
40
20
0
-20
-40
-60
Difference from nominal [nm]
NRLM
NMIA
NIM
SPRING
NMIJ
KRISS
SIRIM
NIMT
VMI
MSL
NPLI
NMIJ2
Laboratory

Fig.3, 4

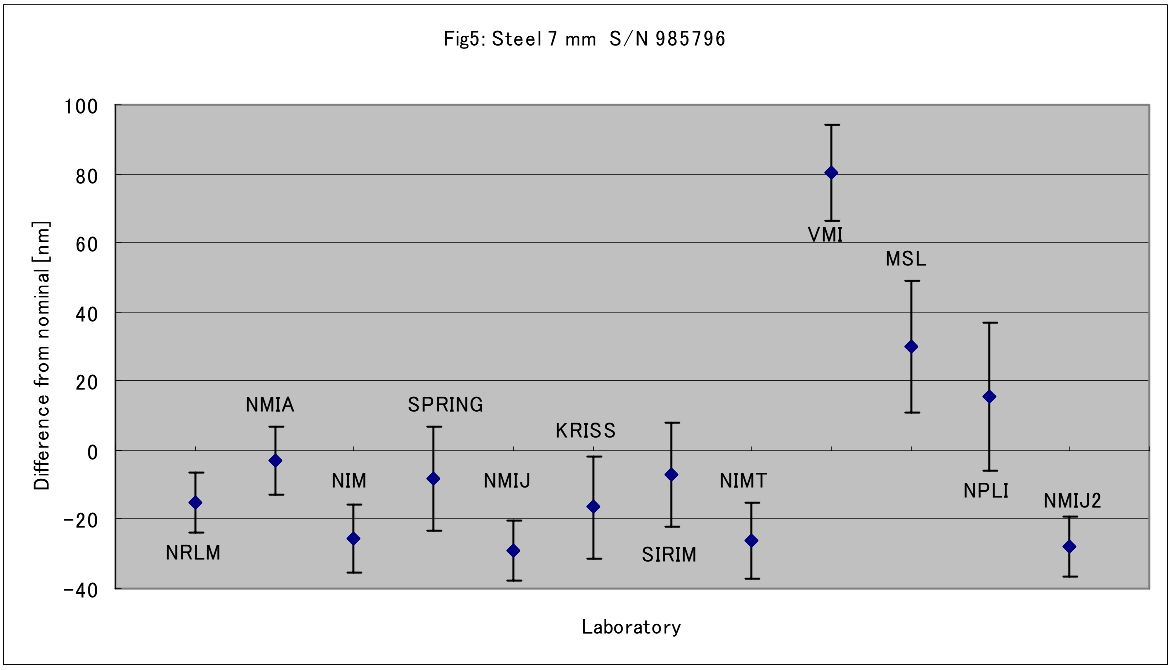


Fig5: Steel 7 mm S/N 985796
Difference from nominal [nm]
100
80
60
40
20
0
-20
-40
NRLM
NMIA
NIM
SPRING
NMIJ
KRISS
SIRIM
NIMT
VMI
MSL
NPLI
NMIJ2
Laboratory

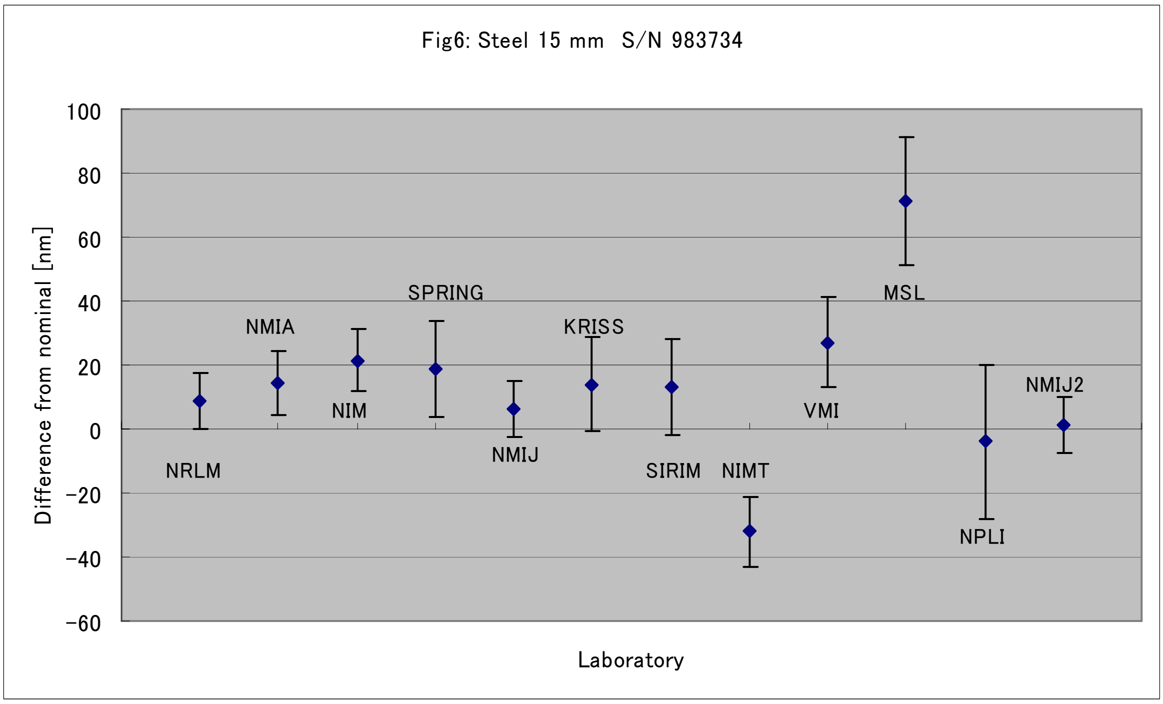


Fig6: Steel 15 mm S/N 983734
Difference from nominal [nm]
100
80
60
40
20
0
-20
-40
-60
NRLM
NMIA
NIM
SPRING
NMIJ
KRISS
SIRIM
NIMT
VMI
MSL
NPLI
NMIJ2
Laboratory

Fig5, 6

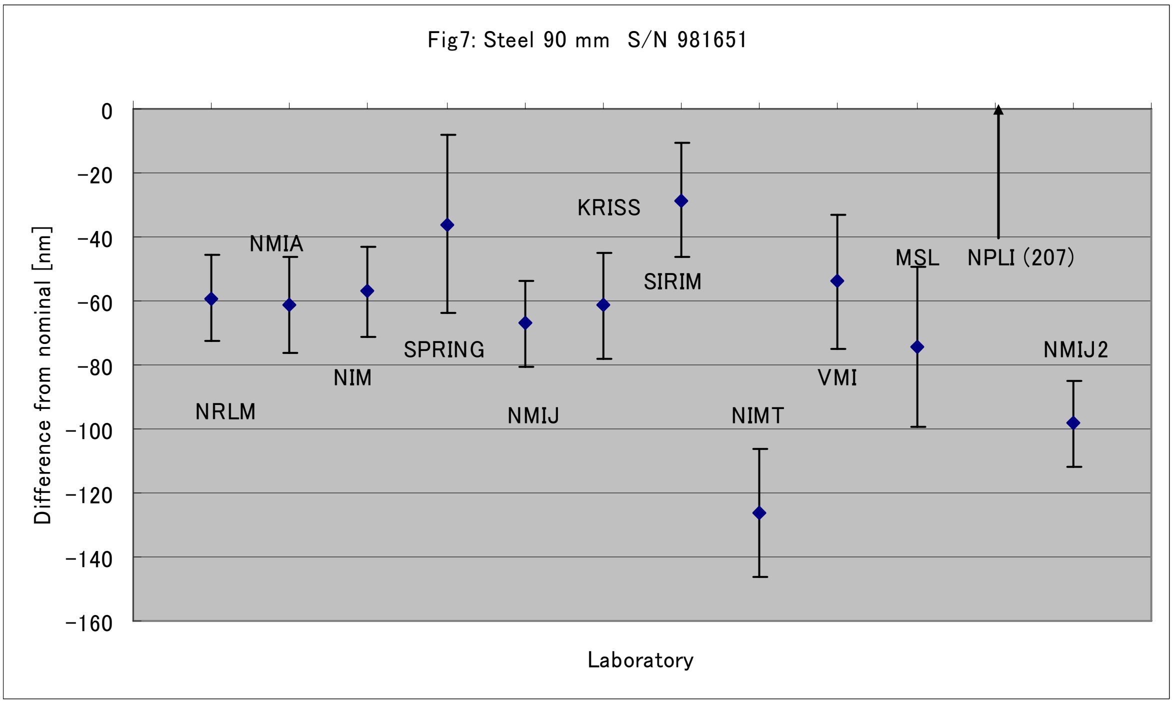


Fig7: Steel 90 mm S/N 981651
Difference from nominal [nm]
0
-20
-40
-60
-80
-100
-120
-140
-160
NRLM
NMIA
NIM
SPRING
NMIJ
KRISS
SIRIM
NIMT
VMI
MSL
NPLI (207)
NMIJ2
Laboratory

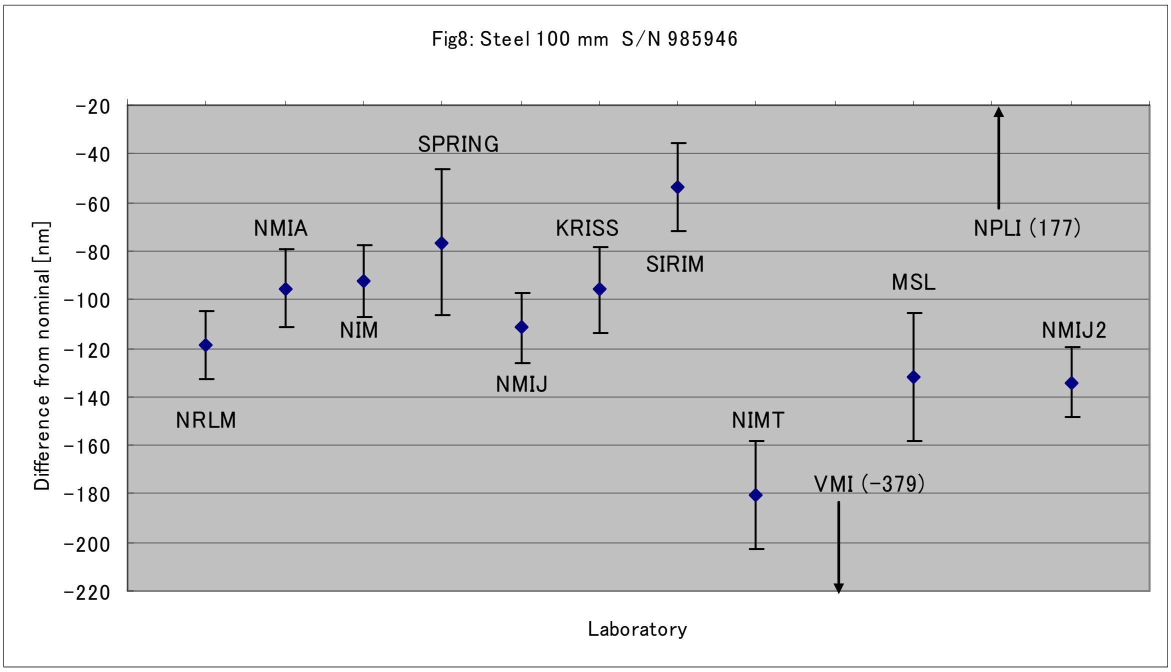


Fig8: Steel 100 mm S/N 985946
Difference from nominal [nm]
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
NRLM
NMIA
NIM
SPRING
NMIJ
KRISS
SIRIM
NIMT
VMI (-379)
MSL
NPLI (177)
NMIJ2
Laboratory

Fig.7, 8

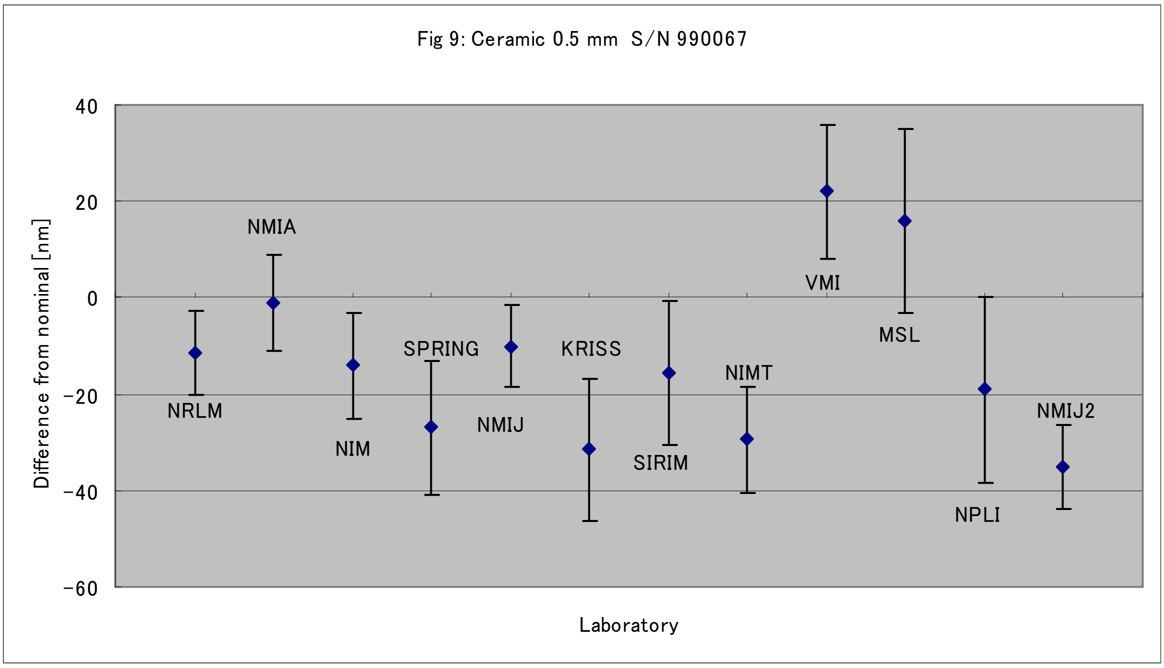


Fig 9: Ceramic 0.5 mm S/N 990067
40
20
0
-20
-40
-60
Difference from nominal [nm]
NRLM
NMIA
NIM
SPRING
NMIJ
KRISS
SIRIM
NIMT
VMI
MSL
NPLI
NMIJ2
Laboratory

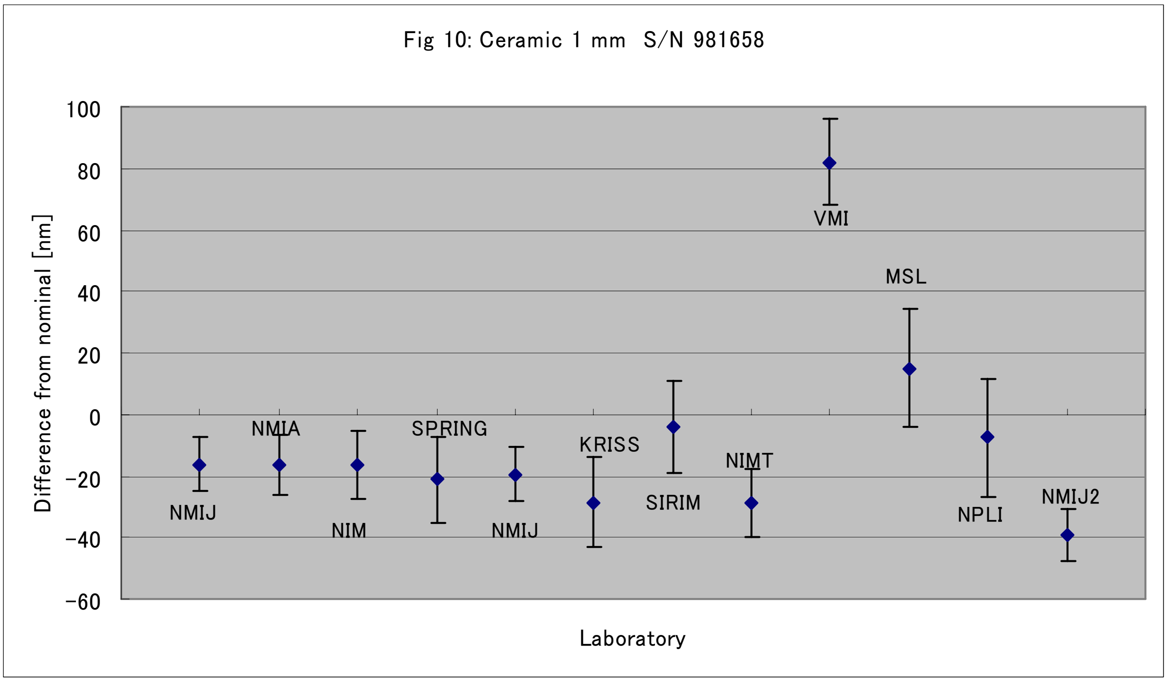


Fig 10: Ceramic 1 mm S/N 981658
100
80
60
40
20
0
-20
-40
-60
Difference from nominal [nm]
NMIJ
NMIA
NIM
SPRING
NMIJ
KRISS
SIRIM
NIMT
VMI
MSL
NPLI
NMIJ2
Laboratory

Fig.9, 10

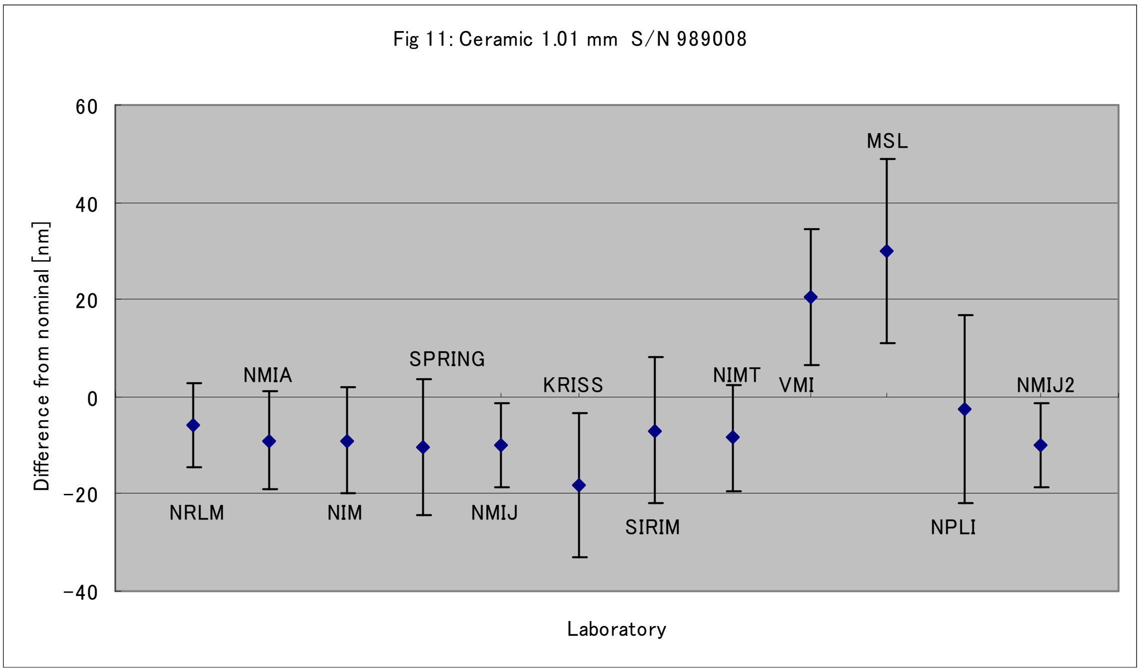


Fig 11: Ceramic 1.01 mm S/N 989008
Difference from nominal [nm]
60
40
20
0
-20
-40
NRLM
NMIA
NIM
SPRING
NMIJ
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SIRIM
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VMI
MSL
NPLI
NMIJ2
Laboratory

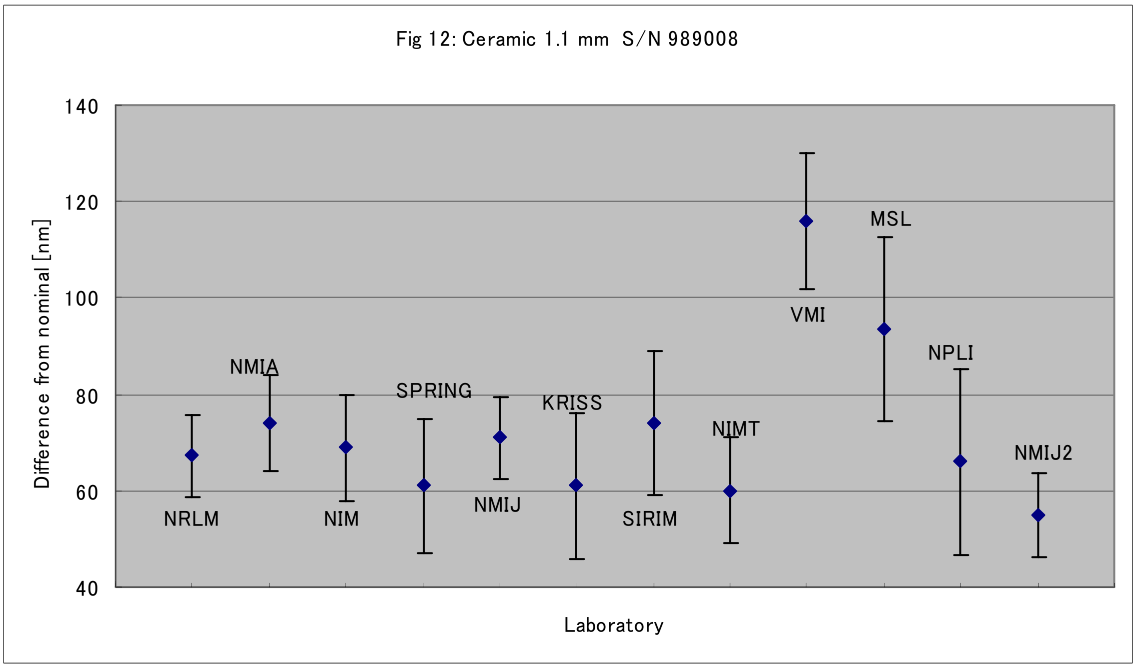


Fig 12: Ceramic 1.1 mm S/N 989008
Difference from nominal [nm]
140
120
100
80
60
40
NRLM
NMIA
NIM
SPRING
NMIJ
KRISS
SIRIM
NIMT
VMI
MSL
NPLI
NMIJ2
Laboratory

Fig.11, 12

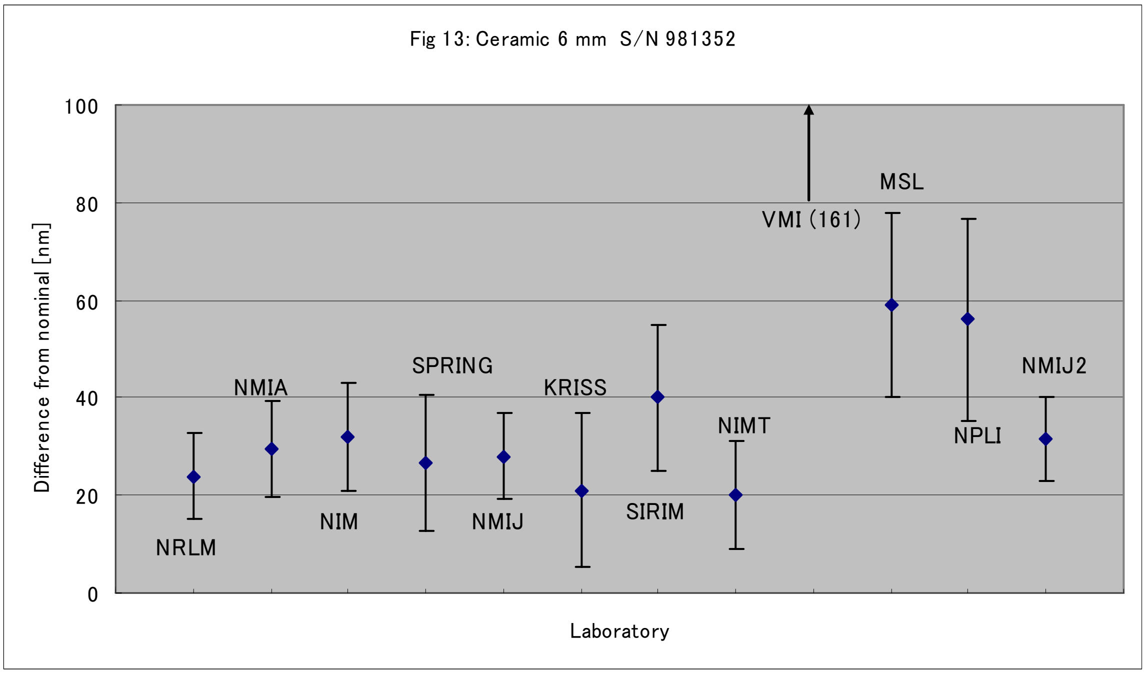


Fig 13: Ceramic 6 mm S/N 981352
Difference from nominal [nm]
100
80
60
40
20
0
Laboratory
NRLM
NMIA
NIM
SPRING
NMIJ
KRISS
SIRIM
NIMT
VMI (161)
MSL
NPLI
NMIJ2

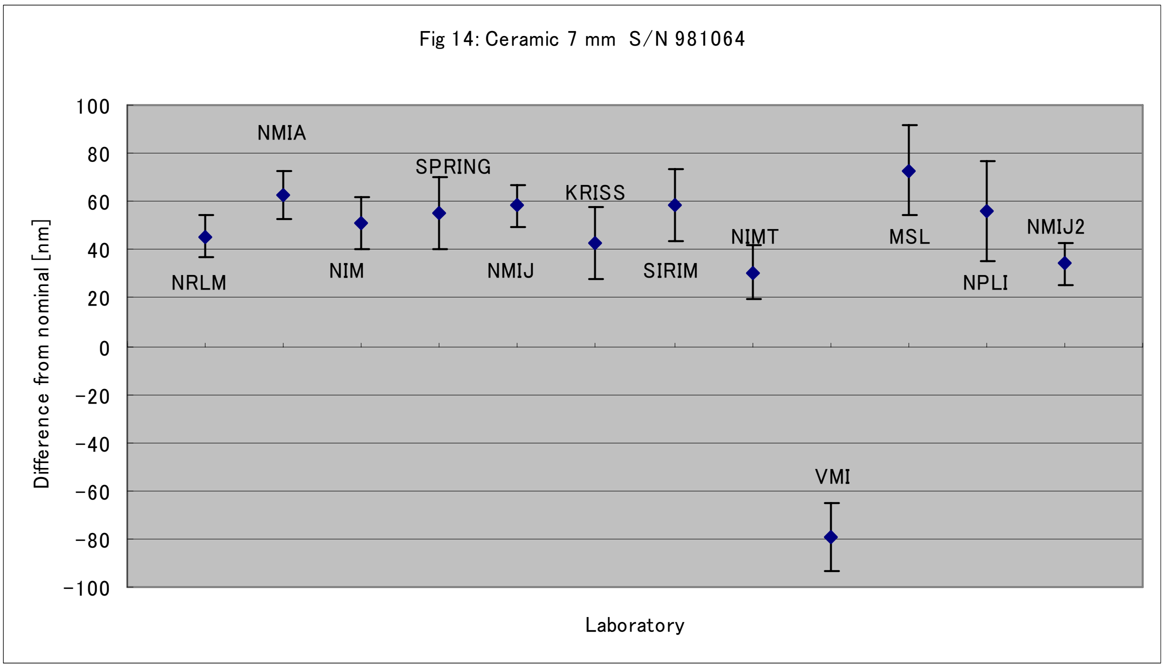


Fig 14: Ceramic 7 mm S/N 981064
Difference from nominal [nm]
100
80
60
40
20
0
-20
-40
-60
-80
-100
Laboratory
NRLM
NMIA
NIM
SPRING
NMIJ
KRISS
SIRIM
NIMT
VMI
MSL
NPLI
NMIJ2

Fig.13, 14

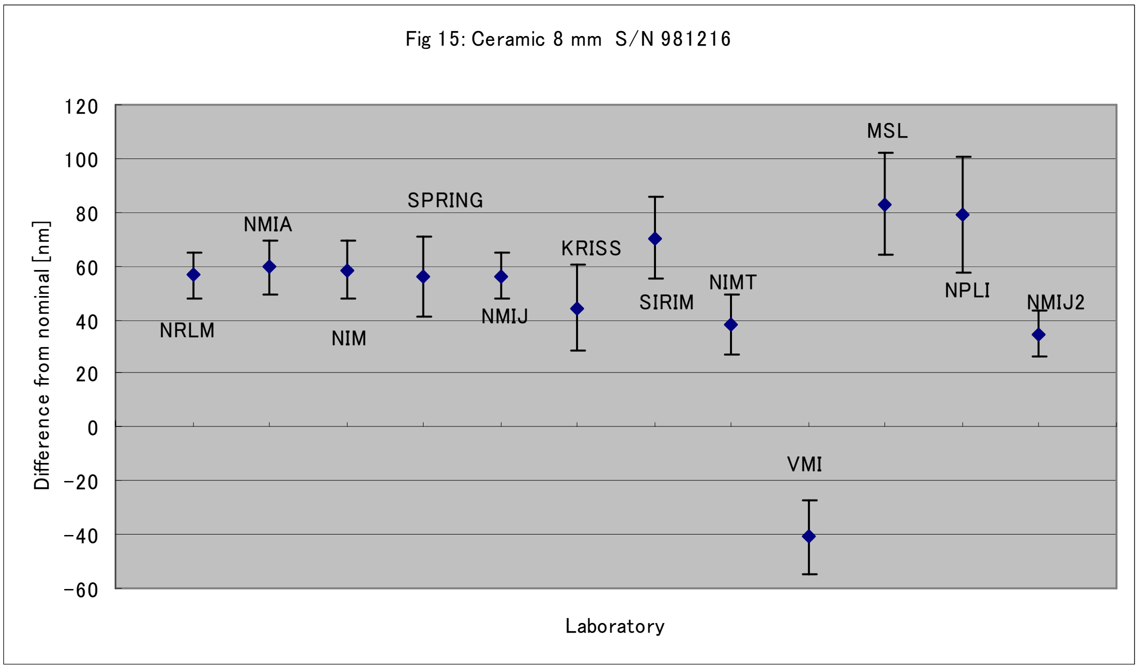


Fig 15: Ceramic 8 mm S/N 981216
Difference from nominal [nm]
120
100
80
60
40
20
0
-20
-40
-60
Laboratory
NRLM
NMIA
NIM
SPRING
NMIJ
KRISS
SIRIM
NIMT
VMI
MSL
NPLI
NMIJ2

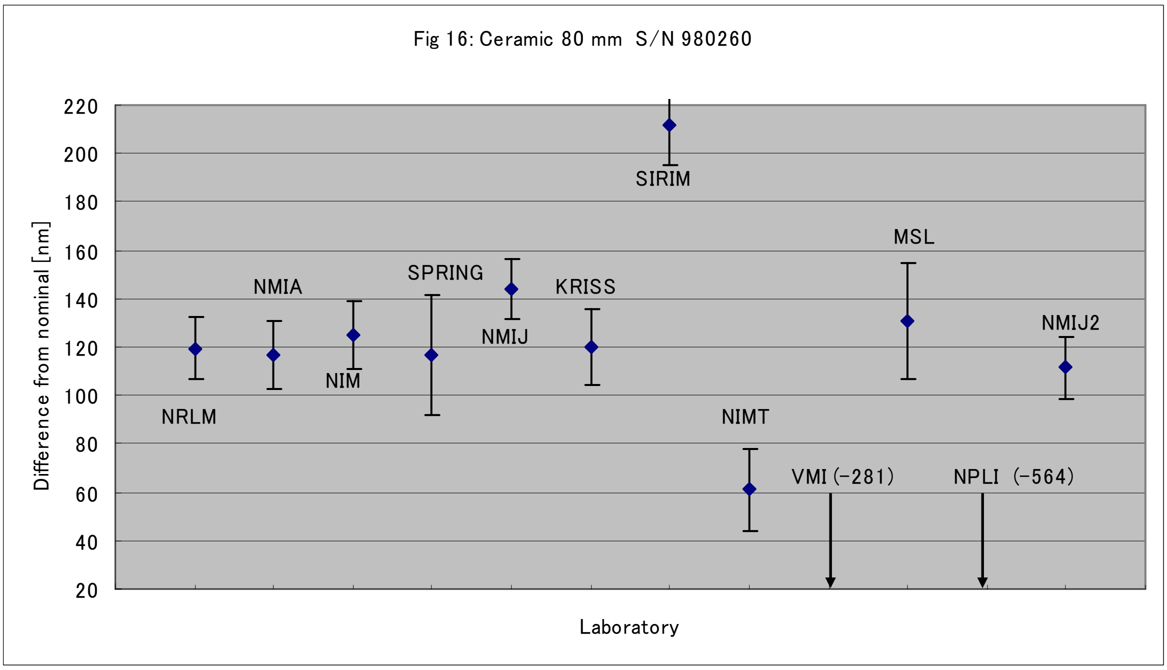


Fig 16: Ceramic 80 mm S/N 980260
Difference from nominal [nm]
220
200
180
160
140
120
100
80
60
40
20
Laboratory
NRLM
NMIA
NIM
SPRING
NMIJ
KRISS
SIRIM
NIMT
VMI (-281)
NPLI (-564)
MSL
NMIJ2

Fig.15, 16

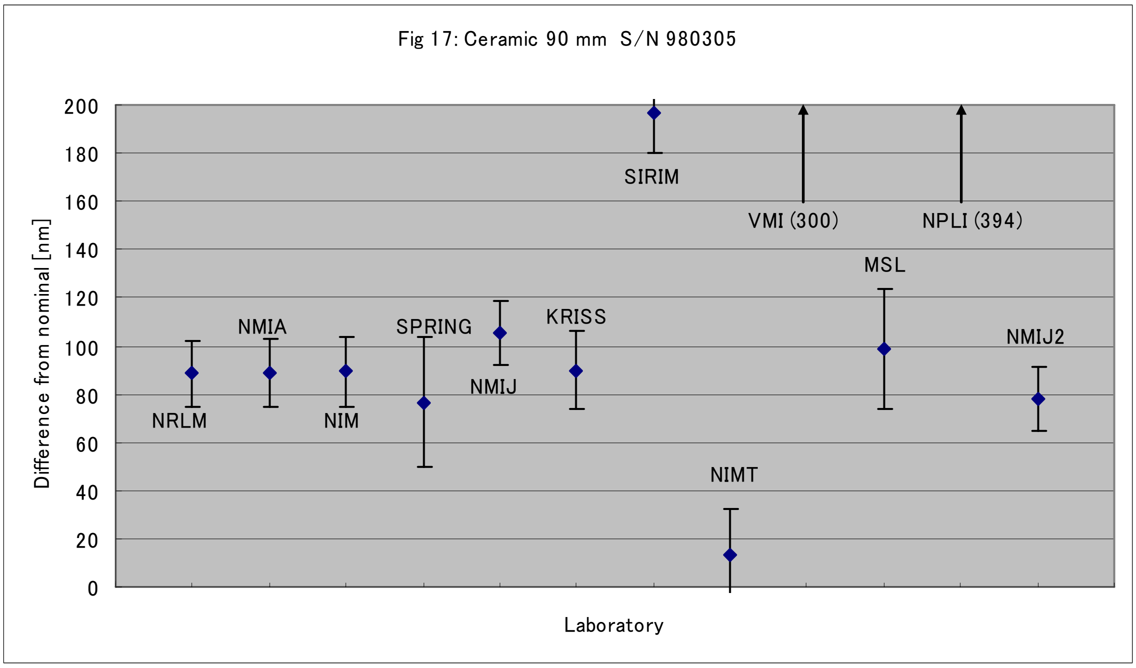


Fig 17: Ceramic 90 mm S/N 980305
Difference from nominal [nm]
200
180
160
140
120
100
80
60
40
20
0
SIRIM
VMI (300)
NPLI (394)
MSL
NMIA
SPRING
KRISS
NMIJ2
NMIJ
NRLM
NIM
NIMT
Laboratory

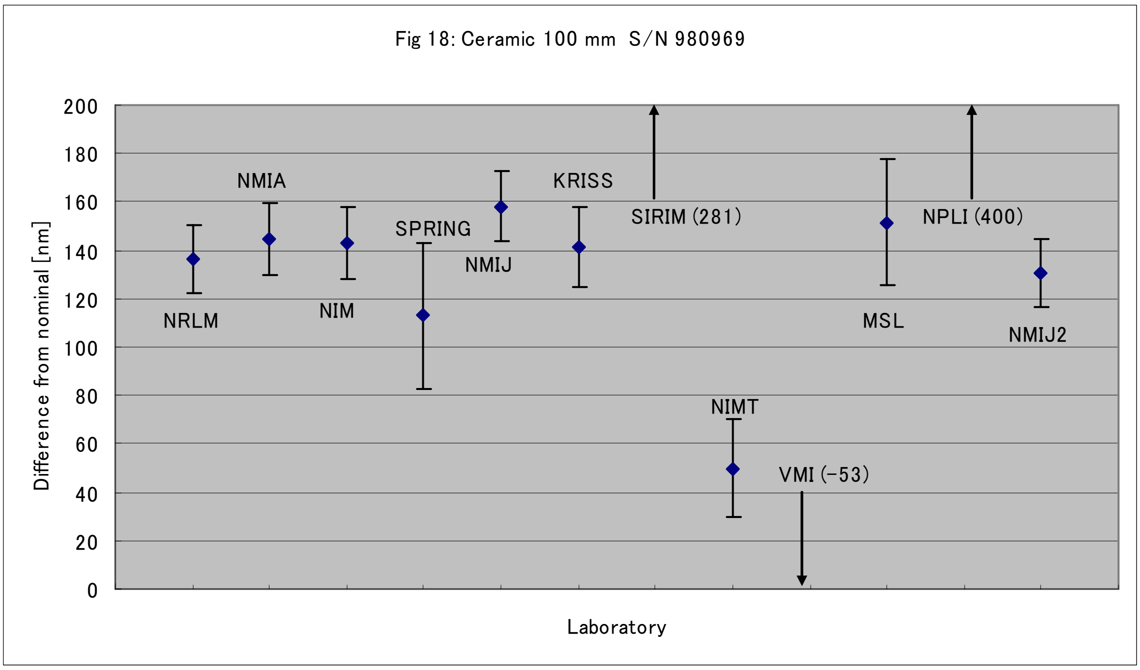


Fig 18: Ceramic 100 mm S/N 980969
Difference from nominal [nm]
200
180
160
140
120
100
80
60
40
20
0
NMIA
KRISS
SIRIM (281)
NPLI (400)
SPRING
NMIJ
NRLM
NIM
MSL
NMIJ2
NIMT
VMI (-53)
Laboratory

Fig.17, 18

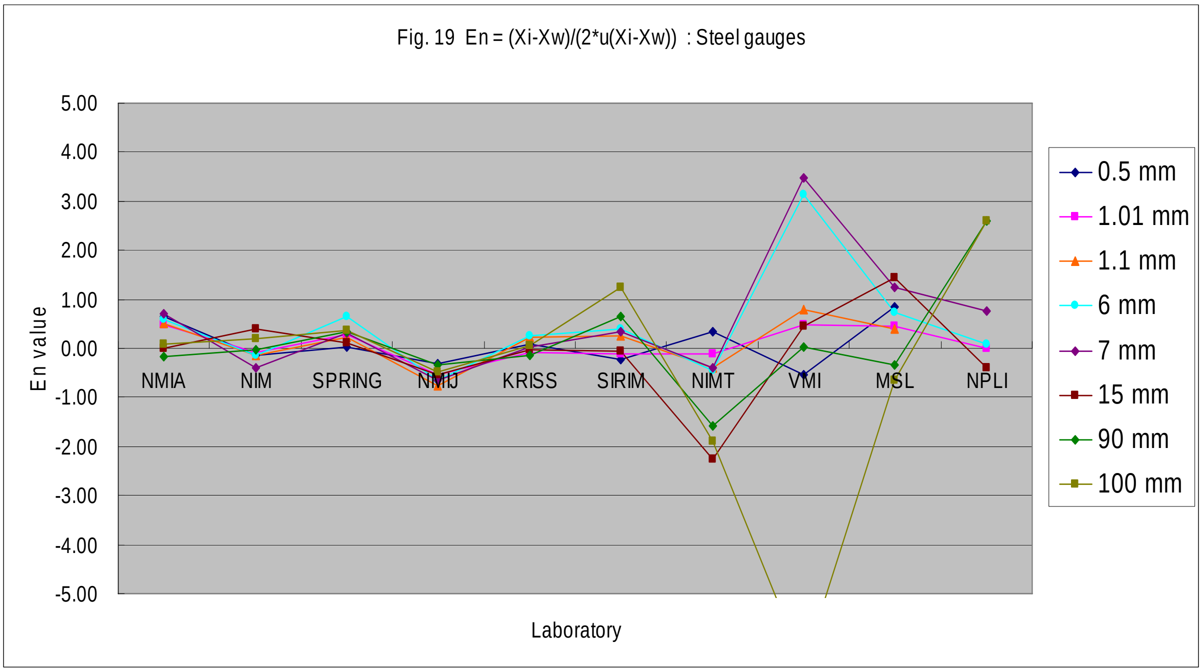


Figure 19: En values for the steel gauges

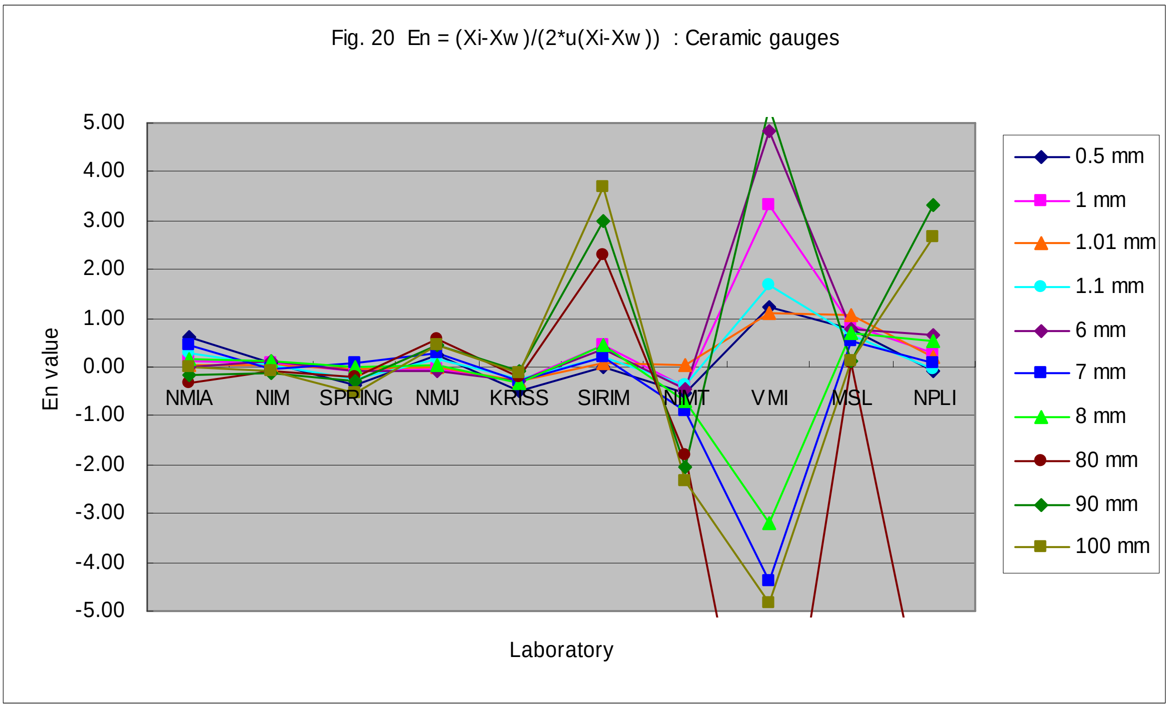


Figure 20: En values for the ceramic gauges)

Appendix A Reporting Forms

A1

Measurement results:

Steel gauge blocks:

Id. no.	nom. length	central length (**deviation** from nominal length)			uncert. (1s)	eff. deg. of freedom
	L (mm)	Δl_{left} (µm)	Δl_{right} (µm)	Δl (µm)	u_c (nm)	n_{eff}
980385	0.5					
980572	1.01					
980458	1.1					
985659	6					
985796	7					
985006	8					
983734	15					
980801	80					
981651	90					
985946	100					

Ceramic gauge blocks:

Id. no.	nom. length	central length (**deviation** from nominal length)			uncert. (1s)	eff. deg. of freedom
	L (mm)	Δl_{left} (µm)	Δl_{right} (µm)	Δl (µm)	u_c (nm)	n_{eff}
990067	0.5					
981658	1					
989008	1.01					
989008	1.1					
981352	6					
981064	7					
981216	8					
980260	80					
980305	90					
980969	100					

A2

Inspection of the measurement surfaces, steel gauge blocks

0.5 mm

left right

1.01 mm

left right

1.1 mm

left right

6 mm

left right

7 mm

left right

8 mm

left right

15 mm

left right

80 mm

left right

90 mm

left right

100 mm

left right

A3

Inspection of the measurement surfaces, ceramic gauge blocks

0.5 mm

left right

1 mm

left right

1.01 mm

left right

1.1 mm

left right

6 mm

left right

7 mm

left right

8 mm

left right

80 mm

left right

90 mm

left right

100 mm

left right

A4

Description of the measurement instrument

Make and Type of interferometer...

....

....

....

....

....

Light sources / Wave lengths used:...

....

....

....

....

Method of fringe fraction determination:...

....

....

....

....

Method used for determination of refractive index of the air:...

....

....

....

....

Range of gauge block temperature during measurements:...

....

....

....

Phase correction:

gauge block material	material of reference flats	phase correction applied (give range, if applicable)
steel		
ceramics		

A5

Uncertainty of measurement

x_i	$u(x_i)$	n_i	$c_i = \partial l / \partial x_i$	$u_i(l)$ / nm

Combined standard uncertainty: $u_c(l) =$

A6

Telefax Telefax Telefax Telefax Telefax

To: **Seta Katuo**
National Reserch Laboratory of Metrology
(this name will be changed in April 2001 but the new name has not been fixed)
1-1-4, Umezono, Tsukuba, Ibaraki 305-8563
Japan
Fax: +81 298-61-4393
e-mail: seta@nrlm.go.jp

From: (participating laboratory)

We confirm having received the standards of the *APMP key comparison, APMP,L-K1 on gauge block measurement* on ....(date).

After visual inspection

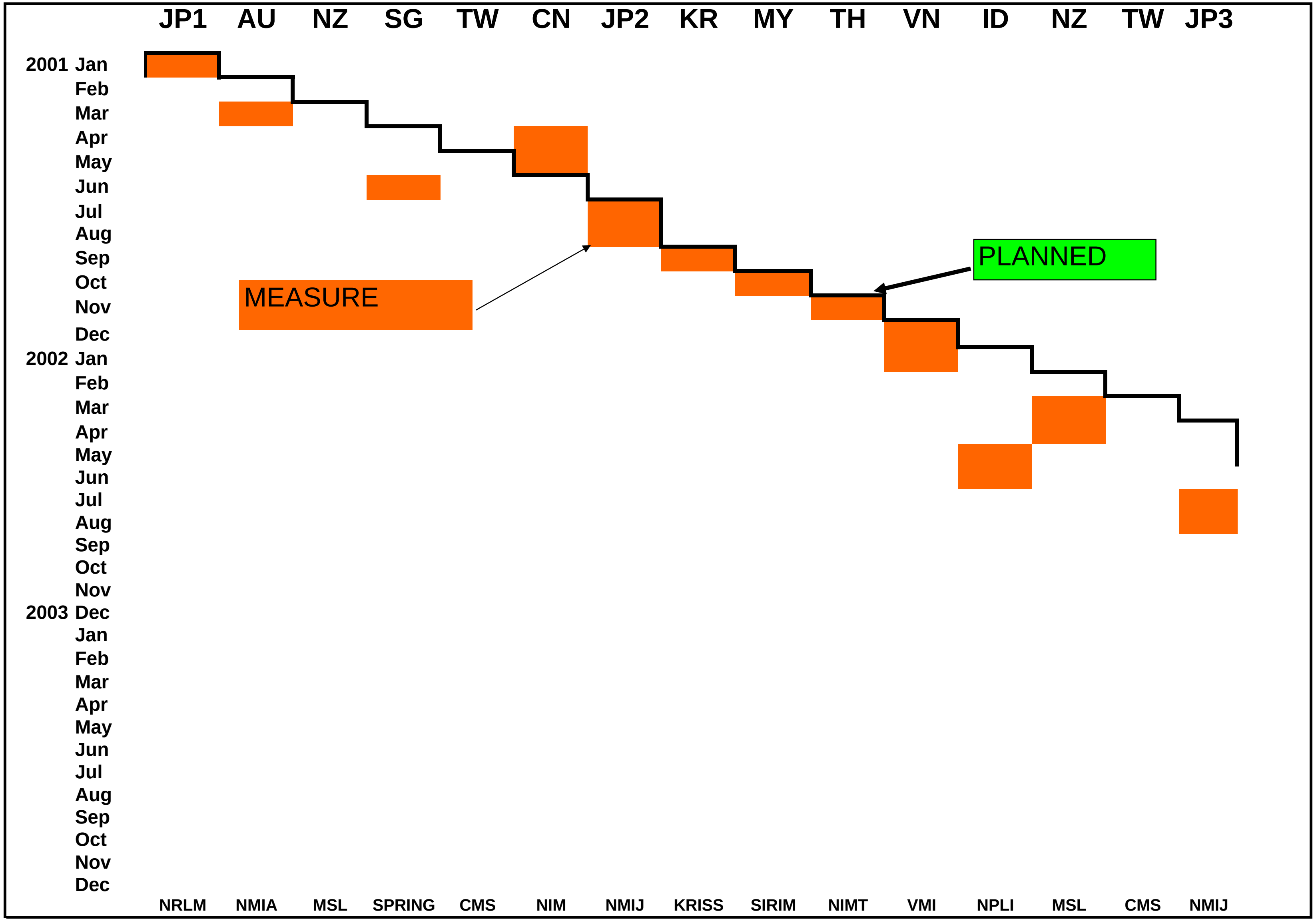
no damage has been noticed.

the following damage(s) must be reported:
....
....
....
....

Date: Signature:

....

Table 1


JP1 AU NZ SG TW CN JP2 KR MY TH VN ID NZ TW JP3
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PLANNED
NRLM NMIA MSL SPRING CMS NIM NMIJ KRISS SIRIM NIMT VMI NPLI MSL CMS NMIJ

Table 2 Steel 0.5mm S/N 980385

	Economy	Laboratory	Dl_{left}(um)	Dl_{right}(um)	Dl (um)	u_c(nm)	Non-weighted x_i-x_{ref}	$(x_i-x_{ref})^2$	Weighted $u^{-2}(x_i)$	$u^{-2}(x_i)*x_i$	wi after convergence w_i	wi(xi-xref)^2	Institute number for xref I
2	Australia	NMIA	0.0490	0.0340	0.0415	10.0	9.789	95.822	0.010	0.415	0.162	25.958	8
3	China	NIM	0.0280	0.0240	0.0260	9.7	-5.711	32.617	0.011	0.276	0.172	1.403	
4	Singapore	SPRING	0.0210	0.0390	0.0300	14.0	-1.711	2.928	0.005	0.153	0.083	0.109	Consistent RB
5	Japan	NMIJ	0.0207	0.0271	0.0239	8.6	-7.811	61.013	0.014	0.323	0.219	5.380	1.438
6	Korea	KRISS	0.0350	0.0280	0.0315	14.8	-0.211	0.045	0.005	0.144	0.074	0.519	
7	Malaysia	SIRIM	0.0230	0.0210	0.0220	15.0	-9.711	94.306	0.004	0.098	0.072	3.386	
8	Thailand	NIMT	0.0390	0.0330	0.0360	11.0	4.289	18.395	0.008	0.298	0.134	6.852	
9	Vietnam	VMI	0.0170	0.0110	0.0140	14.0	-17.711	313.683	0.005	0.071	0.083	18.262	
10	New Zealan	MSL	0.0700	0.0510	0.0605	19.0	28.789	828.800	0.003	0.168	0.045	45.020	
11	India	NPLI	-	-	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
1	Japan	NRLM	0.0302	0.0302	0.0302	8.6	-1.511	2.283	0.014	0.408	0.219	0.399	
12	Japan	NMIJ	-	-	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
								C（after cor	16.227		sum(wi)	1.000	RB
	Non-weighted mean [nm]							uint(x)	4.028		sum(wi(xi-xr	61.869	0.738
	x_{ref} 31.7111							uart(xpilot)	3.150		uext(x)	2.973	
	$u(x_{ref})$ 4.4839												

1st Weighted mean [nm] x_{ref} 30.2134 $u(x_{ref})$ 3.9406		DL	U(DL)	En	O: good	2nd (MSL excluded) x_{ref} 28.8521 $u(x_{ref})$ 4.0282 DL	U(DL)	En	O: good
Australia	NMIA	11.287	19.431	0.581	O	12.648	19.359	0.653	O
China	NIM	-4.213	18.813	-0.224	O	-2.852	18.739	-0.152	O
Singapore	SPRING	-0.213	27.597	-0.008	O	1.148	27.546	0.042	O
Japan	NMIJ	-6.313	16.535	-0.382	O	-4.952	16.451	-0.301	O
Korea	KRISS	1.287	29.219	0.044	O	2.648	29.171	0.091	O
Malaysia	SIRIM	-8.213	29.624	-0.277	O	-6.852	29.577	-0.232	O
Thailand	NIMT	5.787	21.484	0.269	O	7.148	21.419	0.334	O
Vietnam	VMI	-16.213	27.597	-0.588	O	-14.852	27.546	-0.539	O
New Zealan	MSL	30.287	37.704	0.803	O	31.648	37.667	0.840	NA
India	NPLI	#DIV/0!	#NUM!	#DIV/0!	#DIV/0!	#DIV/0!	#NUM!	#DIV/0!	#DIV/0!
Japan	NRLM	-0.013	16.535	-0.001	O	1.348	16.451	0.082	O
Japan	NMIJ	#DIV/0!	#NUM!	#DIV/0!	#DIV/0!	#DIV/0!	#NUM!	#DIV/0!	#DIV/0!

Yellow cells are not used to calculate the weighted mean.

Two gauge blocks were damaged during the international comparison. The damaged gauge blocks are "Steel 8mm" and "Steel 80mm" in nominal length. The damages look so significant. Therefore, NMIJ, the pilot laboratory of APMP-L.K1, decided not to use these two gauges in the rest of the circulation because additional damages for gauge block platens would be caused by using the damaged gauges. NPLI was unable to measure "Steel 0.5 mm", "Steel 1.1 mm" and the left side of "Steel 1.01 mm" in nominal length due to some surface damages.
The other standards showed some damage in the form of scratches and low level corrosion, but were still in an acceptable condition for interferometric measurements.

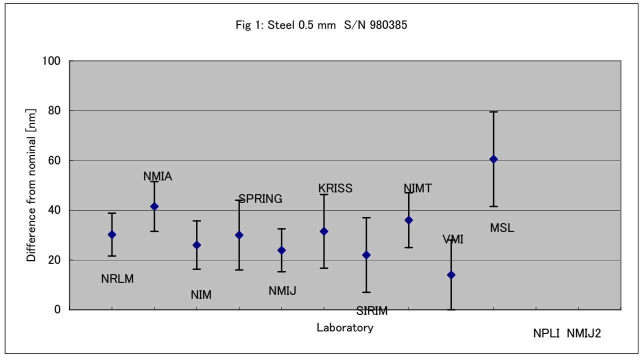


Table 3 Steel 1.01mm S/N 980572

	Economy	Laboratory	Dl_{left}(um)	Dl_{right}(um)	Dl (um)	u_c(nm)	Non-weighted x_i-x_{ref}	$(x_i-x_{ref})^2$	Weighted $u^{-2}(x_i)$	$u^{-2}(x_i)*x_i$	wi after convergence w_i	wi(xi-xref)^2	Institute number for xref I
2	Australia	NMIA	-0.0200	-0.0130	-0.0165	10.0	10.130	102.617	0.010	-0.165	0.157	28.083	9
3	China	NIM	-0.0320	-0.0320	-0.0320	9.7	-5.370	28.837	0.011	-0.340	0.167	0.745	
4	Singapore	SPRING	-0.0310	-0.0100	-0.0205	14.0	6.130	37.577	0.005	-0.105	0.080	7.044	Consistent RB
5	Japan	NMIJ	-0.0432	-0.0444	-0.0438	8.6	-17.170	294.809	0.014	-0.592	0.212	41.028	1.414
6	Korea	KRISS	-0.0330	-0.0330	-0.0330	15.7	-6.370	40.577	0.004	-0.134	0.064	0.617	
7	Malaysia	SIRIM	-0.0390	-0.0280	-0.0335	15.0	-6.870	47.197	0.004	-0.149	0.070	0.910	
8	Thailand	NIMT	-0.0380	-0.0280	-0.0330	11.0	-6.370	40.577	0.008	-0.273	0.130	1.256	
9	Vietnam	VMI	-0.0160	-0.0110	-0.0135	14.0	13.130	172.397	0.005	-0.069	0.080	21.470	
10	New Zealan	MSL	-0.0200	-0.0010	-0.0105	19.0	16.130	260.177	0.003	-0.029	0.043	16.316	
11	India	NPLI	-	-0.0300	-0.0300	19.3	-3.370	11.357	0.003	-0.081	0.042	0.001	
1	Japan	NRLM	-0.0305	-0.0305	-0.0305	8.6	-3.870	14.977	0.014	-0.412	0.212	0.080	
12	Japan	NMIJ	-0.0612	-0.0709	-0.0661	8.6	-39.420	1553.936	0.014	-0.893	0.212	277.152	

C (after cor	15.673	sum(wi)	1.000	RB	
uint(x)	3.959	sum(wi(xi-xr	101.153	0.898	
uart(xpilot)	10.370	uext(x)	3.556		

Non-weighted mean [nm]

x_{ref} -26.6300

$u(x_{ref})$ 3.3930

1st						2nd (MSL excluded)			
Weighted mean [nm]									
x_{ref}	-29.0791					x_{ref}	-29.8857		
$u(x_{ref})$	3.8757					$u(x_{ref})$	3.9589		
		DL	U(DL)	En	O: good	DL	U(DL)	En	O: good
Australia	NMIA	12.579	27.750	0.453	O	13.386	27.703	0.483	O
China	NIM	-2.921	27.321	-0.107	O	-2.114	27.273	-0.078	O
Singapore	SPRING	8.579	33.972	0.253	O	9.386	33.933	0.277	O
Japan	NMIJ	-14.721	25.806	-0.570	O	-13.914	25.755	-0.540	O
Korea	KRISS	-3.921	36.825	-0.106	O	-3.114	36.789	-0.085	O
Malaysia	SIRIM	-4.421	35.638	-0.124	O	-3.614	35.602	-0.102	O
Thailand	NIMT	-3.921	29.225	-0.134	O	-3.114	29.180	-0.107	O
Vietnam	VMI	15.579	33.972	0.459	O	16.386	33.933	0.483	O
New Zealan	MSL	18.579	42.592	0.436	O	19.386	42.561	0.455	NA
India	NPLI	-0.921	43.128	-0.021	O	-0.114	43.098	-0.003	O
Japan	NRLM	-1.421	25.806	-0.055	O	-0.614	25.755	-0.024	O
Japan	NMIJ	-36.971	25.806	-1.433	X	-36.164	25.755	-1.404	X

Two gauge blocks were damaged during the international comparison. The damaged gauge blocks are "Steel 8mm" and "Steel 80mm" in nominal length. The damages look so significant. Therefore, NMIJ, the pilot laboratory of APMP-L.K1, decided not to use these two gauges in the rest of the circulation because additional damages for gauge block platens would be caused by using the damaged gauges. NPLI was unable to measure "Steel 0.5 mm", "Steel 1.1 mm" and the left side of "Steel 1.01 mm" in nominal length due to some surface damages. The other standards showed some damage in the form of scratches and low level corrosion, but were still in an acceptable condition for interferometric measurements.

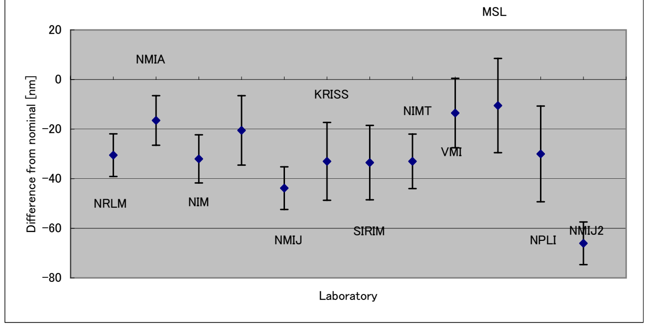


Fig2: Steel 1.01 mm S/N 980572

Table 4 Steel 1.1mm S/N 980458

	Economy	Laboratory	Dl_{left}(um)	Dl_{right}(um)	Dl (um)	u_c(nm)	Non-weighted x_i-x_{ref}	$(x_i-x_{ref})^2$	Weighted $u^{-2}(x_i)$	$u^{-2}(x_i)*x_i$	wi after convergence w_i	wi(xi-xref)^2	Institute number for xref I
2	Australia	NMIA	-0.0030	0.0070	0.0020	10.0	7.106	50.489	0.010	0.020	0.165	24.694	8
3	China	NIM	-0.0060	-0.0210	-0.0135	9.7	-8.394	70.467	0.011	-0.143	0.175	1.877	
4	Singapore	SPRING	-0.0080	0.0020	-0.0030	14.0	2.106	4.433	0.005	-0.015	0.084	4.403	Consistent RB
5	Japan	NMIJ	-0.0318	-0.0231	-0.0275	8.6	-22.344	499.274	0.014	-0.371	0.223	66.206	1.438
6	Korea	KRISS	-0.0030	0.0000	-0.0015	16.9	3.606	13.000	0.004	-0.005	0.058	4.405	
7	Malaysia	SIRIM	-0.0160	0.0120	-0.0020	15.0	3.106	9.644	0.004	-0.009	0.073	4.970	
8	Thailand	NIMT	-0.0150	-0.0260	-0.0205	11.0	-15.394	236.989	0.008	-0.169	0.136	14.395	
9	Vietnam	VMI	0.0130	0.0160	0.0145	14.0	19.606	384.378	0.005	0.074	0.084	51.518	
10	New Zealan	MSL	0.0120	-0.0010	0.0055	19.0	10.606	112.478	0.003	0.015	0.046	11.316	
11	India	NPLI	-	-	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
1	Japan	NRLM	-0.0109	-0.0109	-0.0109	8.6	-5.794	33.576	0.014	-0.147	0.223	0.100	
12	Japan	NMIJ	-	-	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
							C（after cor	16.512			sum(wi)	1.000	RB
							uint(x)	4.063			sum(wi(xi-xr	172.468	1.222
							uart(xpilot)	8.275			uext(x)	4.964	

Non-weighted mean [nm]

x_{ref} -5.1056

$u(x_{ref})$ 4.3798

1st						2nd (MSL excluded)			
Weighted mean [nm]									
x_{ref} -9.5413						x_{ref} -10.2292			
$u(x_{ref})$ 3.9736						$u(x_{ref})$ 4.0635			
		DL	U(DL)	En	O: good	DL	U(DL)	En	O: good
Australia	NMIA	11.541	24.713	0.467	O	12.229	24.655	0.496	O
China	NIM	-3.959	24.230	-0.163	O	-3.271	24.171	-0.135	O
Singapore	SPRING	6.541	31.540	0.207	O	7.229	31.494	0.230	O
Japan	NMIJ	-17.909	22.507	-0.796	O	-17.221	22.443	-0.767	O
Korea	KRISS	8.041	36.786	0.219	O	8.729	36.746	0.238	O
Malaysia	SIRIM	7.541	33.328	0.226	O	8.229	33.284	0.247	O
Thailand	NIMT	-10.959	26.358	-0.416	O	-10.271	26.303	-0.390	O
Vietnam	VMI	24.041	31.540	0.762	O	24.729	31.494	0.785	O
New Zealan	MSL	15.041	40.679	0.370	O	15.729	40.643	0.387	NA
India	NPLI	#DIV/0!	14.517	#DIV/0!	#DIV/0!	#DIV/0!	14.417	#DIV/0!	#DIV/0!
Japan	NRLM	-1.359	22.507	-0.060	O	-0.671	22.443	-0.030	O
Japan	NMIJ	#DIV/0!	14.517	#DIV/0!	#DIV/0!	#DIV/0!	14.417	#DIV/0!	#DIV/0!

Two gauge blocks were damaged during the international comparison. The damaged gauge blocks are "Steel 8mm" and "Steel 80mm" in nominal length. The damages look so significant. Therefore, NMIJ, the pilot laboratory of APMP-L.K1, decided not to use these two gauges in the rest of the circulation because additional damages for gauge block platens would be caused by using the damaged gauges. NPLI was unable to measure "Steel 0.5 mm", "Steel 1.1 mm" and the left side of "Steel 1.01 mm" in nominal length due to some surface damages.
The other standards showed some damage in the form of scratches and low level corrosion, but were still in an acceptable condition for interferometric measurements.

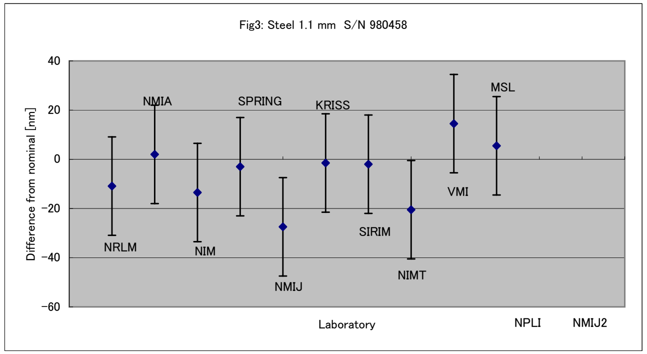


Table 5 Steel 6 mm S/N 985659

	Economy	Laboratory	Dl_{left}(um)	Dl_{right}(um)	Dl (um)	u_c(nm)	Non-weighted x_i-x_{ref}	$(x_i-x_{ref})^2$	Weighted $u^{-2}(x_i)$	$u^{-2}(x_i)*x_i$	wi after convergence w_i	wi(xi-xref)^2	Institute number for xref I
2	Australia	NMIA	0.0010	0.0000	0.0005	10.0	-0.110	0.012	0.010	0.005	0.173	54.285	8
3	China	NIM	-0.0150	-0.0280	-0.0215	9.7	-22.110	488.852	0.011	-0.229	0.184	3.371	
4	Singapore	SPRING	0.0060	0.0070	0.0065	15.0	5.890	34.692	0.004	0.029	0.077	43.235	Consistent RB
5	Japan	NMIJ	-0.0344	-0.0364	-0.0354	8.7	-36.010	1296.720	0.013	-0.468	0.228	75.534	1.438
6	Korea	KRISS	-0.0100	-0.0060	-0.0080	14.8	-8.610	74.132	0.005	-0.037	0.079	6.708	
7	Malaysia	SIRIM	0.0000	-0.0050	-0.0025	15.0	-3.110	9.672	0.004	-0.011	0.077	16.648	
8	Thailand	NIMT	-0.0270	-0.0350	-0.0310	11.0	-31.610	999.192	0.008	-0.256	0.143	27.148	
9	Vietnam	VMI	0.0980	0.0920	0.0950	14.0	94.390	8909.472	0.005	0.485	0.088	1111.068	
10	New Zealan	MSL	0.0230	0.0080	0.0155	19.0	14.890	221.712	0.003	0.043	0.048	51.278	
11	India	NPLI	-0.0080	-0.0180	-0.0130	21.0	-13.610	185.232	0.002	-0.029	0.039	0.698	
1	Japan	NRLM	-0.0012	-0.0012	-0.0012	8.7	-1.810	3.276	0.013	-0.016	0.228	58.617	
12	Japan	NMIJ	-0.0386	-0.0372	-0.0379	8.7	-38.510	1483.020	0.013	-0.501	0.228	97.733	

C（after cor	17.293	sum(wi)	1.000	RB	
uint(x)	4.159	sum(wi(xi-xr	227.626		1.371
uart(xpilot)	11.839	uext(x)	5.702		

Non-weighted mean [nm]

x_{ref} 0.6100

$u(x_{ref})$ 11.6522

1st						2nd (VMI excluded)				3rd (VMI & MSL excluded)			
Weighted mean [nm]													
x_{ref} -7.1234						x_{ref} -15.7219				x_{ref} -17.2175			
$u(x_{ref})$ 3.9014						$u(x_{ref})$ 4.0623				$u(x_{ref})$ 4.1585			
		DL	U(DL)	En	O: good	DL	U(DL)	En	O: good	DL	U(DL)	En	O: good
Australia	NMIA	7.623	29.996	0.254	O	16.222	29.910	0.542	O	17.718	29.857	0.593	O
China	NIM	-14.377	29.599	-0.486	O	-5.778	29.512	-0.196	O	-4.282	29.459	-0.145	O
Singapore	SPRING	13.623	37.413	0.364	O	22.222	37.344	0.595	O	23.718	37.302	0.636	O
Japan	NMIJ	-28.277	28.328	-0.998	O	-19.678	28.238	-0.697	O	-18.182	28.182	-0.645	O
Korea	KRISS	-0.877	37.093	-0.024	O	7.722	37.024	0.209	O	9.218	36.981	0.249	O
Malaysia	SIRIM	4.623	37.413	0.124	O	13.222	37.344	0.354	O	14.718	37.302	0.395	O
Thailand	NIMT	-23.877	31.365	-0.761	O	-15.278	31.283	-0.488	O	-13.782	31.232	-0.441	O
Vietnam	VMI	102.123	35.829	2.850	X	110.722	35.758	3.096	X	112.218	35.713	3.142	X
New Zealan	MSL	22.623	44.088	0.513	O	31.222	44.030	0.709	O	32.718	43.994	0.744	NA
India	NPLI	-5.877	47.579	-0.124	O	2.722	47.525	0.057	O	4.218	47.492	0.089	O
Japan	NRLM	5.923	28.328	0.209	O	14.522	28.238	0.514	O	16.018	28.182	0.568	O
Japan	NMIJ	-30.777	28.328	-1.086	X	-22.178	28.238	-0.785	O	-20.682	28.182	-0.734	O

Yellow cells are not used to calculate the weighted mean.
Red cells have absolute En over one.

Re-calculation excluding one institute with the largest absolute En

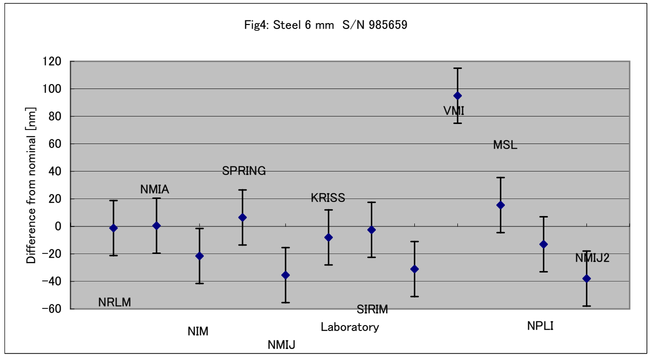


Table 6 Steel 7 mm S/N 985796

	Economy	Laboratory	Dl_{left}(um)	Dl_{right}(um)	Dl (um)	u_c(nm)	Non-weighted x_i-x_{ref}	$(x_i-x_{ref})^2$	Weighted $u^{-2}(x_i)$	$u^{-2}(x_i)*x_i$	wi after convergence w_i	wi(xi-xref)^2	Institute number for xref I
2	Australia	NMIA	-0.0020	-0.0040	-0.0030	10.0	-4.080	16.646	0.010	-0.030	0.173	36.354	8
3	China	NIM	-0.0240	-0.0270	-0.0255	9.7	-26.580	706.496	0.011	-0.271	0.184	11.814	
4	Singapore	SPRING	-0.0070	-0.0090	-0.0080	15.0	-9.080	82.446	0.004	-0.036	0.077	6.930	Consistent RB
5	Japan	NMIJ	-0.0292	-0.0292	-0.0292	8.7	-30.280	916.878	0.013	-0.386	0.229	31.383	1.438
6	Korea	KRISS	-0.0150	-0.0180	-0.0165	14.8	-17.580	309.056	0.005	-0.075	0.079	0.077	
7	Malaysia	SIRIM	-0.0130	-0.0010	-0.0070	15.0	-8.080	65.286	0.004	-0.031	0.077	8.467	
8	Thailand	NIMT	-0.0170	-0.0350	-0.0260	11.0	-27.080	733.326	0.008	-0.215	0.143	10.369	
9	Vietnam	VMI	0.0800	0.0810	0.0805	14.0	79.420	6307.536	0.005	0.411	0.088	848.400	
10	New Zealan	MSL	0.0410	0.0190	0.0300	19.0	28.920	836.366	0.003	0.083	0.048	108.187	
11	India	NPLI	0.0120	0.0190	0.0155	21.4	14.420	207.936	0.002	0.034	0.038	41.153	
1	Japan	NRLM	-0.0150	-0.0150	-0.0150	8.7	-16.080	258.566	0.013	-0.198	0.229	1.417	
12	Japan	NMIJ	-0.0160	-0.0394	-0.0277	8.7	-28.780	828.288	0.013	-0.366	0.229	23.859	

		C（after cor	17.318	sum(wi)	1.000	RB
Non-weighted mean [nm]		uint(x)	4.162	sum(wi(xi-xre	146.547	1.099
x_{ref}	1.0800	uart(xpilot)	4.504	uext(x)	4.576	
$u(x_{ref})$	10.6364					

1st Weighted mean [nm]						2nd (VMI excluded)				3rd (VMI and MSL excluded)			
x_{ref}	-7.8643					x_{ref}	-15.3146			x_{ref}	-17.4885		
$u(x_{ref})$	3.9039					$u(x_{ref})$	4.0652			$u(x_{ref})$	4.1615		
		DL	U(DL)	En	O: good	DL	U(DL)	En	O: good	DL	U(DL)	En	O: good
Australia	NMIA	4.864	20.499	0.237	O	12.315	20.373	0.604	O	14.489	20.295	0.71	O
China	NIM	-17.636	19.914	-0.886	O	-10.185	19.784	-0.515	O	-8.011	19.704	-0.41	O
Singapore	SPRING	-0.136	30.335	-0.004	O	7.315	30.250	0.242	O	9.489	30.197	0.31	O
Japan	NMIJ	-21.336	17.971	-1.187	X	-13.885	17.827	-0.779	O	-11.711	17.738	-0.66	O
Korea	KRISS	-8.636	29.939	-0.288	O	-1.185	29.853	-0.040	O	0.989	29.800	0.49	O
Malaysia	SIRIM	0.864	30.335	0.028	O	8.315	30.250	0.275	O	10.489	30.197	0.35	O
Thailand	NIMT	-18.136	22.454	-0.808	O	-10.685	22.339	-0.478	O	-8.511	22.268	-0.38	O
Vietnam	VMI	88.364	28.358	3.116	X	95.815	28.267	3.390	X	97.989	28.211	3.47	X
New Zealan	MSL	37.864	38.265	0.990	O	45.315	38.197	1.186	X	47.489	38.156	1.24	X
India	NPLI	23.364	43.035	0.543	O	30.815	42.975	0.717	O	32.989	42.939	0.77	O
Japan	NRLM	-7.136	17.971	-0.397	O	0.315	17.827	0.018	O	2.489	17.738	0.00	O
Japan	NMIJ	-19.836	17.971	-1.104	X	-12.385	17.827	-0.695	O	-10.211	17.738	-0.58	O

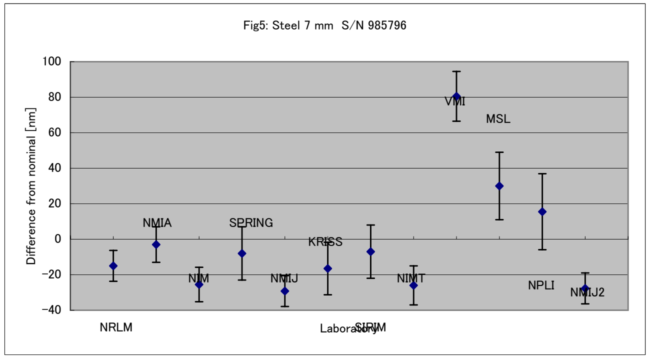


Table 7 Steel 8 mm S/N 985006

	Economy	Laboratory	Dl_{left}(um)	Dl_{right}(um)	Dl (um)	u_c(nm)	Non-weighted x_i-x_{ref}	$(x_i-x_{ref})^2$	Weighted $u^{-2}(x_i)$	$u^{-2}(x_i)*x_i$	wi after converge w_i	wi(xi
2	Australia	NMIA	0.0370	0.0280	0.0325	10.0	19.070	363.665	0.010	0.325	0.236	1:
3	China	NIM	0.0000	0.0070	0.0035	9.7	-9.930	98.605	0.011	0.037	0.251	:
4	Singapore	SPRING	0.0180	0.0370	0.0275	16.0	14.070	197.965	0.004	0.107	0.092	:
5	Japan	NMIJ	-0.0009	-0.0098	-0.0054	8.7	-18.780	352.688	0.013	-0.071	0.312	·
6	Korea	KRISS	0.0020	0.0160	0.0090	14.8	-4.430	19.625	0.005	0.041	0.108	
7	Malaysia	SIRIM	-	-	#DIV/0!	-	#DIV/0!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	#V/
8	Thailand	NIMT	-	-	#DIV/0!	-	#DIV/0!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	#V/
9	Vietnam	VMI	-	-	#DIV/0!	-	#DIV/0!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	#V/
10	New Zealan	MSL	-	-	#DIV/0!	-	#DIV/0!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	#V/
11	India	NPLI	-	-	#DIV/0!	-	#DIV/0!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	#V/
1	Japan	NRLM	0.0148	0.0148	0.0148	8.7	1.370	1.877	0.013	0.196	0.312	
12	Japan	NMIJ	-	-	#DIV/0!	-	#DIV/0!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	#V/

C（after cor	23.634	sum(wi)	
uint(x)	4.862	sum(wi(xi-xr	2:
uart(xpilot)	10.075	uext(x)	

Non-weighted mean [nm]

x_{ref} 13.4300

$u(x_{ref})$ 7.1852

1st

Weighted mean [nm]

x_{ref} 10.3997

$u(x_{ref})$ 4.8615

		DL	U(DL)	En	O: good
Australia	NMIA	22.100	26.674	0.829	O
China	NIM	-6.900	26.227	-0.263	O
Singapore	SPRING	17.100	36.544	0.468	O
Japan	NMIJ	-15.750	24.784	-0.635	O
Korea	KRISS	-1.400	34.462	-0.041	O
Malaysia	SIRIM	#DIV/0!	#VALUE!	#DIV/0!	#DIV/0!
Thailand	NIMT	#DIV/0!	#VALUE!	#DIV/0!	#DIV/0!
Vietnam	VMI	#DIV/0!	#VALUE!	#DIV/0!	#DIV/0!
New Zealan	MSL	#DIV/0!	#VALUE!	#DIV/0!	#DIV/0!
India	NPLI	#DIV/0!	#VALUE!	#DIV/0!	#DIV/0!
Japan	NRLM	4.400	24.784	0.178	O
Japan	NMIJ	#DIV/0!	#VALUE!	#DIV/0!	#DIV/0!

Two gauge blocks were damaged during the international comparison. The damaged gauge blocks are "Steel 8mm" and "Steel 80mm" in nominal length. The damages look so significant. Therefore, NMIJ, the pilot laboratory of APMP-L.K1, decided not to use these two gauges in the rest of the circulation because additional damages for gauge block platens would be caused by using the damaged gauges. NPLI was unable to measure "Steel 0.5 mm",

Table 8 Steel 15 mm S/N 983734

	Economy	Laboratory	DI_{left}(um)	DI_{right}(um)	DI (um)	u_c(nm)	Non-weighted x_i-x_{ref}	$(x_i-x_{ref})^2$	Weighted $u^{-2}(x_i)$	$u^{-2}(x_i)*x_i$	wi after convergence w_i	wi(xi-xref)^2	Institute number for xref
													I
2	Australia	NMIA	0.0090	0.0200	0.0145	10.0	-0.465	0.216	0.010	0.145	0.190	0.000	8
3	China	NIM	0.0170	0.0260	0.0215	9.8	6.535	42.706	0.010	0.224	0.197	9.578	
4	Singapore	SPRING	0.0120	0.0250	0.0185	17.0	3.535	12.496	0.003	0.064	0.066	1.032	Consistent RB
5	Japan	NMIJ	0.0130	-0.0007	0.0062	8.8	-8.815	77.704	0.013	0.079	0.245	17.210	1.438
6	Korea	KRISS	0.0160	0.0120	0.0140	14.6	-0.965	0.931	0.005	0.066	0.089	0.025	
7	Malaysia	SIRIM	-0.0030	0.0290	0.0130	15.0	-1.965	3.861	0.004	0.058	0.084	0.198	
8	Thailand	NIMT	-0.0430	-0.0210	-0.0320	11.0	-46.965	2205.711	0.008	-0.264	0.157	339.296	
9	Vietnam	VMI	0.0290	0.0250	0.0270	14.0	12.035	144.841	0.005	0.138	0.097	15.031	
10	New Zealan	MSL	0.0590	0.0830	0.0710	20.0	56.035	3139.921	0.003	0.178	0.047	151.121	
11	India	NPLI	0.0020	-0.0100	-0.0040	24.1	-18.965	359.671	0.002	-0.007	0.033	11.213	
1	Japan	NRLM	0.0086	0.0086	0.0086	8.8	-6.365	40.513	0.013	0.111	0.245	8.622	
12	Japan	NMIJ	0.0044	-0.0023	0.0011	8.8	-13.915	193.627	0.013	0.014	0.245	44.516	

		C (after cor	18.959	sum(wi)	1.000	RB
Non-weighted mean [nm]		uint(x)	4.354	sum(wi(xi-xr	54.289	0.640
x_{ref}	14.9650	uart(xpilot)	2.224	uext(x)	2.785	
$u(x_{ref})$	8.1568					

1st
Weighted mean [nm]
x_{ref} 10.7016
$u(x_{ref})$ 3.9681

2nd (NIMT excluded)
x_{ref} 17.0896
$u(x_{ref})$ 4.2545

3rd (NIMT and MSL excluded)
x_{ref} 14.5344
$u(x_{ref})$ 4.3542

Economy	Laboratory	1st DL	1st U(DL)	1st En	1st O: good	2nd DL	2nd U(DL)	2nd En	2nd O: good	3rd DL	3rd U(DL)	3rd En	3rd O: good
Australia	NMIA	3.798	18.889	0.201	O	-2.590	18.638	-0.139	O	-0.034	18.546	-0.002	O
China	NIM	10.798	18.465	0.585	O	4.410	18.208	0.242	O	6.966	18.114	0.385	O
Singapore	SPRING	7.798	33.359	0.234	O	1.410	33.217	0.042	O	3.966	33.165	0.120	O
Japan	NMIJ	-4.552	16.327	-0.279	O	-10.940	16.035	-0.682	O	-8.384	15.928	-0.526	O
Korea	KRISS	3.298	28.451	0.116	O	-3.090	28.285	-0.109	O	-0.534	28.224	-0.019	O
Malaysia	SIRIM	2.298	29.271	0.079	O	-4.090	29.110	-0.140	O	-1.534	29.051	-0.053	O
Thailand	NIMT	-42.702	20.995	-2.034	X	-49.090	20.770	-2.364	X	-46.534	20.687	-2.249	X
Vietnam	VMI	16.298	27.218	0.599	O	9.910	27.044	0.366	O	12.466	26.980	0.462	O
New Zealan	MSL	60.298	39.456	1.528	X	53.910	39.337	1.370	X	56.466	39.293	1.437	X
India	NPLI	-14.702	47.750	-0.308	O	-21.090	47.651	-0.443	O	-18.534	47.615	-0.389	O
Japan	NRLM	-2.102	16.327	-0.129	O	-8.490	16.035	-0.529	O	-5.934	15.928	-0.373	O
Japan	NMIJ	-9.652	16.327	-0.591	O	-16.040	16.035	-1.000	X	-13.484	15.928	-0.847	O

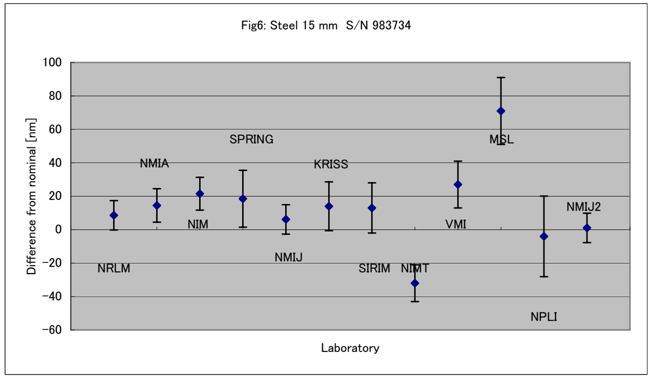


Table 9 Steel 80 mm S/N 980801

							Non-weighted		Weighted		wi after converg	
	Economy	Laboratory	Dl_{left}(um)	Dl_{right}(um	Dl (um)	u_c(nm)	x_i-x_{ref}	$(x_i$-$x_{ref})^2$	$u^{-2}(x_i)$	$u^{-2}(x_i)$*x_i	w_i	wi(x
2	Australia	NMIA	0.0500	0.0440	0.0470	14.0	10.300	106.090	0.005	0.240	0.242	
3	China	NIM	0.0220	0.0440	0.0330	13.4	-3.700	13.690	0.006	0.184	0.265	
4	Singapore	SPRING	0.0720	0.0740	0.0730	27.0	36.300	1317.690	0.001	0.100	0.065	1
5	Japan	NMIJ	0.0236	-0.0026	0.0105	12.6	-26.200	686.440	0.006	0.066	0.299	1
6	Korea	KRISS	0.0290	0.0110	0.0200	19.2	-16.700	278.890	0.003	0.054	0.129	
7	Malaysia	SIRIM	-	-	#DIV/0!	-	#DIV/0!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	#V
8	Thailand	NIMT	-	-	#DIV/0!	-	#DIV/0!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	#V
9	Vietnam	VMI	-	-	#DIV/0!	-	#DIV/0!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	#V
10	New Zealan	MSL	-	-	#DIV/0!	-	#DIV/0!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	#V
11	India	NPLI	-	-	#DIV/0!	-	#DIV/0!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	#V
1	Japan	NRLM	0.0269	0.0269	0.0269	12.6	-9.800	96.040	0.006	0.169	0.299	
12	Japan	NMIJ	-	-	#DIV/0!	-	#DIV/0!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	#V

C（after cor	47.496	sum(wi)	
uint(x)	6.892	sum(wi(xi-xr	3
uart(xpilot)	8.200	uext(x)	

Non-weighted mean [nm]

x_{ref} 36.7000

$u(x_{ref})$ 10.9608

1st

Weighted mean [nm]

x_{ref} 30.5924

$u(x_{ref})$ 6.8917

Economy	Laboratory	DL	U(DL)	En	O: good
Australia	NMIA	16.408	29.376	0.559	O
China	NIM	2.408	28.235	0.085	O
Singapore	SPRING	42.408	54.726	0.775	O
Japan	NMIJ	-20.092	26.721	-0.752	O
Korea	KRISS	-10.592	39.415	-0.269	O
Malaysia	SIRIM	#DIV/0!	#VALUE!	#DIV/0!	#DIV/0!
Thailand	NIMT	#DIV/0!	#VALUE!	#DIV/0!	#DIV/0!
Vietnam	VMI	#DIV/0!	#VALUE!	#DIV/0!	#DIV/0!
New Zealan	MSL	#DIV/0!	#VALUE!	#DIV/0!	#DIV/0!
India	NPLI	#DIV/0!	#VALUE!	#DIV/0!	#DIV/0!
Japan	NRLM	-3.692	26.721	-0.138	O
Japan	NMIJ	#DIV/0!	#VALUE!	#DIV/0!	#DIV/0!

Two gauge blocks were damaged during the international comparison. The damaged gauge blocks are "Steel 8mm" and "Steel 80mm" in nominal length. The damages look so significant. Therefore, NMIJ, the pilot laboratory of APMP-L.K1, decided not to use these two gauges in the rest of the circulation because additional damages for gauge block platens would be caused by using the damaged gauges. NPLI was unable to measure "Steel 0.5 mm", "Steel 1.1 mm" and the left side of

Table 10 Steel 90 mm S/N 981651

	Economy	Laboratory	Dl_{left}(um)	Dl_{right}(um)	Dl (um)	u_c(nm)	Non-weighted x_i-x_{ref}	Non-weighted $(x_i-x_{ref})^2$	Weighted $u^{-2}(x_i)$	Weighted $u^{-2}(x_i)$*x_i	wi after convergence w_i	wi after convergence wi(xi-xref)^2	Institute number for xref I
2	Australia	NMIA	-0.0580	-0.0650	-0.0615	15.0	-25.545	652.547	0.004	-0.273	0.175	5.597	7
3	China	NIM	-0.0590	-0.0550	-0.0570	14.0	-21.045	442.892	0.005	-0.291	0.201	0.267	
4	Singapore	SPRING	-0.0430	-0.0290	-0.0360	28.0	-0.045	0.002	0.001	-0.046	0.050	19.801	Consistent RB
5	Japan	NMIJ	-0.0723	-0.0618	-0.0671	13.4	-31.095	966.899	0.006	-0.373	0.219	27.546	1.468
6	Korea	KRISS	-0.0630	-0.0600	-0.0615	16.6	-25.545	652.547	0.004	-0.223	0.143	4.570	
7	Malaysia	SIRIM	-0.0370	-0.0200	-0.0285	18.0	7.455	55.577	0.003	-0.088	0.122	90.968	
8	Thailand	NIMT	-0.1310	-0.1220	-0.1265	20.0	-90.545	8198.397	0.003	-0.316	0.099	491.821	
9	Vietnam	VMI	-0.0530	-0.0550	-0.0540	21.0	-18.045	325.622	0.002	-0.122	0.089	0.305	
10	New Zealand	MSL	-0.0970	-0.0520	-0.0745	25.0	-38.545	1485.717	0.002	-0.119	0.063	21.939	
11	India	NPLI	0.2050	0.2090	0.2070	49.6	242.955	59027.132	0.000	0.084	0.016	1106.757	
1	Japan	NRLM	-0.0591	-0.0591	-0.0591	13.4	-23.145	535.691	0.006	-0.329	0.219	2.322	
12	Japan	NMIJ	-0.0895	-0.1073	-0.0984	13.4	-62.445	3899.378	0.006	-0.548	0.219	397.425	
								C（after con	39.410		sum(wi)	1.000	RB
Non-weighted mean [nm]								uint(x)	6.278		sum(wi(xi-xre	149.054	0.794
x_{ref}	-35.9550							uart(xpilot)	11.997		uext(x)	4.984	
$u(x_{ref})$	28.2464												

1st — Weighted mean [nm]: x_{ref} -59.1817, $u(x_{ref})$ 5.7850

Economy	Laboratory	DL	U(DL)	En	O: good
Australia	NMIA	-2.318	36.631	-0.063	O
China	NIM	2.182	35.011	0.062	O
Singapore	SPRING	23.182	59.815	0.388	O
Japan	NMIJ	-7.868	34.059	-0.231	O
Korea	KRISS	-2.318	39.294	-0.059	O
Malaysia	SIRIM	30.682	41.687	0.736	O
Thailand	NIMT	-67.318	45.186	-1.490	X
Vietnam	VMI	5.182	46.966	0.110	O
New Zealand	MSL	-15.318	54.238	-0.282	O
India	NPLI	266.182	101.402	2.625	X
Japan	NRLM	0.082	34.059	0.002	O
Japan	NMIJ	-39.218	34.059	-1.151	X

2nd (NPLI excluded）: x_{ref} -62.8526, $u(x_{ref})$ 5.8248

Economy	Laboratory	DL	U(DL)	En	O: good
Australia	NMIA	1.353	36.605	0.037	O
China	NIM	5.853	34.985	0.167	O
Singapore	SPRING	26.853	59.799	0.449	O
Japan	NMIJ	-4.197	34.032	-0.123	O
Korea	KRISS	1.353	39.271	0.034	O
Malaysia	SIRIM	34.353	41.665	0.824	O
Thailand	NIMT	-63.647	45.166	-1.409	X
Vietnam	VMI	8.853	46.946	0.189	O
New Zealand	MSL	-11.647	54.221	-0.215	O
India	NPLI	269.853	101.393	2.661	X
Japan	NRLM	3.753	34.032	0.110	O
Japan	NMIJ	-35.547	34.032	-1.045	X

3rd (NPLI and NIMTexcluded）: x_{ref} -56.9536, $u(x_{ref})$ 6.0887

Economy	Laboratory	DL	U(DL)	En	O: good
Australia	NMIA	-4.546	36.433	-0.125	O
China	NIM	-0.046	34.805	-0.001	O
Singapore	SPRING	20.954	59.694	0.351	O
Japan	NMIJ	-10.096	33.847	-0.298	O
Korea	KRISS	-4.546	39.110	-0.116	O
Malaysia	SIRIM	28.454	41.514	0.685	O
Thailand	NIMT	-69.546	45.026	-1.545	X
Vietnam	VMI	2.954	46.812	0.063	O
New Zealand	MSL	-17.546	54.105	-0.324	O
India	NPLI	263.954	101.331	2.605	X
Japan	NRLM	-2.146	33.847	-0.063	O
Japan	NMIJ	-41.446	33.847	-1.225	X

4th (NPLI, NIMTand MSL ex: x_{ref} -55.8472, $u(x_{ref})$ 6.2778

Economy	Laboratory	DL	U(DL)
Australia	NMIA	-5.653	36.305
China	NIM	-1.153	34.670
Singapore	SPRING	19.847	59.616
Japan	NMIJ	-11.203	33.709
Korea	KRISS	-5.653	38.991
Malaysia	SIRIM	27.347	41.401
Thailand	NIMT	-70.653	44.922
Vietnam	VMI	1.847	46.712
New Zealand	MSL	-18.653	54.019
India	NPLI	262.847	101.285
Japan	NRLM	-3.253	33.709
Japan	NMIJ	-42.553	33.709

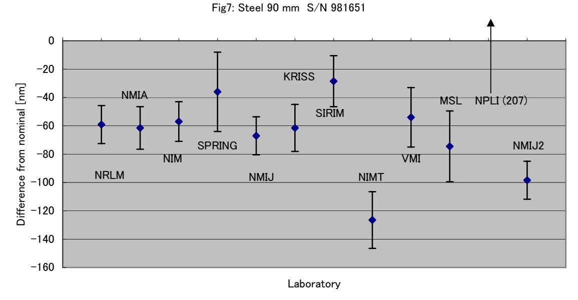


Fig7: Steel 90 mm S/N 981651

Table 11 Steel 100 mm S/N 985946

	Economy	Laboratory	DI_{left}(um)	DI_{right}(um)	DI (um)	u_c(nm)	Non-weighted x_i-x_{ref}	$(x_i-x_{ref})^2$	Weighted $u^{-2}(x_i)$	$u^{-2}(x_i)*x_i$	wi after convergence w_i	wi(xi-xref)^2	Institute number for xref I
2	Australia	NMIA	-0.0940	-0.0970	-0.0955	16.0	8.565	73.359	0.004	-0.373	0.220	1.449	5
3	China	NIM	-0.0950	-0.0900	-0.0925	14.7	11.565	133.749	0.005	-0.428	0.261	8.073	
4	Singapore	SPRING	-0.0760	-0.0770	-0.0765	30.0	27.565	759.829	0.001	-0.085	0.063	29.094	Consistent RB
5	Japan	NMIJ	-0.1080	-0.1153	-0.1117	14.3	-7.585	57.532	0.005	-0.546	0.275	50.792	1.554
6	Korea	KRISS	-0.0960	-0.0960	-0.0960	17.6	8.065	65.044	0.003	-0.310	0.182	0.776	
7	Malaysia	SIRIM	-0.0630	-0.0450	-0.0540	18.0	50.065	2506.504	0.003	-0.167	0.174	337.403	
8	Thailand	NIMT	-0.1820	-0.1790	-0.1805	22.0	-76.435	5842.309	0.002	-0.373	0.116	790.365	
9	Vietnam	VMI	-0.3770	-0.3800	-0.3785	22.0	-274.435	75314.569	0.002	-0.782	0.116	9147.084	
10	New Zealan	MSL	-0.1360	-0.1280	-0.1320	26.0	-27.935	780.364	0.001	-0.195	0.083	95.889	
11	India	NPLI	0.1800	0.1730	0.1765	53.0	280.565	78716.719	0.000	0.063	0.020	1510.824	
1	Japan	NRLM	-0.1187	-0.1187	-0.1187	14.3	-14.635	214.183	0.005	-0.580	0.275	117.200	
12	Japan	NMIJ	-0.1324	-0.1357	-0.1341	14.3	-29.985	899.100	0.005	-0.656	0.275	356.447	
							C（after conv	56.295			sum(wi)	1.000	RB
							uint(x)	7.503			sum(wi(xi-xr	90.185	0.633
							uart(xpilot)	6.613			uext(x)	4.748	

Non-weighted mean [nm]

x_{ref} -104.0650

$u(x_{ref})$ 42.7200

1st
Weighted mean [nm]
x_{ref} -119.1787
$u(x_{ref})$ 6.1065

2nd (VMI excluded): x_{ref} -97.5319, $u(x_{ref})$ 6.3562

3rd (VMI and NPLI excluded): x_{ref} -101.5308, $u(x_{ref})$ 6.4024

4th (VMI, NPLI and NIMT excluded): x_{ref} -94.2239, $u(x_{ref})$ 6.6921

5th (VMI, NPLI, NIMT and MSL exclude: x_{ref} -91.5437, $u(x_{ref})$ 6.9254

Economy	Laboratory	1st DL	U(DL)	En	O: good	2nd DL	U(DL)	En	O: good
Australia	NMIA	23.679	32.400	0.731	O	2.032	32.207	0.063	O
China	NIM	26.679	29.835	0.894	O	5.032	29.625	0.170	O
Singapore	SPRING	42.679	60.214	0.709	O	21.032	60.111	0.350	O
Japan	NMIJ	7.529	29.047	0.259	O	-14.118	28.832	-0.490	O
Korea	KRISS	23.179	35.564	0.652	O	1.532	35.388	0.043	O
Malaysia	SIRIM	65.179	36.356	1.793	X	43.532	36.184	1.203	X
Thailand	NIMT	-61.321	44.292	-1.384	X	-82.968	44.151	-1.879	X
Vietnam	VMI	-259.321	44.292	-5.855	X	-280.968	44.151	-6.364	X
New Zealan	MSL	-12.821	52.247	-0.245	O	-34.468	52.128	-0.661	O
India	NPLI	295.679	106.121	2.786	X	274.032	106.063	2.584	X
Japan	NRLM	0.479	29.047	0.016	O	-21.168	28.832	-0.734	O
Japan	NMIJ	-14.871	29.047	-0.512	O	-36.518	28.832	-1.267	X

Economy	Laboratory	3rd DL	U(DL)	En	O: good	4th DL	U(DL)	En	O: good	5th DL	U(DL)	En	(
Australia	NMIA	6.031	32.171	0.187	O	-1.276	31.934	-0.040	O	-3.956	31.734	-0.125	
China	NIM	9.031	29.586	0.305	O	1.724	29.328	0.059	O	-0.956	29.111	-0.033	
Singapore	SPRING	25.031	60.091	0.417	O	17.724	59.965	0.296	O	15.044	59.859	0.251	
Japan	NMIJ	-10.119	28.791	-0.351	O	-17.426	28.526	-0.611	O	-20.106	28.302	-0.710	
Korea	KRISS	5.531	35.355	0.156	O	-1.776	35.140	-0.051	O	-4.456	34.959	-0.127	
Malaysia	SIRIM	47.531	36.152	1.315	X	40.224	35.941	1.119	X	37.544	35.764	1.050	
Thailand	NIMT	-78.969	44.124	-1.790	X	-86.276	43.952	-1.963	X	-88.956	43.807	-2.031	
Vietnam	VMI	-276.969	44.124	-6.277	X	-284.276	43.952	-6.468	X	-286.956	43.807	-6.550	
New Zealan	MSL	-30.469	52.105	-0.585	O	-37.776	51.959	-0.727	O	-40.456	51.837	-0.780	
India	NPLI	278.031	106.052	2.622	X	270.724	105.980	2.554	X	268.044	105.920	2.531	
Japan	NRLM	-17.169	28.791	-0.596	O	-24.476	28.526	-0.858	O	-27.156	28.302	-0.960	
Japan	NMIJ	-32.519	28.791	-1.130	X	-39.826	28.526	-1.396	X	-42.506	28.302	-1.502	

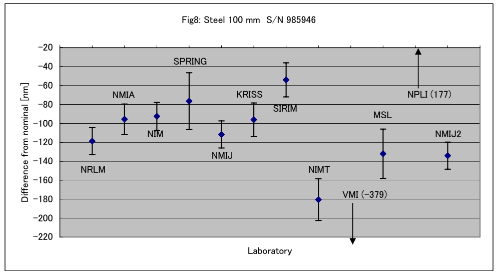


Table 12 Ceramic 0.5 mm S/N 990067

							Non-weighted		Weighted		wi after convergence		Institute number for xref
	Economy	Laboratory	Dl_{left}(um)	Dl_{right}(um)	Dl (um)	u_c(nm)	x_i-x_{ref}	$(x_i-x_{ref})^2$	$u^{-2}(x_i)$	$u^{-2}(x_i)*x_i$	w_i	wi(xi-xref)^2	I
2	Australia	NMIA	0.0050	-0.0070	-0.0010	10.0	9.960	99.202	0.010	-0.010	0.176	39.394	8
3	China	NIM	-0.0060	-0.0220	-0.0140	11.0	-3.040	9.242	0.008	-0.116	0.145	0.561	
4	Singapore	SPRING	-0.0240	-0.0300	-0.0270	14.0	-16.040	257.282	0.005	-0.138	0.090	10.930	Consistent RB
5	Japan	NMIJ	-0.0188	-0.0014	-0.0101	8.6	0.860	0.740	0.014	-0.137	0.238	8.180	1.438
6	Korea	KRISS	-0.0370	-0.0260	-0.0315	14.8	-20.540	421.892	0.005	-0.144	0.080	19.383	
7	Malaysia	SIRIM	-0.0120	-0.0190	-0.0155	15.0	-4.540	20.612	0.004	-0.069	0.078	0.017	
8	Thailand	NIMT	-0.0230	-0.0360	-0.0295	11.0	-18.540	343.732	0.008	-0.244	0.145	26.635	
9	Vietnam	VMI	0.0240	0.0200	0.0220	14.0	32.960	1086.362	0.005	0.112	0.090	129.360	
10	New Zealan	MSL	0.0170	0.0150	0.0160	19.0	26.960	726.842	0.003	0.044	0.049	49.788	
11	India	NPLI	-0.0200	-0.0180	-0.0190	19.3	-8.040	64.642	0.003	-0.051	0.047	0.435	
1	Japan	NRLM	-0.0115	-0.0115	-0.0115	8.6	-0.540	0.292	0.014	-0.155	0.238	4.741	
12	Japan	NMIJ	-0.0342	-0.0361	-0.0352	8.6	-24.190	585.156	0.014	-0.475	0.238	87.548	
							C（after cor		17.591		sum(wi)	1.000	RB
							uint(x)		4.194		sum(wi(xi-xr	105.535	0.926
							uart(xpilot)		8.127		uext(x)	3.883	

Non-weighted mean [nm]

x_{ref} -10.9600

$u(x_{ref})$ 5.8028

1st						2nd (VMI excluded)				3rd (VMI and MSL excluded)			
Weighted mean [nm]													
x_{ref} -11.6035						x_{ref} -14.4793				x_{ref} -15.9646			
$u(x_{ref})$ 3.9308						$u(x_{ref})$ 4.0956				$u(x_{ref})$ 4.1942			
		DL	U(DL)	En	O: good	DL	U(DL)	En	O: good	DL	U(DL)	En	O: good
Australia	NMIA	10.604	24.543	0.432	O	13.479	24.435	0.552	O	14.965	24.368	0.614	O
China	NIM	-2.396	26.199	-0.091	O	0.479	26.097	0.018	O	1.965	26.035	0.075	O
Singapore	SPRING	-15.396	31.406	-0.490	O	-12.521	31.322	-0.400	O	-11.035	31.270	-0.353	O
Japan	NMIJ	1.504	22.321	0.067	O	4.379	22.202	0.197	O	5.865	22.128	0.265	O
Korea	KRISS	-19.896	32.841	-0.606	O	-17.021	32.760	-0.520	O	-15.535	32.710	-0.475	O
Malaysia	SIRIM	-3.896	33.202	-0.117	O	-1.021	33.122	-0.031	O	0.465	33.073	0.014	O
Thailand	NIMT	-17.896	26.199	-0.683	O	-15.021	26.097	-0.576	O	-13.535	26.035	-0.520	O
Vietnam	VMI	33.604	31.406	1.070	X	36.479	31.322	1.165	X	37.965	31.270	1.214	X
New Zealan	MSL	27.604	40.575	0.680	O	30.479	40.510	0.752	O	31.965	40.470	0.790	NA
India	NPLI	-7.396	41.138	-0.180	O	-4.521	41.074	-0.110	O	-3.035	41.034	-0.074	O
Japan	NRLM	0.104	22.321	0.005	O	2.979	22.202	0.134	O	4.465	22.128	0.202	O
Japan	NMIJ	-23.546	22.321	-1.055	X	-20.671	22.202	-0.931	O	-19.185	22.128	-0.867	O

Fig 9: Ceramic 0.5 mm S/N 990067

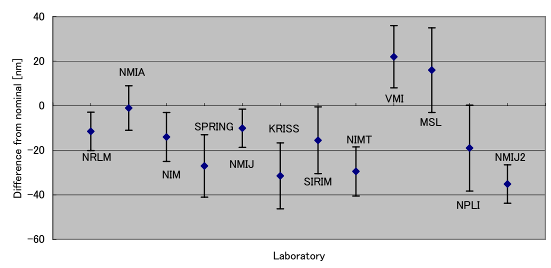


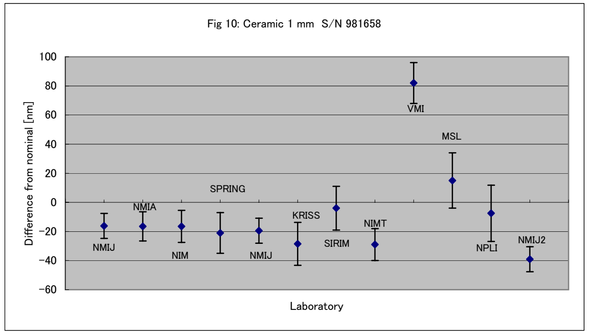
Table 13 Ceramic 1 mm S/N 981658

	Economy	Laboratory	Dl_{left}(um)	Dl_{right}(um)	Dl (um)	u_c(nm)	Non-weighted x_i-x_{ref}	$(x_i-x_{ref})^2$	Weighted $u^{-2}(x_i)$	$u^{-2}(x_i)*x_i$	wi after convergence w_i	wi(xi-xref)^2	Institute number for xref I
2	Australia	NMIA	-0.0170	-0.0160	-0.0165	10.0	-11.955	142.922	0.010	-0.165	0.176	1.086	8
3	China	NIM	-0.0180	-0.0150	-0.0165	11.0	-11.955	142.922	0.008	-0.136	0.145	0.897	
4	Singapore	SPRING	-0.0230	-0.0190	-0.0210	14.0	-16.455	270.767	0.005	-0.107	0.090	0.365	Consistent RB
5	Japan	NMIJ	-0.0215	-0.0174	-0.0195	8.6	-14.905	222.159	0.014	-0.263	0.238	0.052	1.438
6	Korea	KRISS	-0.0300	-0.0270	-0.0285	14.8	-23.955	573.842	0.005	-0.130	0.080	7.272	
7	Malaysia	SIRIM	0.0000	-0.0080	-0.0040	15.0	0.545	0.297	0.004	-0.018	0.078	17.554	
8	Thailand	NIMT	-0.0280	-0.0300	-0.0290	11.0	-24.455	598.047	0.008	-0.240	0.145	14.584	
9	Vietnam	VMI	0.0790	0.0850	0.0820	14.0	86.545	7490.037	0.005	0.418	0.090	915.270	
10	New Zealar	MSL	0.0240	0.0060	0.0150	19.0	19.545	382.007	0.003	0.042	0.049	56.279	
11	India	NPLI	-0.0110	-0.0040	-0.0075	19.3	-2.955	8.732	0.003	-0.020	0.047	6.229	
1	Japan	NRLM	-0.0162	-0.0162	-0.0162	8.6	-11.655	135.839	0.014	-0.219	0.238	1.844	
12	Japan	NMIJ	-0.0433	-0.0349	-0.0391	8.6	-34.555	1194.048	0.014	-0.529	0.238	96.244	
							C（after conve	17.591			sum(wi)	1.000	RB
							uint(x)	4.194			sum(wi(xi-xref)^	48.038	0.625
							uart(xpilot)	7.153			uext(x)	2.620	

Non-weighted mean [nm]

x_{ref} -4.5450

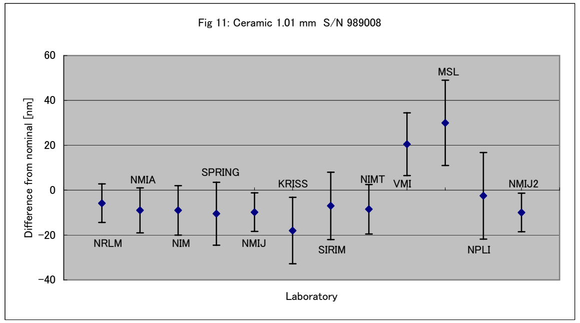
$u(x_{ref})$ 10.4519



1st Weighted mean [nm]						2nd (VMI excluded)				3rd (VMI and MSL excluded)			
x_{ref}		-9.5686				x_{ref}	-17.4051			x_{ref}	-18.9842		
$u(x_{ref})$		3.9308				$u(x_{ref})$	4.0956			$u(x_{ref})$	4.1942		
		DL	U(DL)	En	O: good	DL	U(DL)	En	O: good	DL	U(DL)	En	O: good
Australia	NMIA	-6.931	23.300	-0.297	O	0.905	23.186	0.039	O	2.484	23.115	0.107	O
China	NIM	-6.931	25.038	-0.277	O	0.905	24.932	0.036	O	2.484	24.866	0.100	O
Singapore	SPRING	-11.431	30.445	-0.375	O	-3.595	30.358	-0.118	O	-2.016	30.304	-0.067	O
Japan	NMIJ	-9.881	20.946	-0.472	O	-2.045	20.819	-0.098	O	-0.466	20.740	-0.022	O
Korea	KRISS	-18.931	31.922	-0.593	O	-11.095	31.839	-0.348	O	-9.516	31.788	-0.299	O
Malaysia	SIRIM	5.569	32.294	0.172	O	13.405	32.212	0.416	O	14.984	32.161	0.466	O
Thailand	NIMT	-19.431	25.038	-0.776	O	-11.595	24.932	-0.465	O	-10.016	24.866	-0.403	O
Vietnam	VMI	91.569	30.445	3.008	X	99.405	30.358	3.274	X	100.984	30.304	3.332	X
New Zealar	MSL	24.569	39.836	0.617	O	32.405	39.769	0.815	O	33.984	39.728	0.855	NA
India	NPLI	2.069	40.408	0.051	O	9.905	40.343	0.246	O	11.484	40.302	0.285	O
Japan	NRLM	-6.631	20.946	-0.317	O	1.205	20.819	0.058	O	2.784	20.740	0.134	O
Japan	NMIJ	-29.531	20.946	-1.410	X	-21.695	20.819	-1.042	X	-20.116	20.740	-0.970	O

Table 14 Ceramic 1.01 mm S/N 989008

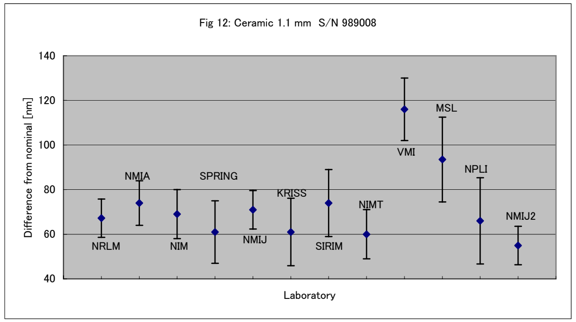
	Economy	Laboratory	Dl_{left}(um)	Dl_{right}(um)	Dl (um)	u_c(nm)	Non-weighted x_i-x_{ref}	$(x_i-x_{ref})^2$	Weighted $u^{-2}(x_i)$	$u^{-2}(x_i)*x_i$	wi after convergence w_i	wi(xi-xref)^2	Institute number for xref I
2	Australia	NMIA	-0.0080	-0.0100	-0.0090	10.0	-6.620	43.824	0.010	-0.090	0.176	0.046	8
3	China	NIM	-0.0070	-0.0110	-0.0090	11.0	-6.620	43.824	0.008	-0.074	0.145	0.038	
4	Singapore	SPRING	-0.0100	-0.0110	-0.0105	14.0	-8.120	65.934	0.005	-0.054	0.090	0.088	Consistent RB
5	Japan	NMIJ	-0.0129	-0.0067	-0.0098	8.6	-7.420	55.056	0.014	-0.133	0.238	0.020	1.438
6	Korea	KRISS	-0.0200	-0.0160	-0.0180	14.8	-15.620	243.984	0.005	-0.082	0.080	5.787	
7	Malaysia	SIRIM	-0.0080	-0.0060	-0.0070	15.0	-4.620	21.344	0.004	-0.031	0.078	0.493	
8	Thailand	NIMT	-0.0060	-0.0110	-0.0085	11.0	-6.120	37.454	0.008	-0.070	0.145	0.149	
9	Vietnam	VMI	0.0220	0.0190	0.0205	14.0	22.880	523.494	0.005	0.105	0.090	80.839	
10	New Zealan	MSL	0.0260	0.0340	0.0300	19.0	32.380	1048.464	0.003	0.083	0.049	76.075	
11	India	NPLI	0.0150	-0.0200	-0.0025	19.3	-0.120	0.014	0.003	-0.007	0.047	2.322	
1	Japan	NRLM	-0.0058	-0.0058	-0.0058	8.6	-3.420	11.696	0.014	-0.078	0.238	3.277	
12	Japan	NMIJ	-0.0131	-0.0068	-0.0100	8.6	-7.570	57.305	0.014	-0.135	0.238	0.046	
							C（after cor	17.591		sum(wi)	1.000	RB	
Non-weighted mean [nm]							uint(x)	4.194		sum(wi(xi-xr	8.942	0.269	
x_{ref}	-2.3800						uart(xpilot)	1.359		uext(x)	1.130		
$u(x_{ref})$	4.8113												



1st Weighted mean [nm]						2nd(MSL excluded)				3rd(MSL and VMI excluded)			
x_{ref}	-5.4545					x_{ref}	-7.0399			x_{ref}	-9.5117		
$u(x_{ref})$	3.9308					$u(x_{ref})$	4.0178			$u(x_{ref})$	4.1942		
		DL	U(DL)	En	O: good	DL	U(DL)	En	O: good	DL	U(DL)	En	O: good
Australia	NMIA	-3.545	18.590	-0.191	O	-1.960	18.515	-0.106	O	0.512	18.358	0.028	O
China	NIM	-3.545	20.726	-0.171	O	-1.960	20.660	-0.095	O	0.512	20.519	0.025	O
Singapore	SPRING	-5.045	27.011	-0.187	O	-3.460	26.960	-0.128	O	-0.988	26.852	-0.037	O
Japan	NMIJ	-4.345	15.538	-0.280	O	-2.760	15.449	-0.179	O	-0.288	15.260	-0.019	O
Korea	KRISS	-12.545	28.666	-0.438	O	-10.960	28.618	-0.383	O	-8.488	28.516	-0.298	O
Malaysia	SIRIM	-1.545	29.079	-0.053	O	0.040	29.031	0.001	O	2.512	28.931	0.087	O
Thailand	NIMT	-3.045	20.726	-0.147	O	-1.460	20.660	-0.071	O	1.012	20.519	0.049	O
Vietnam	VMI	25.955	27.011	0.961	O	27.540	26.960	1.022	X	30.012	26.852	1.118	X
New Zealan	MSL	35.455	37.277	0.951	O	37.040	37.240	0.995	NA	39.512	37.162	1.063	NA
India	NPLI	2.955	37.889	0.078	O	4.540	37.852	0.120	O	7.012	37.775	0.186	O
Japan	NRLM	-0.345	15.538	-0.022	O	1.240	15.449	0.080	O	3.712	15.260	0.243	O
Japan	NMIJ	-4.495	15.538	-0.289	O	-2.910	15.449	-0.188	O	-0.438	15.260	-0.029	O

Table 15 Ceramic 1.1 mm S/N 989008

							Non-weighted		Weighted		wi after convergence		Institute number for xref
	Economy	Laboratory	D_{left}(um)	D_{right}(um)	D(um)	u_c(nm)	x_i-x_{ref}	$(x_i-x_{ref})^2$	$u^{-2}(x_i)$	$u^{-2}(x_i)*x_i$	w_i	wi(xi-xref)^2	I
2	Australia	NMIA	0.0790	0.0690	0.0740	10.0	-0.545	0.297	0.010	0.740	0.176	6.469	8
3	China	NIM	0.0680	0.0700	0.0690	11.0	-5.545	30.747	0.008	0.570	0.146	0.162	
4	Singapore	SPRING	0.0580	0.0640	0.0610	14.0	-13.545	183.467	0.005	0.311	0.090	4.343	Consistent RB
5	Japan	NMIJ	0.0707	0.0712	0.0710	8.6	-3.595	12.924	0.014	0.959	0.239	2.154	1.438
6	Korea	KRISS	0.0590	0.0630	0.0610	15.1	-13.545	183.467	0.004	0.268	0.077	3.734	
7	Malaysia	SIRIM	0.0590	0.0890	0.0740	15.0	-0.545	0.297	0.004	0.329	0.078	2.875	
8	Thailand	NIMT	0.0630	0.0570	0.0600	11.0	-14.545	211.557	0.008	0.496	0.146	9.207	
9	Vietnam	VMI	0.1130	0.1190	0.1160	14.0	41.455	1718.517	0.005	0.592	0.090	207.913	
10	New Zealan	MSL	0.0880	0.0990	0.0935	19.0	18.955	359.292	0.003	0.259	0.049	31.922	
11	India	NPLI	0.0540	0.0780	0.0660	19.3	-8.545	73.017	0.003	0.177	0.047	0.179	
1	Japan	NRLM	0.0672	0.0672	0.0672	8.6	-7.345	53.949	0.014	0.909	0.239	0.133	
12	Japan	NMIJ	0.0550	0.0549	0.0550	8.6	-19.595	383.964	0.014	0.743	0.239	40.297	
								C (after cor	17.647		sum(wi)	1.000	RB
Non-weighted mean [nm]								uint(x)	4.201		sum(wi(xi-xr	29.123	0.486
x_{ref}	74.5450							uart(xpilot)	4.831		uext(x)	2.040	
$u(x_{ref})$	5.5514												



1st						2nd (VMI excluded)				3rd (VMI and MSL excluded)			
Weighted mean [nm]													
x_{ref}	72.8413					x_{ref}	69.1366			x_{ref}	67.9456		
$u(x_{ref})$	3.9363					$u(x_{ref})$	4.1018			$u(x_{ref})$	4.2008		
		DL	U(DL)	En	O: good	DL	U(DL)	En	O: good	DL	U(DL)	En	O: good
Australia	NMIA	1.159	20.770	0.056	O	4.863	20.641	0.236	O	6.054	20.561	0.294	O
China	NIM	-3.841	22.702	-0.169	O	-0.137	22.585	-0.006	O	1.054	22.512	0.047	O
Singapore	SPRING	-11.841	28.555	-0.415	O	-8.137	28.462	-0.286	O	-6.946	28.404	-0.245	O
Japan	NMIJ	-1.891	18.089	-0.105	O	1.813	17.942	0.101	O	3.004	17.850	0.168	O
Korea	KRISS	-11.841	30.715	-0.386	O	-8.137	30.628	-0.266	O	-6.946	30.575	-0.227	O
Malaysia	SIRIM	1.159	30.519	0.038	O	4.863	30.431	0.160	O	6.054	30.377	0.199	O
Thailand	NIMT	-12.841	22.702	-0.566	O	-9.137	22.585	-0.405	O	-7.946	22.512	-0.353	O
Vietnam	VMI	43.159	28.555	1.511	X	46.863	28.462	1.647	X	48.054	28.404	1.692	X
New Zealan	MSL	20.659	38.411	0.538	O	24.363	38.341	0.635	O	25.554	38.298	0.667	NA
India	NPLI	-6.841	39.004	-0.175	O	-3.137	38.936	-0.081	O	-1.946	38.894	-0.050	O
Japan	NRLM	-5.641	18.089	-0.312	O	-1.937	17.942	-0.108	O	-0.746	17.850	-0.042	O
Japan	NMIJ	-17.891	18.089	-0.989	O	-14.187	17.942	-0.791	O	-12.996	17.850	-0.728	O

Table 16 Ceramic 6 mm S/N 981352

	Economy	Laborator	Dl_{left}(um)	Dl_{right}(um	Dl (um)	u_c(nm)	Non-weighted x_i-x_{ref}	$(x_i-x_{ref})^2$	Weighted $u^{-2}(x_i)$	$u^{-2}(x_i)*x_i$	wi after convergence w_i	wi(xi-xref)^2	Institute number for xref I
2	Australia	NMIA	0.0310	0.0280	0.0295	10.0	-17.755	315.240	0.010	0.295	0.182	0.016	8
3	China	NIM	0.0340	0.0300	0.0320	11.0	-15.255	232.715	0.008	0.264	0.150	1.175	
4	Singapore	SPRING	0.0250	0.0280	0.0265	15.0	-20.755	430.770	0.004	0.118	0.081	0.590	Consistent RB
5	Japan	NMIJ	0.0214	0.0347	0.0281	8.7	-19.205	368.832	0.013	0.371	0.240	0.319	1.438
6	Korea	KRISS	0.0160	0.0260	0.0210	15.7	-26.255	689.325	0.004	0.085	0.074	4.962	
7	Malaysia	SIRIM	0.0400	0.0400	0.0400	15.0	-7.255	52.635	0.004	0.178	0.081	9.416	
8	Thailand	NIMT	0.0230	0.0170	0.0200	11.0	-27.255	742.835	0.008	0.165	0.150	12.723	
9	Vietnam	VMI	0.1580	0.1630	0.1605	14.0	113.245	12824.430	0.005	0.819	0.093	1598.553	
10	New Zealar	MSL	0.0600	0.0580	0.0590	19.0	11.745	137.945	0.003	0.163	0.050	44.699	
11	India	NPLI	0.0740	0.0380	0.0560	20.7	8.745	76.475	0.002	0.131	0.042	30.457	
1	Japan	NRLM	0.0239	0.0239	0.0239	8.7	-23.355	545.456	0.013	0.316	0.240	6.754	
12	Japan	NMIJ	0.0321	0.0311	0.0316	8.7	-15.655	245.079	0.013	0.417	0.240	1.379	
							C（after con	18.175			sum(wi)	1.000	RB
Non-weighted mean [nm]							uint(x)	4.263			sum(wi(xi-x	59.659	0.685
x_{ref}	47.2550						uart(xpilot)	2.225			uext(x)	2.919	
$u(x_{ref})$	13.2796												

		1st				2nd (VMI excluded）				3rd (VMI and MSL excluded）			
Weighted mean [nm]													
x_{ref}	41.1671					x_{ref}	30.6317			x_{ref}	29.2035		
$u(x_{ref})$	3.9875					$u(x_{ref})$	4.1598			$u(x_{ref})$	4.2632		
		DL	U(DL)	En	O: good	DL	U(DL)	En	O: good	DL	U(DL)	En	O: good
Australia	NMIA	-11.667	18.873	-0.618	O	-1.132	18.724	-0.060	O	0.297	18.631	0.016	O
China	NIM	-9.167	20.981	-0.437	O	1.368	20.847	0.066	O	2.797	20.763	0.135	O
Singapore	SPRING	-14.667	29.261	-0.501	O	-4.132	29.165	-0.142	O	-2.703	29.105	-0.093	O
Japan	NMIJ	-13.117	16.092	-0.815	O	-2.582	15.917	-0.162	O	-1.153	15.807	-0.073	O
Korea	KRISS	-20.167	30.695	-0.657	O	-9.632	30.603	-0.315	O	-8.203	30.546	-0.269	O
Malaysia	SIRIM	-1.167	29.261	-0.040	O	9.368	29.165	0.321	O	10.797	29.105	0.371	O
Thailand	NIMT	-21.167	20.981	-1.009	X	-10.632	20.847	-0.510	O	-9.203	20.763	-0.443	O
Vietnam	VMI	119.333	27.207	4.386	X	129.868	27.103	4.792	X	131.297	27.039	4.856	X
New Zealar	MSL	17.833	37.419	0.477	O	28.368	37.344	0.760	O	29.797	37.297	0.799	NA
India	NPLI	14.833	40.868	0.363	O	25.368	40.799	0.622	O	26.797	40.756	0.657	O
Japan	NRLM	-17.267	16.092	-1.073	X	-6.732	15.917	-0.423	O	-5.303	15.807	-0.336	O
Japan	NMIJ	-9.567	16.092	-0.595	O	0.968	15.917	0.061	O	2.397	15.807	0.152	O

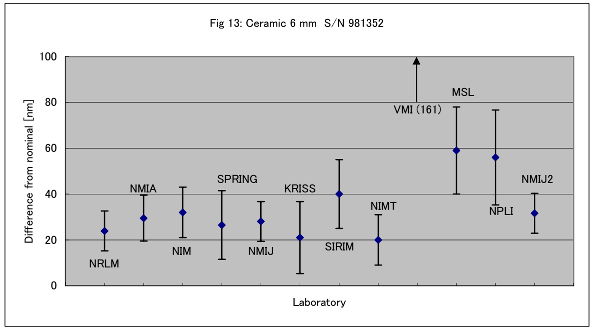


Table 17 Ceramic 7 mm S/N 981064

							Non-weighted		Weighted		wi after convergence		Institute number for xref
	Economy	Laboratory	Dl_{left}(um)	Dl_{right}(um)	Dl (um)	u_c(nm)	x_i-x_{ref}	$(x_i-x_{ref})^2$	$u^{-2}(x_i)$	$u^{-2}(x_i)*x_i$	w_i	wi(xi-xref)^2	I
2	Australia	NMIA	0.0650	0.0610	0.0630	10.0	22.110	488.852	0.010	0.630	0.180	20.492	8
3	China	NIM	0.0560	0.0460	0.0510	11.0	10.110	102.212	0.008	0.421	0.149	0.267	
4	Singapore	SPRING	0.0540	0.0560	0.0550	15.0	14.110	199.092	0.004	0.244	0.080	0.567	Consistent RB
5	Japan	NMIJ	0.0578	0.0590	0.0584	8.7	17.510	306.600	0.013	0.772	0.238	8.750	1.438
6	Korea	KRISS	0.0410	0.0450	0.0430	14.8	2.110	4.452	0.005	0.196	0.082	7.179	
7	Malaysia	SIRIM	0.0560	0.0610	0.0585	15.0	17.610	310.112	0.004	0.260	0.080	3.042	
8	Thailand	NIMT	0.0310	0.0300	0.0305	11.0	-10.390	107.952	0.008	0.252	0.149	71.070	
9	Vietnam	VMI	-0.0810	-0.0780	-0.0795	14.0	-120.390	14493.752	0.005	-0.406	0.092	1598.942	
10	New Zealar	MSL	0.0720	0.0740	0.0730	19.0	32.110	1031.052	0.003	0.202	0.050	21.320	
11	India	NPLI	0.0620	0.0500	0.0560	21.0	15.110	228.312	0.002	0.127	0.041	0.548	
1	Japan	NRLM	0.0455	0.0455	0.0455	8.7	4.610	21.252	0.013	0.601	0.238	11.142	
12	Japan	NMIJ	0.0344	0.0343	0.0344	8.7	-6.540	42.772	0.013	0.454	0.238	77.087	
								C（after conve	18.030		sum(wi)	1.000	RB
Non-weighted mean [nm]								uint(x)	4.246		sum(wi(xi-x	111.916	0.942
x_{ref}	40.8900							uart(xpilot)	6.949		uext(x)	3.998	
$u(x_{ref})$	13.8534												

1st						2nd (VMI excluded)				3rd (VMI and MSL excluded)			
Weighted mean [nm]													
x_{ref}	42.6222					x_{ref}	53.3220			x_{ref}	52.3391		
$u(x_{ref})$	3.9736					$u(x_{ref})$	4.1440			$u(x_{ref})$	4.2462		
		DL	U(DL)	En	O: good	DL	U(DL)	En	O: good	DL	U(DL)	En	O: good
Australia	NMIA	20.378	23.021	0.885	O	9.678	22.901	0.423	O	10.661	22.826	0.467	O
China	NIM	8.378	24.779	0.338	O	-2.322	24.667	-0.094	O	-1.339	24.597	-0.054	O
Singapore	SPRING	12.378	32.093	0.386	O	1.678	32.007	0.052	O	2.661	31.953	0.083	O
Japan	NMIJ	15.778	20.803	0.758	O	5.078	20.669	0.246	O	6.061	20.586	0.294	O
Korea	KRISS	0.378	31.720	0.012	O	-10.322	31.632	-0.326	O	-9.339	31.578	-0.296	O
Malaysia	SIRIM	15.878	32.093	0.495	O	5.178	32.007	0.162	O	6.161	31.953	0.193	O
Thailand	NIMT	-12.122	24.779	-0.489	O	-22.822	24.667	-0.925	O	-21.839	24.597	-0.888	O
Vietnam	VMI	-122.122	30.232	-4.039	X	-132.822	30.141	-4.407	X	-131.839	30.084	-4.382	X
New Zealar	MSL	30.378	39.673	0.766	O	19.678	39.604	0.497	O	20.661	39.560	0.522	NA
India	NPLI	13.378	43.520	0.307	O	2.678	43.456	0.062	O	3.661	43.417	0.084	O
Japan	NRLM	2.878	20.803	0.138	O	-7.822	20.669	-0.378	O	-6.839	20.586	-0.332	O
Japan	NMIJ	-8.272	20.803	-0.398	O	-18.972	20.669	-0.918	O	-17.989	20.586	-0.874	O

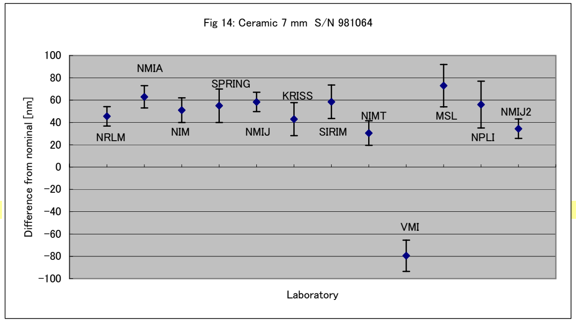
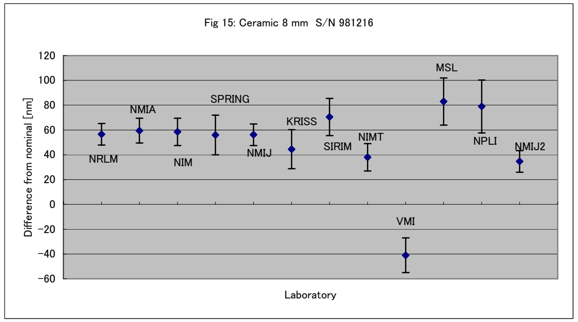


Table 18 Ceramic 8 mm S/N 981216

	Economy	Laboratory	Dl_{left}(um)	Dl_{right}(um)	Dl (um)	u_c(nm)	Non-weighted x_i-x_{ref}	$(x_i-x_{ref})^2$	Weighted $u^{-2}(x_i)$	$u^{-2}(x_i)*x_i$	wi after convergence w_i	wi(xi-xref)^2	Institute number for xref I
2	Australia	NMIA	0.0600	0.0590	0.0595	10.0	9.080	82.446	0.010	0.595	0.184	2.805	8
3	China	NIM	0.0660	0.0510	0.0585	11.0	8.080	65.286	0.008	0.483	0.152	1.283	
4	Singapore	SPRING	0.0570	0.0550	0.0560	16.0	5.580	31.136	0.004	0.219	0.072	0.012	Consistent RB
5	Japan	NMIJ	0.0555	0.0569	0.0562	8.7	5.780	33.408	0.013	0.743	0.243	0.089	1.438
6	Korea	KRISS	0.0450	0.0440	0.0445	15.7	-5.920	35.046	0.004	0.181	0.075	9.190	
7	Malaysia	SIRIM	0.0700	0.0710	0.0705	15.0	20.080	403.206	0.004	0.313	0.082	18.164	
8	Thailand	NIMT	0.0360	0.0400	0.0380	11.0	-12.420	154.256	0.008	0.314	0.152	47.077	
9	Vietnam	VMI	-0.0440	-0.0380	-0.0410	14.0	-91.420	8357.616	0.005	-0.209	0.094	875.871	
10	New Zealar	MSL	0.0820	0.0840	0.0830	19.0	32.580	1061.456	0.003	0.230	0.051	38.274	
11	India	NPLI	0.0830	0.0750	0.0790	21.3	28.580	816.816	0.002	0.174	0.041	22.213	
1	Japan	NRLM	0.0566	0.0566	0.0566	8.7	6.180	38.192	0.013	0.748	0.243	0.245	
12	Japan	NMIJ	0.0341	0.0352	0.0347	8.7	-15.770	248.693	0.013	0.458	0.243	106.643	

	C（after conv	18.398	sum(wi) 1.000	RB
Non-weighted mean [nm]	uint(x)	4.289	sum(wi(xi-x 100.832	0.885
x_{ref} 50.4200	uart(xpilot)	7.251	uext(x) 3.795	
$u(x_{ref})$ 11.0758				



1st Weighted mean [nm]: x_{ref} 48.8955, $u(x_{ref})$ 4.0088

2nd (VMI excluded): x_{ref} 56.9247, $u(x_{ref})$ 4.1840

3rd (VMI and MSL excluded): x_{ref} 55.5958, $u(x_{ref})$ 4.2893

Economy	Laboratory	1st DL	U(DL)	En	O: good	2nd DL	U(DL)	En	O: good	3rd DL	U(DL)	En	O: good
Australia	NMIA	10.605	23.367	0.454	O	2.575	23.244	0.111	O	3.904	23.167	0.169	O
China	NIM	9.605	25.100	0.383	O	1.575	24.986	0.063	O	2.904	24.914	0.117	O
Singapore	SPRING	7.105	34.206	0.208	O	-0.925	34.122	-0.027	O	0.404	34.069	0.012	O
Japan	NMIJ	7.305	21.184	0.345	O	-0.725	21.048	-0.034	O	0.604	20.964	0.029	O
Korea	KRISS	-4.395	33.645	-0.131	O	-12.425	33.559	-0.370	O	-11.096	33.506	-0.331	O
Malaysia	SIRIM	21.605	32.342	0.668	O	13.575	32.253	0.421	O	14.904	32.198	0.463	O
Thailand	NIMT	-10.895	25.100	-0.434	O	-18.925	24.986	-0.757	O	-17.596	24.914	-0.706	O
Vietnam	VMI	-89.895	30.496	-2.948	X	-97.925	30.402	-3.221	X	-96.596	30.343	-3.183	X
New Zealar	MSL	34.105	39.875	0.855	O	26.075	39.803	0.655	O	27.404	39.758	0.689	NA
India	NPLI	30.105	44.281	0.680	O	22.075	44.216	0.499	O	23.404	44.175	0.530	O
Japan	NRLM	7.705	21.184	0.364	O	-0.325	21.048	-0.015	O	1.004	20.964	0.048	O
Japan	NMIJ	-14.245	21.184	-0.672	O	-22.275	21.048	-1.058	X	-20.946	20.964	-0.999	O

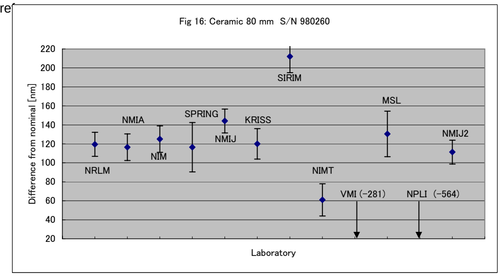
Table 19 Ceramic 80 mm S/N 980260

	Economy	Laboratory	Dl_{left}(um)	Dl_{right}(um)	Dl(um)	u_c(nm)	Non-weighted x_i-x_{ref}	Non-weighted $(x_i-x_{ref})^2$	Weighted $u^{-2}(x_i)$	Weighted $u^{-2}(x_i)*x_i$	wi after convergence w_i	wi after convergence wi(xi-xref)^2	Institute number for xref I
2	Australia	NMIA	0.1100	0.1230	0.1165	14.0	98.440	9690.434	0.005	0.594	0.234	26.070	5
3	China	NIM	0.1240	0.1260	0.1250	14.0	106.940	11436.164	0.005	0.638	0.234	0.995	
4	Singapore	SPRING	0.1170	0.1160	0.1165	26.0	98.440	9690.434	0.001	0.172	0.068	7.559	Consistent RB
5	Japan	NMIJ	0.1401	0.1481	0.1441	12.6	126.040	15886.082	0.006	0.908	0.288	83.703	1.554
6	Korea	KRISS	0.1250	0.1150	0.1200	16.1	101.940	10391.764	0.004	0.463	0.177	8.814	
7	Malaysia	SIRIM	0.2020	0.2220	0.2120	17.0	193.940	37612.724	0.003	0.734	0.158	1142.964	
8	Thailand	NIMT	0.0480	0.0740	0.0610	17.0	42.940	1843.844	0.003	0.211	0.158	691.476	
9	Vietnam	VMI	-0.2830	-0.2790	-0.2810	18.0	-299.060	89436.884	0.003	-0.867	0.141	23531.930	
10	New Zealar	MSL	0.1360	0.1250	0.1305	24.0	112.440	12642.754	0.002	0.227	0.079	0.939	
11	India	NPLI	-0.5630	-0.5650	-0.5640	42.2	-582.060	338793.844	0.001	-0.317	0.026	12278.850	
1	Japan	NRLM	0.1195	0.1195	0.1195	12.6	101.440	10290.074	0.006	0.753	0.288	16.501	
12	Japan	NMIJ	0.1157	0.1070	0.1114	12.6	93.290	8703.024	0.006	0.701	0.288	71.216	
								C（after conve	45.787		sum(wi)	1.000	RB
								uint(x)	6.767		sum(wi(xi-xre	127.142	0.833
								uart(xpilot)	9.844		uext(x)	5.638	

Non-weighted mean [nm]

x_{ref} 18.0600

$u(x_{ref})$ 77.2748



		1st Weighted mean [nm] x_{ref} 80.9001, $u(x_{ref})$ 5.4118				2nd (VMI excluded) x_{ref} 116.8641, $u(x_{ref})$ 5.6743				3rd (VMI and NPLI excluded) x_{ref} 129.4008, $u(x_{ref})$ 5.7263			
		DL	U(DL)	En	O: good	DL	U(DL)	En	O: good	DL	U(DL)	En	O: good
Australia	NMIA	35.600	32.472	1.096	X	-0.364	32.292	-0.011	O	-12.901	32.256	-0.400	O
China	NIM	44.100	32.472	1.358	X	8.136	32.292	0.252	O	-4.401	32.256	-0.136	O
Singapore	SPRING	35.600	54.538	0.653	O	-0.364	54.432	-0.007	O	-12.901	54.410	-0.237	O
Japan	NMIJ	63.200	30.091	2.100	X	27.236	29.897	0.911	O	14.699	29.857	0.492	O
Korea	KRISS	39.100	36.156	1.081	X	3.136	35.995	0.087	O	-9.401	35.962	-0.261	O
Malaysia	SIRIM	131.100	37.768	3.471	X	95.136	37.614	2.529	X	82.599	37.582	2.198	X
Thailand	NIMT	-19.900	37.768	-0.527	O	-55.864	37.614	-1.485	X	-68.401	37.582	-1.820	X
Vietnam	VMI	-361.900	39.578	-9.144	X	-397.864	39.431	-10.090	X	-410.401	39.401	-10.416	X
New Zealar	MSL	49.600	50.739	0.978	O	13.636	50.624	0.269	O	1.099	50.601	0.022	O
India	NPLI	-644.900	85.987	-7.500	X	-680.864	85.919	-7.924	X	-693.401	85.906	-8.072	X
Japan	NRLM	38.600	30.091	1.283	X	2.636	29.897	0.088	O	-9.901	29.857	-0.332	O
Japan	NMIJ	30.450	30.091	1.012	X	-5.514	29.897	-0.184	O	-18.051	29.857	-0.605	O

		4th (VMI, NPLI and SIRIM excluded) x_{ref} 118.8295, $u(x_{ref})$ 6.0817				5th (VMI, NPLI, SIRIM and NIMTexcluded) x_{ref} 127.3170, $u(x_{ref})$ 6.5127				6th (VMI, NPLI, SIRIM, NIMTand MSL excluded x_{ref} 127.0639, $u(x_{ref})$ 6.7666			
		DL	U(DL)	En	O: good	DL	U(DL)	En	O: good	DL	U(DL)	En	O: good
Australia	NMIA	-2.330	31.994	-0.073	O	-10.817	31.653	-0.342	O	-10.564	31.439	-0.336	O
China	NIM	6.170	31.994	0.193	O	-2.317	31.653	-0.073	O	-2.064	31.439	-0.066	O
Singapore	SPRING	-2.330	54.255	-0.043	O	-10.817	54.055	-0.200	O	-10.564	53.930	-0.196	O
Japan	NMIJ	25.270	29.575	0.854	O	16.783	29.206	0.575	O	17.036	28.974	0.588	O
Korea	KRISS	1.170	35.728	0.033	O	-7.317	35.423	-0.207	O	-7.064	35.232	-0.200	O
Malaysia	SIRIM	93.170	37.358	2.494	X	84.683	37.066	2.285	X	84.936	36.884	2.303	X
Thailand	NIMT	-57.830	37.358	-1.548	X	-66.317	37.066	-1.789	X	-66.064	36.884	-1.791	X
Vietnam	VMI	-399.830	39.187	-10.203	X	-408.317	38.909	-10.494	X	-408.064	38.735	-10.535	X
New Zealar	MSL	11.670	50.435	0.231	O	3.183	50.219	0.063	O	3.436	50.084	0.069	NA
India	NPLI	-682.830	85.808	-7.958	X	-691.317	85.681	-8.068	X	-691.064	85.603	-8.073	X
Japan	NRLM	0.670	29.575	0.023	O	-7.817	29.206	-0.268	O	-7.564	28.974	-0.261	O
Japan	NMIJ	-7.480	29.575	-0.253	O	-15.967	29.206	-0.547	O	-15.714	28.974	-0.542	O

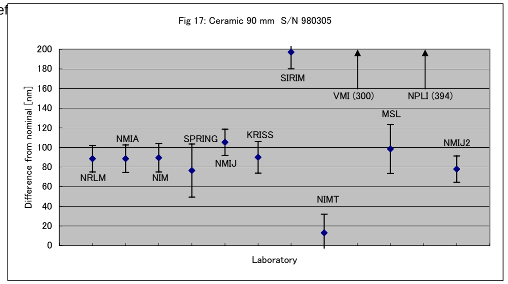
Table 20 Ceramic 90 mm S/N 980305

	Economy	Laboratory	Dl_{left}(um)	Dl_{right}(um)	Dl(um)	u_c(nm)	Non-weighted x_i-x_{ref}	Non-weighted $(x_i-x_{ref})^2$	Weighted $u^{-2}(x_i)$	Weighted $u^{-2}(x_i)*x_i$	wi after convergence w_i	wi after convergence wi(xi-xref)^2	Institute number for xref: I
2	Australia	NMIA	0.0890	0.0880	0.0885	14.0	-56.675	3212.056	0.005	0.452	0.247	4.418	5
3	China	NIM	0.0980	0.0810	0.0895	14.5	-55.675	3099.706	0.005	0.426	0.230	2.401	
4	Singapore	SPRING	0.0860	0.0670	0.0765	27.0	-68.675	4716.256	0.001	0.105	0.066	17.491	Consistent RB
5	Japan	NMIJ	0.0999	0.1106	0.1053	13.4	-39.925	1594.006	0.006	0.586	0.270	42.265	1.554
6	Korea	KRISS	0.0880	0.0920	0.0900	16.1	-55.175	3044.281	0.004	0.347	0.187	1.391	
7	Malaysia	SIRIM	0.1890	0.2050	0.1970	17.0	51.825	2685.831	0.003	0.682	0.168	1821.200	
8	Thailand	NIMT	0.0180	0.0080	0.0130	19.0	-132.175	17470.231	0.003	0.036	0.134	852.433	
9	Vietnam	VMI	0.3020	0.2970	0.2995	19.0	154.325	23816.206	0.003	0.830	0.134	5733.264	
10	New Zealar	MSL	0.1110	0.0860	0.0985	25.0	-46.675	2178.556	0.002	0.158	0.077	2.579	
11	India	NPLI	0.3760	0.4120	0.3940	45.1	248.825	61913.881	0.000	0.194	0.024	2160.190	
1	Japan	NRLM	0.0885	0.0885	0.0885	13.4	-56.675	3212.056	0.006	0.493	0.270	4.822	
12	Japan	NMIJ	0.0710	0.0849	0.0780	13.4	-67.225	4519.201	0.006	0.434	0.270	58.889	
								C（after con	48.410		sum(wi)	1.000	RB
								uint(x)	6.958		sum(wi(xi-x	67.965	0.592
								uart(xpilot)	7.948		uext(x)	4.122	

Non-weighted mean [nm]

x_{ref} 145.1750

$u(x_{ref})$ 37.0781



1st

Weighted mean [nm]

x_{ref} 120.1337

$u(x_{ref})$ 5.6122

Economy	Laboratory	DL	U(DL)	En	O: good
Australia	NMIA	-31.634	30.178	-1.048	X
China	NIM	-30.634	31.108	-0.985	O
Singapore	SPRING	-43.634	55.161	-0.791	O
Japan	NMIJ	-14.884	29.068	-0.512	O
Korea	KRISS	-30.134	34.111	-0.883	O
Malaysia	SIRIM	76.866	35.815	2.146	X
Thailand	NIMT	-107.134	39.632	-2.703	X
Vietnam	VMI	179.366	39.632	4.526	X
New Zealar	MSL	-21.634	51.251	-0.422	O
India	NPLI	273.866	90.900	3.013	X
Japan	NRLM	-31.634	29.068	-1.088	X
Japan	NMIJ	-42.184	29.068	-1.451	X

2nd (VMI excluded）: x_{ref} 102.9882, $u(x_{ref})$ 5.8743

3rd (VMI and NPLI excluded）: x_{ref} 97.9658, $u(x_{ref})$ 5.9248

Economy	Laboratory	2nd DL	2nd U(DL)	2nd En	2nd O: good	3rd DL	3rd U(DL)	3rd En	3rd O: good
Australia	NMIA	-14.488	29.978	-0.483	O	-9.466	29.938	-0.316	O
China	NIM	-13.488	30.914	-0.436	O	-8.466	30.875	-0.274	O
Singapore	SPRING	-26.488	55.052	-0.481	O	-21.466	55.030	-0.390	O
Japan	NMIJ	2.262	28.860	0.078	O	7.284	28.819	0.253	O
Korea	KRISS	-12.988	33.934	-0.383	O	-7.966	33.899	-0.235	O
Malaysia	SIRIM	94.012	35.646	2.637	X	99.034	35.613	2.781	X
Thailand	NIMT	-89.988	39.480	-2.279	X	-84.966	39.450	-2.154	X
Vietnam	VMI	196.512	39.480	4.978	X	201.534	39.450	5.109	X
New Zealar	MSL	-4.488	51.134	-0.088	O	0.534	51.111	0.010	O
India	NPLI	291.012	90.833	3.204	X	296.034	90.820	3.260	X
Japan	NRLM	-14.488	28.860	-0.502	O	-9.466	28.819	-0.328	O
Japan	NMIJ	-25.038	28.860	-0.868	O	-20.016	28.819	-0.695	O

4th (VMI, NPLI and SIRIM excluded）: x_{ref} 84.2736, $u(x_{ref})$ 6.3211

5th (VMI, NPLI, SIRIM and NIMT excluded）: x_{ref} 93.1442, $u(x_{ref})$ 6.7030

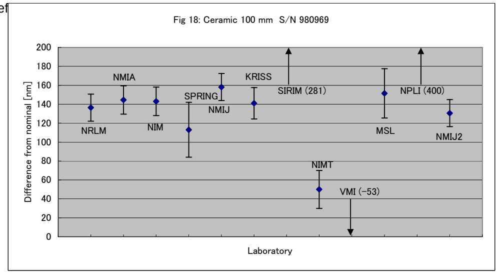
6th (VMI, NPLI, SIRIM, NIMT and MSL excluded: x_{ref} 92.7293, $u(x_{ref})$ 6.9577

Economy	Laboratory	4th DL	4th U(DL)	4th En	4th O: good	5th DL	5th U(DL)	5th En	5th O: good	6th DL	6th U(DL)	6th En	6th O: good
Australia	NMIA	4.226	29.612	0.143	O	-4.644	29.274	-0.159	O	-4.229	29.036	-0.146	O
China	NIM	5.226	30.559	0.171	O	-3.644	30.232	-0.121	O	-3.229	30.001	-0.108	O
Singapore	SPRING	-7.774	54.853	-0.142	O	-16.644	54.672	-0.304	O	-16.229	54.544	-0.298	O
Japan	NMIJ	20.976	28.480	0.737	O	12.106	28.129	0.430	O	12.521	27.880	0.449	O
Korea	KRISS	5.726	33.611	0.170	O	-3.144	33.314	-0.094	O	-2.729	33.104	-0.082	O
Malaysia	SIRIM	112.726	35.339	3.190	X	103.856	35.057	2.962	X	104.271	34.858	2.991	X
Thailand	NIMT	-71.274	39.203	-1.818	X	-80.144	38.948	-2.058	X	-79.729	38.769	-2.057	X
Vietnam	VMI	215.226	39.203	5.490	X	206.356	38.948	5.298	X	206.771	38.769	5.333	X
New Zealar	MSL	14.226	50.920	0.279	O	5.356	50.725	0.106	O	5.771	50.587	0.114	NA
India	NPLI	309.726	90.713	3.414	X	300.856	90.604	3.321	X	301.271	90.527	3.328	X
Japan	NRLM	4.226	28.480	0.148	O	-4.644	28.129	-0.165	O	-4.229	27.880	-0.152	O
Japan	NMIJ	-6.324	28.480	-0.222	O	-15.194	28.129	-0.540	O	-14.779	27.880	-0.530	O

Table 21 Ceramic 100 mm S/N 980969

	Economy	Laboratory	Dl_{left}(um)	Dl_{right}(um)	Dl (um)	u_c(nm)	Non-weighted x_i-x_{ref}	Non-weighted $(x_i-x_{ref})^2$	Weighted $u^{-2}(x_i)$	Weighted $u^{-2}(x_i)*x_i$	wi after convergence w_i	wi after convergence wi(xi-xref)^2	Institute number for xref I
2	Australia	NMIA	0.1470	0.1420	0.1445	15.0	-8.460	71.572	0.004	0.642	0.238	0.062	5
3	China	NIM	0.1510	0.1350	0.1430	15.0	-9.960	99.202	0.004	0.636	0.238	0.964	
4	Singapore	SPRING	0.1240	0.1020	0.1130	29.0	-39.960	1596.802	0.001	0.134	0.064	65.363	Consistent RB
5	Japan	NMIJ	0.1473	0.1689	0.1581	14.3	5.140	26.420	0.005	0.773	0.262	44.942	1.554
6	Korea	KRISS	0.1390	0.1430	0.1410	16.5	-11.960	143.042	0.004	0.518	0.197	3.170	
7	Malaysia	SIRIM	0.2850	0.2770	0.2810	18.0	128.040	16394.242	0.003	0.867	0.166	3061.866	
8	Thailand	NIMT	0.0440	0.0560	0.0500	20.0	-102.960	10600.762	0.003	0.125	0.134	1210.638	
9	Vietnam	VMI	-0.0540	-0.0510	-0.0525	20.0	-205.460	42213.812	0.003	-0.131	0.134	5231.764	
10	New Zealar	MSL	0.1510	0.1520	0.1515	26.0	-1.460	2.132	0.001	0.224	0.079	3.341	
11	India	NPLI	0.4160	0.3840	0.4000	48.0	247.040	61028.762	0.000	0.174	0.023	1513.856	
1	Japan	NRLM	0.1364	0.1364	0.1364	14.3	-16.560	274.234	0.005	0.667	0.262	19.453	
12	Japan	NMIJ	0.1254	0.1358	0.1306	14.3	-22.360	499.970	0.005	0.639	0.262	54.482	

Non-weighted mean [nm]		C（after conv	53.644	sum(wi)	1.000 RB
x_{ref}	152.9600	uint(x)	7.324	sum(wi(xi-x	114.502 0.730
$u(x_{ref})$	38.3227	uart(xpilot)	8.369	uext(x)	5.350



1st
Weighted mean [nm]
x_{ref} 138.3314
$u(x_{ref})$ 5.9089

Economy	Laboratory	DL	U(DL)	En	O: good
Australia	NMIA	6.169	32.257	0.191	O
China	NIM	4.669	32.257	0.145	O
Singapore	SPRING	-25.331	59.199	-0.428	O
Japan	NMIJ	19.769	30.959	0.639	O
Korea	KRISS	2.669	35.064	0.076	O
Malaysia	SIRIM	142.669	37.901	3.764	X
Thailand	NIMT	-88.331	41.719	-2.117	X
Vietnam	VMI	-190.831	41.719	-4.574	X
New Zealar	MSL	13.169	53.334	0.247	O
India	NPLI	261.669	96.729	2.705	X
Japan	NRLM	-1.931	30.959	-0.062	O
Japan	NMIJ	-7.731	30.959	-0.250	O

2nd(VMI excluded)
x_{ref} 156.5816
$u(x_{ref})$ 6.1850

Laboratory	DL	U(DL)	En	O: good
NMIA	-12.082	32.049	-0.377	O
NIM	-13.582	32.049	-0.424	O
SPRING	-43.582	59.086	-0.738	O
NMIJ	1.518	30.743	0.049	O
KRISS	-15.582	34.873	-0.447	O
SIRIM	124.418	37.725	3.298	X
NIMT	-106.582	41.559	-2.565	X
VMI	-209.082	41.559	-5.031	X
MSL	-5.082	53.209	-0.096	O
NPLI	243.418	96.660	2.518	X
NRLM	-20.182	30.743	-0.656	O
NMIJ	-25.982	30.743	-0.845	O

3rd(VMI and SIRIM excluded)
x_{ref} 139.9251
$u(x_{ref})$ 6.5860

Laboratory	DL	U(DL)	En	O: good
NMIA	4.575	31.728	0.144	O
NIM	3.075	31.728	0.097	O
SPRING	-26.925	58.912	-0.457	O
NMIJ	18.175	30.408	0.598	O
KRISS	1.075	34.578	0.031	O
SIRIM	141.075	37.452	3.767	X
NIMT	-89.925	41.312	-2.177	X
VMI	-192.425	41.312	-4.658	X
MSL	11.575	53.016	0.218	O
NPLI	260.075	96.554	2.694	X
NRLM	-3.525	30.408	-0.116	O
NMIJ	-9.325	30.408	-0.307	O

4th(VMI, SIRIM and NPLI excluded)
x_{ref} 134.9350
$u(x_{ref})$ 6.6489

Laboratory	DL	U(DL)	En	O: good
NMIA	9.565	31.676	0.302	O
NIM	8.065	31.676	0.255	O
SPRING	-21.935	58.884	-0.373	O
NMIJ	23.165	30.353	0.763	O
KRISS	6.065	34.530	0.176	O
SIRIM	146.065	37.408	3.905	X
NIMT	-84.935	41.272	-2.058	X
VMI	-187.435	41.272	-4.542	X
MSL	16.565	52.984	0.313	O
NPLI	265.065	96.537	2.746	X
NRLM	1.465	30.353	0.048	O
NMIJ	-4.335	30.353	-0.143	O

5th (VMI, SIRIM, NPLI and NIMT excluded)
x_{ref} 145.4882
$u(x_{ref})$ 7.0499

Laboratory	DL	U(DL)	En	O: good
NMIA	-0.988	31.327	-0.032	O
NIM	-2.488	31.327	-0.079	O
SPRING	-32.488	58.697	-0.553	O
NMIJ	12.612	29.989	0.421	O
KRISS	-4.488	34.211	-0.131	O
SIRIM	135.512	37.113	3.651	X
NIMT	-95.488	41.005	-2.329	X
VMI	-197.988	41.005	-4.828	X
MSL	6.012	52.777	0.114	O
NPLI	254.512	96.423	2.640	X
NRLM	-9.088	29.989	-0.303	O
NMIJ	-14.888	29.989	-0.496	O

6th (VMI, SIRIM, NPLI, NIMT and MSL excluded
x_{ref} 145.0112
$u(x_{ref})$ 7.3242

Laboratory	DL	U(DL)	En	O: good
NMIA	-0.511	31.074	-0.016	O
NIM	-2.011	31.074	-0.065	O
SPRING	-32.011	58.563	-0.547	O
NMIJ	13.089	29.725	0.440	O
KRISS	-4.011	33.979	-0.118	O
SIRIM	135.989	36.900	3.685	X
NIMT	-95.011	40.812	-2.328	X
VMI	-197.511	40.812	-4.840	X
MSL	6.489	52.627	0.123	NA
NPLI	254.989	96.341	2.647	X
NRLM	-8.611	29.725	-0.290	O
NMIJ	-14.411	29.725	-0.485	O

Table 22 Summary and En number for steel gauges

Xi-Xref 2*u(Xi-Xref)

(a) 1st (All institutes are used for Reference values)

Nominal Length [mm]	0.5	1.01	1.1	6	7	8	15	80	90	100
NMIA	11 ± 19	13 ± 28	12 ± 25	8 ± 30	5 ± 20	22 ± 27	4 ± 19	16 ± 29	-2 ± 37	24 ± 32
NIM	-4 ± 19	-3 ± 27	-4 ± 24	-14 ± 30	-18 ± 20	-7 ± 26	11 ± 18	2 ± 28	2 ± 35	27 ± 30
SPRING	0 ± 28	9 ± 34	7 ± 32	14 ± 37	0 ± 30	17 ± 37	8 ± 33	42 ± 55	23 ± 60	43 ± 60
NMIJ	-6 ± 17	-15 ± 26	-18 ± 23	-28 ± 28	-21 ± 18	-16 ± 25	-5 ± 16	-20 ± 27	-8 ± 34	8 ± 29
KRISS	1 ± 29	-4 ± 37	8 ± 37	-1 ± 37	-9 ± 30	-1 ± 34	3 ± 28	-11 ± 39	-2 ± 39	23 ± 36
SIRIM	-8 ± 30	-4 ± 36	8 ± 33	5 ± 37	1 ± 30	- ± -	2 ± 29	- ± -	31 ± 42	65 ± 36
NIMT	6 ± 21	-4 ± 29	-11 ± 26	-24 ± 31	-18 ± 22	- ± -	-43 ± 21	- ± -	-67 ± 45	-61 ± 44
VMI	-16 ± 28	16 ± 34	24 ± 32	102 ± 36	88 ± 28	- ± -	16 ± 27	- ± -	5 ± 47	-259 ± 44
MSL	30 ± 38	19 ± 43	15 ± 41	23 ± 44	38 ± 38	- ± -	60 ± 39	- ± -	-15 ± 54	-13 ± 52
NPLI	- ± -	-1 ± 43	- ± -	-6 ± 48	23 ± 43	- ± -	-15 ± 48	- ± -	266 ± 101	296 ± 106

Xi-Xref 2*u(Xi-Xref)

(b) After convergence

Nominal Length [mm]	0.5	1.01	1.1	6	7	8	15	80	90	100
NMIA	13 ± 19	13 ± 28	12 ± 25	18 ± 30	14 ± 20	22 ± 27	0 ± 19	16 ± 29	-6 ± 36	3 ± 31
NIM	-3 ± 19	-2 ± 27	-3 ± 24	-4 ± 29	-8 ± 20	-7 ± 26	7 ± 18	2 ± 28	-1 ± 35	6 ± 29
SPRING	1 ± 28	9 ± 34	7 ± 31	24 ± 37	9 ± 30	17 ± 37	4 ± 33	42 ± 55	20 ± 60	22 ± 60
NMIJ	-5 ± 16	-14 ± 26	-17 ± 22	-18 ± 28	-12 ± 18	-16 ± 25	-8 ± 16	-20 ± 27	-11 ± 34	-14 ± 28
KRISS	3 ± 29	-3 ± 37	9 ± 37	9 ± 37	1 ± 30	-1 ± 34	-1 ± 28	-11 ± 39	-6 ± 39	2 ± 34
SIRIM	-7 ± 30	-4 ± 36	8 ± 33	15 ± 37	10 ± 30	- ± -	-2 ± 29	- ± -	27 ± 41	44 ± 35
NIMT	7 ± 21	-3 ± 29	-10 ± 26	-14 ± 31	-9 ± 22	- ± -	-47 ± 21	- ± -	-71 ± 45	-82 ± 43
VMI	-15 ± 28	16 ± 34	25 ± 31	112 ± 36	98 ± 28	- ± -	12 ± 27	- ± -	2 ± 47	-280 ± 43
MSL	32 ± 38	19 ± 43	16 ± 41	33 ± 44	47 ± 38	- ± -	56 ± 39	- ± -	-19 ± 54	-34 ± 52
NPLI	- ± -	0 ± 43	- ± -	4 ± 47	33 ± 43	- ± -	-19 ± 48	- ± -	263 ± 101	275 ± 106

(c) En number after convergence: Steel

Nominal Length [mm]	0.5	1.01	1.1	6	7	8	15	80	90	100
NMIA	0.65	0.48	0.50	0.59	0.71	0.83	0.00	0.56	-0.16	0.08
NIM	-0.15	-0.08	-0.14	-0.15	-0.41	-0.26	0.38	0.09	-0.03	0.20
SPRING	0.04	0.28	0.23	0.64	0.31	0.47	0.12	0.77	0.33	0.36
NMIJ	-0.30	-0.54	-0.77	-0.65	-0.66	-0.64	-0.53	-0.75	-0.33	-0.49
KRISS	0.09	-0.08	0.24	0.25	0.03	-0.04	-0.02	-0.27	-0.14	0.06
SIRIM	-0.23	-0.10	0.25	0.39	0.35		-0.05		0.66	1.25
NIMT	0.33	-0.11	-0.39	-0.44	-0.38		-2.25		-1.57	-1.90
VMI	-0.54	0.48	0.79	3.14	3.47		0.46		0.04	-6.46
MSL	0.84	0.46	0.39	0.74	1.24		1.44		-0.35	-0.66
NPLI		0.00		0.09	0.77		-0.39		2.60	2.60

Two gauge blocks were damaged during the international comparison. The damaged gauge blocks are "Steel 8mm" and "Steel 80mm" in nominal length. The damages look so significant. Therefore, NMIJ, the pilot laboratory of APMP-L.K1, decided not to use these two gauges in the rest of the circulation because additional damages for gauge block platens would be caused by using the damaged gauges. NPLI was unable to measure "Steel 0.5 mm" , "Steel 1.1 mm" and the left side of "Steel 1.01 mm" in nominal length due to some surface damages. The other standards showed some damage in the form of scratches and low level corrosion, but were still in an acceptable condition for interferometric measurements.

Fig. 19 En = (Xi-Xw)/(2*u(Xi-Xw)) : Steel gauges

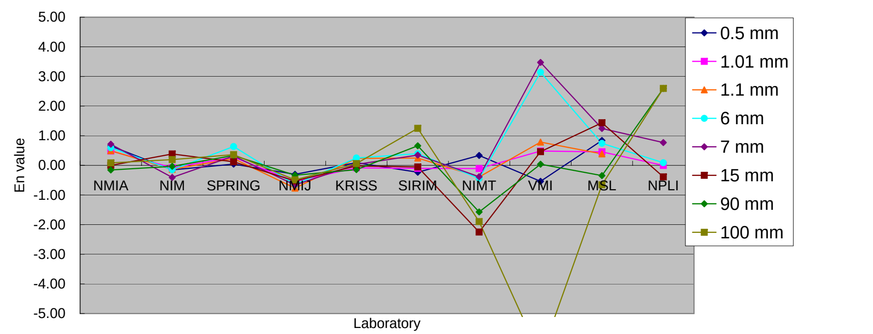


Table 23 Summary and En number for ceramic gauges

Xi-Xref 2*u(Xi-Xref)

(a) 1st (All institutes are used for Reference values)

Nominal Length [mm]	0.5	1	1.01	1.1	6	7	8	80	90	100
NMIA	11 ± 25	-7 ± 23	-4 ± 19	1 ± 21	-12 ± 19	20 ± 23	11 ± 23	36 ± 32	-32 ± 30	6 ± 32
NIM	-2 ± 26	-7 ± 25	-4 ± 21	-4 ± 23	-9 ± 21	8 ± 25	10 ± 25	44 ± 32	-31 ± 31	5 ± 32
SPRING	-15 ± 31	-11 ± 30	-5 ± 27	-12 ± 29	-15 ± 29	12 ± 32	7 ± 34	36 ± 55	-44 ± 55	-25 ± 59
NMIJ	2 ± 22	-10 ± 21	-4 ± 16	-2 ± 18	-13 ± 16	16 ± 21	7 ± 21	63 ± 30	-15 ± 29	20 ± 31
KRISS	-20 ± 33	-19 ± 32	-13 ± 29	-12 ± 31	-20 ± 31	0 ± 32	-4 ± 34	39 ± 36	-30 ± 34	3 ± 35
SIRIM	-4 ± 33	6 ± 32	-2 ± 29	1 ± 31	-1 ± 29	16 ± 32	22 ± 32	131 ± 38	77 ± 36	143 ± 38
NIMT	-18 ± 26	-19 ± 25	-3 ± 21	-13 ± 23	-21 ± 21	-12 ± 25	-11 ± 25	-20 ± 38	-107 ± 40	-88 ± 42
VMI	34 ± 31	92 ± 30	26 ± 27	43 ± 29	119 ± 27	-122 ± 30	-90 ± 30	-362 ± 40	179 ± 40	-191 ± 42
MSL	28 ± 41	25 ± 40	35 ± 37	21 ± 38	18 ± 37	30 ± 40	34 ± 40	50 ± 51	-22 ± 51	13 ± 53
NPLI	-7 ± 41	2 ± 40	3 ± 38	-7 ± 39	15 ± 41	13 ± 44	30 ± 44	-645 ± 86	274 ± 91	262 ± 97

Xi-Xref 2*u(Xi-Xref)

(b) After convergence

Nominal Length [mm]	0.5	1	1.01	1.1	6	7	8	80	90	100
NMIA	15 ± 24	2 ± 23	1 ± 18	6 ± 21	0 ± 19	11 ± 23	4 ± 23	-11 ± 31	-4 ± 29	-1 ± 31
NIM	2 ± 26	2 ± 25	1 ± 21	1 ± 23	3 ± 21	-1 ± 25	3 ± 25	-2 ± 31	-3 ± 30	-2 ± 31
SPRING	-11 ± 31	-2 ± 30	-1 ± 27	-7 ± 28	-3 ± 29	3 ± 32	0 ± 34	-11 ± 54	-16 ± 55	-32 ± 59
NMIJ	6 ± 22	0 ± 21	0 ± 15	3 ± 18	-1 ± 16	6 ± 21	1 ± 21	17 ± 29	13 ± 28	13 ± 30
KRISS	-16 ± 33	-10 ± 32	-8 ± 29	-7 ± 31	-8 ± 31	-9 ± 32	-11 ± 34	-7 ± 35	-3 ± 33	-4 ± 34
SIRIM	0 ± 33	15 ± 32	3 ± 29	6 ± 30	11 ± 29	6 ± 32	15 ± 32	85 ± 37	104 ± 35	136 ± 37
NIMT	-14 ± 26	-10 ± 25	1 ± 21	-8 ± 23	-9 ± 21	-22 ± 25	-18 ± 25	-66 ± 37	-80 ± 39	-95 ± 41
VMI	38 ± 31	101 ± 30	30 ± 27	48 ± 28	131 ± 27	-132 ± 30	-97 ± 30	-408 ± 39	207 ± 39	-198 ± 41
MSL	32 ± 40	34 ± 40	40 ± 37	26 ± 38	30 ± 37	21 ± 40	27 ± 40	3 ± 50	6 ± 51	6 ± 53
NPLI	-3 ± 41	11 ± 40	7 ± 38	-2 ± 39	27 ± 41	4 ± 43	23 ± 44	-691 ± 86	301 ± 91	255 ± 96

(c) En number after convergence: Ceramic

Nominal Length [mm]	0.5	1.01	1.1	6	7	8	15	80	90	100
NMIA	0.61	0.11	0.03	0.29	0.02	0.47	0.17	-0.34	-0.15	-0.02
NIM	0.08	0.10	0.02	0.05	0.13	-0.05	0.12	-0.07	-0.11	-0.06
SPRING	-0.35	-0.07	-0.04	-0.24	-0.09	0.08	0.01	-0.20	-0.30	-0.55
NMIJ	0.27	-0.02	-0.02	0.17	-0.07	0.29	0.03	0.59	0.45	0.44
KRISS	-0.47	-0.30	-0.30	-0.23	-0.27	-0.30	-0.33	-0.20	-0.08	-0.12
SIRIM	0.01	0.47	0.09	0.20	0.37	0.19	0.46	2.30	2.99	3.69
NIMT	-0.52	-0.40	0.05	-0.35	-0.44	-0.89	-0.71	-1.79	-2.06	-2.33
VMI	1.21	3.33	1.12	1.69	4.86	-4.38	-3.18	-10.53	5.33	-4.84
MSL	0.79	0.86	1.06	0.67	0.80	0.52	0.69	0.07	0.11	0.12
NPLI	-0.07	0.28	0.19	-0.05	0.66	0.08	0.53	-8.07	3.33	2.65

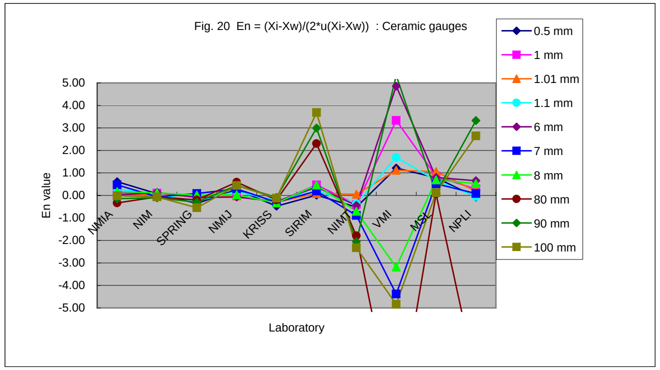


Table 24 Measurement instruments and conditions reported by the participating laboratories

Laboratory	Make and Type of interferometer	Light sources / Wavelengths used	Method of fringe fraction determination	Method used for determination of refractive index of the air	Range of gauge block temperature during measurements	Material of reference flats: for steel and ceramics	Phase correction applied: for steel and ceramics
NMIA	Hilger Watts Gauge measuring interferometer TN190.2 modified for video output and laser light source	Iodine stabilised lasers at 633 nm and 543 nm ($1*10^{-9}$ frequency stability)	Manual selection of fringe position / automatic determination of fringe fraction	Direct measurement of temperature, pressure and humidity. Refractive index determined using Edlen's equations as modified by Birch and Downs and Ciddor (Applied Optics. V35, No.9, p1566-73, 1996)	19.9 C to 20.0 C	for steel: steel for ceramic: steel	for steel: -6 nm (roughness difference) [platen 9 nm / gauge 3nm] for ceramic: -18 nm [platen 9 nm / gauge 11 nm / dielectric -20 nm]
NIM	An improved Koester interferometer made by Carl Zeiss, the former East Germany	A Lamb dip frequency stabilized He-Ne laser (wavelength in vacuum = 632.99142 nm)	to take the interference pattern by CCD camera and to determine the fringe fraction by computer with a special program.	The refractive index of air is determined by measuring the properties affecting the density of air, and then calculating the index using a modified version of the Edlen equation.	19.9 C to 20.1 C	for steel: glass for ceramic: glass	for steel : +58.9 nm for ceramic: +35.9 nm
SPRING	NPL-TESA Twyman Green Automatic Gauge Block Interferometer	Red and green He-Ne lasers / Two wavelength used (633 nm and 543 nm)	The fringe fraction was determined by an automatic fringe displacement system. The extracted displacement intensity profile from the image was measured by a simple image analyzer, followed by the computing of the fringe fraction.	The refractive index of the air was determined by measuring the air temperature, pressure and humidity, and applying the Edlen equation. (Reference: Metrologia, 1997, 34, 479-493)	19.832 C to 20.052 C	for steel: steel for ceramic: ceramic	for steel: -25.95 nm to -31 nm for ceramic: -28.36 nm to -31.12 nm
NMIJ	NRLM-Tsugami GB interferometer based on Twyman-Green's interferometer	633 nm He-Ne laser Isotope lamp of ^{198}Hg: 4 wavelengths are available	Manual positioning of the fringe between reticles by moving optical wedge and position measurements by a displacement transducer	The refractive index of the air is determined by using Ciddor's equation (Applied Optics, Vol.35, No.9, pp.1566-1573 (1996). The environmental data of air temperature, air pressure, dew point and CO2 content in the equipment were measured.	19.825 C to 20.262 C	for steel: glass for ceramic: glass	for steel: +12.1 nm to +51.3 nm for ceramic: +25.7 nm to +52.7 nm
KRISS	1. Make: Modified Tsugami (NRLM-Tsugami Gauge Block Interferometer) 2. Twyman-Green type 3.Range = 0.5 mm to 250 mm	Two spectral lams are used (1) Cd lamp: 0.6440, 0.5087, 0.4801, 0.4679 um: for gauges less than 10 mm (2) Hg isotope lamp: 0.5792, 0.5771, 0.5462, 0.4360 um: for gauges longer than 10 mm	FFT (Fast Fourier Transform) method has been applied to the intensity variation of three fixed points on the interferogram, one on the gauge block, and two on the platen.	The refractive index of air is calculated with the modified Edlen's formula by using the measured data of temperature, relative humidity, pressure, and CO2 density of the air inside the interferometer	19.937 C to 20.042 C	for steel: steel for ceramic: ceramic	for steel: +1.1 nm to +6.1 nm for ceramic: -1.5 nm to +1.9 nm
SIRIM	NPL-TESA gauge block interferometer based on Twyman-Green Interferometer	Two frequency-stabilised He-Ne lasers with wavelengths 633 nm and 543 nm were used. These lasers were traceable to NPL-made iodine-stabilised He-Ne lasers at NMC-SIRIM Berhad.	The gauge blocks were calibrated by interferometric measurement using the exact-fraction method. Platens with surface finish similar to the gauge block surface were used for wringing the gauge blocks: for steel gauge blocks, steel platen was used; for ceramic gauge blocks, ceramic platen was used. First surface 'left' was wrung onto the platen and positioned vertically in interferometer chamber. Interference fringes were observed using a CCD camera linked to a PC. The gauge blocks were conditioned imside the chamber for at least 15 hours. After stabilisation, a series of measurement consisting of not less than three length determinations was carried out using the computer software supplied with the interferometer system. Corrections due to temperature, humidity and atmospheric pressure were automatically calculated gy the computer software. The above procedure was repeated with 'right' surface wrung onto the platen. Results for 'wring left' and 'wring right' were obtaind from average of three measurements. The phase correction were measured with 4 gauge blocks.	The refractive index of air was calculated using the Edlen formula. Data from air temperature probe, pressure transducer and dew point meter were input to the computer automatically.	(1) For steel gauge blocks: gauge temp range: 19.800 C to 20.050 C air temp range: 19.943 C to 20.291 C (2) For ceramic gauge blocks: gauge temp range: 19.806 C to 20.144 C air temp range: 20.047 C to 20.442 C	for steel: steel for ceramic: ceramic	for steel : -29 nm for ceramic: -18 nm
NIMT	Mitutoyo, Michelson Interferometer, model: GBI	Stabilized He-Ne laser / Wavelength used 632.990867 nm	Computerized phase difference angle determination with "8-point Average 4-slit" method	Modified Edlen equation	20.1337 C to 21.1382 C	for steel: steel for ceramic: steel	for steel : 0 nm for ceramic: -20 nm
VMI	The gauge blocks are wrung onto a glass platen and measured by an interferometer-Michelson type with on laser source. As the first step before a measurement by the interferometer, the measurement of gauge blocks by a contact interferometer was made to pre-determine the central length of gauge blocks with uncertainty U= (0.05 + 1L) um; [L]:m	He-Ne stabilized laser source wavelength 632.911373 nm	The fringe fraction are measured by CCD camera and frame grabber of image processor.	The refractive index of air, n, is determined by the Edlens's equation using the measured values of air temperature, atmospheric pressure and water vapor pressure of air.	The temperature of gauge blocks was within (20.0+-0.5) C. The temperature change during a measurement is less than 0.02 C. The temperature of the gauge block is measured two times, at the start and at the end of the measurement.	for steel: Glass platen for ceramic: Glass platen	for steel : 9 nm for ceramic: 37 nm
MSL	NPL Hilger Type TN 190.2 gauge block interferometer. This is a Fizeau type interferometer and has been modified to include a fibre optic feed for the laser light, a video camera to observe the fringe pattern, and motors to select the wavelength and gauge block. All this is done under computer control. [1]	HP5500C Zeeman stabilised helium-neon laser, wavelength in vacuum = 632.991405 nm. Mercury-198 lamp, green line, wavelength in vacuum = 546.22705 nm Note: The Mercury lamp green line is only used to determine the fringe order. The gauge length is calculated from the fringe fraction obtained from the laser source.	The interference pattern viewed by the video camera is displayed on the computer screen. The operator places three computer generated moveable cross hairs on the image, one on the central gauge fringe and two on the platen fringes immediately adjacent to the gauge fringe. The fringe fraction is determined from the position of the cross hairs.	Calibrated sensors measure air temperature, pressure and humidity fefore and after ezch fringe measurement. The revised Edlen equations given in [2] are used to calculate the refractive index of the air.	For gauges less than or equal to 15 mm the gauge temperature was in the range 19.80 C to 20.25 C. For gauges greater than 15 mm the gauge temperature was in the range 19.95 C to 20.05 C.	for steel: steel for ceramic: steel	for steel : -32 nm for ceramic: -29 nm
NPLI	NPL-HILGER GAUGE INTERFEROMETER MODEL TN-180	Cd-114 ISOTOPIC LAMP MONOCROMATIC WAVE LENGTHS RED, GREEN, BLUE & VIOLET	EYE ESTIMATION	FOR REFRACTIVITY AS PER AMBIENT AIR CONDITIONS TAKEN FROM TABLES SUPPLIED BY NPL, TEDDINGTON, UK	19.52 C to 20.45 C UNCERTAINTY BUDGET BASED ON 20+-0.5 C	for steel: TUNGSTEN CARBIDE for ceramic: TUNGSTEN CARBIDE	for steel : +15 nm for ceramic: +10 nm

[1] E.F.Howick and C.M. Sutton, Improvements to a 1960's Hilger gauge block interferometer, in Recent Developments in Optical Gauge Block Metrology, SPIE Proceedings 3477
[2] R. Muijlwijk, Update of the Edlen Formulae for the Refractive Index of Air, Metrologia 25, 189 (1988)

Table 25 Summary of measurement uncertainty: (a)steel, (b) ceramic

Standard uncertainty u(L) = [a, b*L] = SQRT(a^2+(b*L)^2)

(a) steel

Coeff.	a	b	Length (m)	0.0005	0.00101	0.0011	0.006	0.007	0.008	0.015	0.08	0.09	0.1
NMIA	0.0097	0.123		0.0097	0.0097	0.0097	0.00973	0.00974	0.00975	0.00987	0.01382	0.01472	0.01566
NIM	0.01096	0.0974		0.01096	0.01096	0.01096	0.01098	0.01098	0.01099	0.01106	0.01345	0.01403	0.01466
SPRING	0.0144	0.26		0.0144	0.0144	0.0144	0.01448	0.01451	0.01455	0.01492	0.0253	0.02748	0.02972
NMIJ	0.0086	0.114		0.0086	0.0086	0.0086	0.00863	0.00864	0.00865	0.00877	0.01254	0.01339	0.01428
KRISS	0.014	0.09		0.014	0.014	0.014	0.01401	0.01401	0.01402	0.01406	0.01574	0.01617	0.01664
SIRIM	0.015	0.1		0.015	0.015	0.015	0.01501	0.01502	0.01502	0.01507	0.017	0.01749	0.01803
NIMT	0.01052	0.19		0.01052	0.01052	0.01052	0.01058	0.0106	0.01063	0.0109	0.01849	0.02008	0.02172
VMI	0.014	0.173		0.014	0.014	0.014	0.01404	0.01405	0.01407	0.01424	0.01969	0.02094	0.02226
MSL	0.0194	0.17		0.0194	0.0194	0.0194	0.01943	0.01944	0.01945	0.01957	0.02369	0.02471	0.02579
NPLI	0.019	0.34		0.01917	0.01934	0.01937	0.02104	0.02138	0.02172	0.0241	0.0462	0.0496	0.053

(b) ceramics

Coeff.	a	b	Length (m)	0.0005	0.001	0.00101	0.0011	0.006	0.007	0.008	0.08	0.09	0.1
NMIA	0.0097	0.117		0.0097	0.0097	0.0097	0.0097	0.00973	0.00973	0.00975	0.01348	0.01432	0.0152
NIM	0.01217	0.0876		0.01217	0.01217	0.01217	0.01217	0.01218	0.01219	0.01219	0.01404	0.0145	0.01499
SPRING	0.0144	0.25		0.0144	0.0144	0.0144	0.0144	0.01448	0.01451	0.01454	0.02464	0.02671	0.02885
NMIJ	0.0086	0.114		0.0086	0.0086	0.0086	0.0086	0.00863	0.00864	0.00865	0.01254	0.01339	0.01428
KRISS	0.014	0.09		0.014	0.014	0.014	0.014	0.01401	0.01401	0.01402	0.01574	0.01617	0.01664
SIRIM	0.015	0.09		0.015	0.015	0.015	0.015	0.01501	0.01501	0.01502	0.01664	0.01705	0.01749
NIMT	0.01052	0.17		0.01052	0.01052	0.01052	0.01052	0.01057	0.01059	0.01061	0.01719	0.01857	0.01999
VMI	0.014	0.15		0.014	0.014	0.014	0.014	0.01403	0.01404	0.01405	0.01844	0.01945	0.02052
MSL	0.0194	0.17		0.0194	0.0194	0.0194	0.0194	0.01943	0.01944	0.01945	0.02369	0.02471	0.02579
NPLI	0.019	0.29		0.01915	0.01929	0.01929	0.01932	0.02074	0.02103	0.02132	0.0422	0.0451	0.048

This table shows the calculated uncertainties by the formulae with [a, b*L] format, which is equal to SQRT(a^2+(b*L)^2).

Blue cells mean some difference between the formulae and the uncertainty reported with the central lengths.
Light blue cells mean slight difference between the formulae and the uncertainty reported with the central lengths.

NPLI represent the formulae with a+b*L format.

The pilot's comments:
For the MRA we show u(L) and this is what we hope to demonstrate in the Key Comparison. Unfortunately the Technical Protocol did not specifically ask participants to state their uncertainty this way, although many did. I have attempted to extract the a and b coefficients from the informatiuon supplied and this is shown in the table. Please check your values and let me know if you want a change.

KRISS's comments:
The combined standard uncertainty of gauge block calibration by interferometry in KRISS is based on equation Q[0.014, 0.090L].
In some cases when the parallelism of the gauge block seems to be not so good, then the uncertainty value might be slightly increased according to the amount of the parallelism.

NIM's comments:
There are some difference between the formulae and the uncertainty reported with the central lengths in our report. The reason is that the effection for variation in length of gauge block is depending on its nominal length. But it is not linear. Your report use its maximum length(L=100mm) in the formulae. The uncertainty of results reported by us is calculated in individual value. We think it is more reasonable then using maximum length.

Table 26 Birge ratio: (a)steel, (b) ceramic

(a) Steel

Gauge Length [mm]	0.5	1.01	1.1	6	7	8	15	80	90	100
Birge Ratio	0.74	0.90	1.22	1.37	1.10	1.57	0.64	1.30	0.79	0.63
consistent RB less than	1.44	1.41	1.44	1.44	1.44	1.55	1.44	1.55	1.47	1.55

Steel 8mm and 80 mm are not used because of damage

(b) Ceramic

Gauge Length [mm]	0.5	1	1.01	1.1	6	7	8	80	90	100
Birge Ratio	0.93	0.62	0.27	0.49	0.68	0.94	0.88	0.83	0.59	0.73
consistent RB less than	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.55	1.55	1.55

Table 27 BIPM

Xi-Xref 2*u(Xi-Xref)

(a) Steel

Nominal Length [mm]	0.5	1.01	1.1	6	7	15	90	100
NMIA	13 ± 19	13 ± 28	12 ± 25	17 ± 30	14 ± 20	0 ± 19	-6 ± 36	3 ± 31
NIM	-3 ± 19	-2 ± 27	-3 ± 24	-5 ± 29	-8 ± 20	7 ± 18	-1 ± 35	6 ± 29
SPRING	1 ± 28	9 ± 34	7 ± 31	23 ± 36	9 ± 30	4 ± 29	20 ± 60	22 ± 60
NMIJ	-5 ± 16	-14 ± 26	-17 ± 22	-18 ± 28	-12 ± 18	-8 ± 16	-11 ± 34	-14 ± 28
KRISS	3 ± 29	-3 ± 37	9 ± 37	9 ± 37	1 ± 30	-1 ± 28	-6 ± 39	2 ± 34
SIRIM	-7 ± 30	-4 ± 36	8 ± 33	14 ± 37	10 ± 30	-2 ± 29	27 ± 41	44 ± 35
NIMT	7 ± 21	-3 ± 29	-10 ± 26	-14 ± 31	-9 ± 22	-47 ± 21	-71 ± 45	-82 ± 43
VMI	-15 ± 28	16 ± 34	25 ± 31	112 ± 36	98 ± 28	12 ± 27	2 ± 47	-280 ± 43
MSL	32 ± 38	19 ± 43	16 ± 41	32 ± 44	47 ± 38	56 ± 39	-19 ± 54	-34 ± 52
NPLI	- ± -	0 ± 43	- ± -	4 ± 47	33 ± 43	-19 ± 48	263 ± 101	275 ± 106

Two gauge blocks were damaged during the international comparison. The damaged gauge blocks are "Steel 8mm" and "Steel 80mm" in nominal length. The damages look so significant. Therefore, NMIJ, the pilot laboratory of APMP-L.K1, decided not to use these two gauges in the rest of the circulation because additional damages for the other gauges would be caused by using the damaged gauges. NPLI was unable to measure "Steel 0.5 mm", "Steel 1.1 mm" and the left side of "Steel 1.01 mm" in nominal length due to some surface damages.
The other standards showed some damage in the form of scratches and low level corrosion, but were still in an acceptable condition for interferometric measurements.

(b) Ceramic

Nominal Length [mm]	0.5	1	1.01	1.1	6	7	8	80	90	100
NMIA	15 ± 24	2 ± 23	1 ± 18	6 ± 21	0 ± 19	11 ± 23	4 ± 23	-11 ± 31	-4 ± 29	-1 ± 31
NIM	2 ± 26	2 ± 25	1 ± 21	1 ± 23	3 ± 21	-1 ± 25	3 ± 25	-2 ± 31	-3 ± 30	-2 ± 31
SPRING	-11 ± 31	-2 ± 30	-1 ± 27	-7 ± 28	-3 ± 27	3 ± 32	0 ± 32	-11 ± 52	-16 ± 55	-32 ± 61
NMIJ	6 ± 22	0 ± 21	0 ± 15	3 ± 18	-1 ± 16	6 ± 21	1 ± 21	17 ± 29	13 ± 28	13 ± 30
KRISS	-16 ± 33	-10 ± 32	-8 ± 29	-7 ± 31	-8 ± 31	-9 ± 32	-11 ± 34	-7 ± 35	-3 ± 33	-4 ± 34
SIRIM	0 ± 33	15 ± 32	3 ± 29	6 ± 30	11 ± 29	6 ± 32	15 ± 32	85 ± 37	104 ± 35	136 ± 37
NIMT	-14 ± 26	-10 ± 25	1 ± 21	-8 ± 23	-9 ± 21	-22 ± 25	-18 ± 25	-66 ± 37	-80 ± 39	-95 ± 41
VMI	38 ± 31	101 ± 30	30 ± 27	48 ± 28	131 ± 27	-132 ± 30	-97 ± 30	-408 ± 39	207 ± 39	-198 ± 41
MSL	32 ± 40	34 ± 40	40 ± 37	26 ± 38	30 ± 37	21 ± 40	27 ± 40	3 ± 50	6 ± 51	6 ± 53
NPLI	-3 ± 41	11 ± 40	7 ± 38	-2 ± 39	27 ± 41	4 ± 43	23 ± 44	-691 ± 86	301 ± 91	255 ± 96

Reference values were calculated as weighted mean values excluding measurement values with ablolute En larger than one and of MSL.
Red cells mean that the absolute En numbers of the gauges for the institutes are lager than one or MSL.
Orange cells mean MSL's values with absolute En numer equal to or less than one.
Yellow cells mean that the measurements were unable because of some gauge damage.

Table 28 Comments on DraftA-V1 of APMP.L-K1

Mailing list S/N	Name of responder	NMI of responder	Comments	The pilot's comments
[apmp.l-k1: 00004]	Kang	KRISS	(1) For the uncertainty reporting, KRISS did not give the "a", "b" values for Q[a,b] format, which were not required formally. The combined standard uncertainty of gauge block calibration by interferometry in KRISS is based on equation Q[0.014, 0.090L]. In some cases when the parallelism of the gauge block seems to be not so good, then the uncertainty value might be slightly increased according to the amount of the parallelism.	Your explanation is added in the excel worksheet of "Uncertainty" of Appendix B.
[apmp.l-k1: 00007]	Nick	NMIA	(1) I think you have adopted a very reasonable approach using a weighted mean and excluding from the weighted mean those with En values > 1. This appears to have worked quite well. One problem with this approach is that the En value of the excluded participants become larger, because they no longer pull the reference value towards themselves. Of course this effect can be reduced a bit by re-calculating their U(DL) uncertainty which should no longer have the -uext uncertainty included. I tried this on the marginal cases but it didn't make a significant difference to their En value. In fact there aren't many marginal cases anyway and I think this justifies your approach.	Thanks for the comment.
			(2) Some labs appear to have a problem with longer gauges (temperature problems?). One lab has a problem with ceramic gauges. Most of these problems appear near the end of the comparison when the gauges were becoming scratched, so we should factor this in when looking at results that are just outside the En = 1.0 value.	The pilot remains the procedure of exclusion because it is difficult to set up another threshold of En>1.5, 1.2 or so.
			(3) Ruedi Thalmann (CCL K1 pilot) was not prepared to exclude anyone from the reference value except where participants hadn't complied with the technical protocol, so while I agree with your analysis, I think it is very important that all participants send an OK to draft A before draft B is released, particularly as January is a popular month for holidays in many countries.	The pilot asks all participants to send back "OK" for the DraftA-V2 which adopts the the determination of reference value with exclusion of En>1.
			(4) Once agreement has been reached on draft A, we should follow the lead of the WGDM and produce a report on outcomes. This should be the responsibility of the TCL although the pilot can put a first draft together. I think an easy way of doing this would be to ask all participants to comment on their results and if their results don't justify their claimed uncertainties, what they wish to do about it. This is an opportunity to help each other with bi-laterals and extra training etc.	After we reach an agreement on DraftA-V2, TCL and the pilot will begin to produce a report on outcomes. The pilot will arrange a follow-up comparison of APMP-LK1 on request.

			(5) I have checked through your calculations and the entries for CSIRO are all correct. I am quite happy with the En values we have recorded. Since taking part in this comparison we have changed our CMC uncertainty claim from Q[0.0097, 0.123 L] steel Q[0.0097, 0.117 L] ceramic (as in your report) to Q[0.019, 0.10 L] for all materials. As this increases our uncertainties for gauges in this comparison our En values would be reduced a small amount, so I feel the comparison supports our current claims.	The pilot remains the uncertainty of CSIRO in APMP-LK1. It supports the current CMC claims of CSIRO.
[apmp.l-k1: 00013]	Eleanor	MSL	(1) MSL's results show a consistent offset from the reference value. On average, our measurements are 21 nm higher than the reference values. After examining our records of the comparison, I have found we made a mistake, as we did not include the phase corrections in our reported results. We determined the phase corrections for both the steel and ceramic sets by wringing stacks. We then applied the corrections to our results. I then did some more analysis with the uncorrected results and I mistakenly (stupidly, I'm still kicking myself) managed to put the uncorrected results into the final report. Our steel gauge block reported results are therefore 32 nm too large and our ceramic gauge block reported results are 29 nm too large. The values for these phase corrections were included in the report but were not actually applied to our reported length measurements.	Thanks for your explanations. Your situation is understood very well.
			(2) I understand that the Guidelines for comparisons make it difficult to change comparison results at this stage, but I would still appreciate this change being considered by the comparison participants. Alternatively, could this correction be noted in the comparison discussion or elsewhere?	I think that the example of CCL-K1 is a similar case as refered by Nick. The proposal of the pilot is as follows: 1. The values of MSL are excluded for the determination of reference values. 2. Your values remain in the report for information. They will be good evidences for your competence on peer review. 3. Your situation is described in the report of DraftA-V2 (in Draft B as well). The description will another good evidence on peer review.

			(3) MSL's quality system requires that I reissue a report after finding a mistake of this kind. To do this, I need NMIJ to return the original copy of the report I sent. I will mark it "withdrawn", issue a corrected version and send both reports (withdrawn original, corrected new report) back to NMIJ.	NMIJ will send your original report. The pilot understands your situation based on your quality system. The pilot will receive the both reports (withdrawn original, corrected new report). However, the withdrawn original will be still alive for APMP-LK1 because the withdrawal is not accepted from the view point of MRA guideline. The phase correction values of 32 nm and 29 nm will be clearly described in the APMP-LK1 DraftA-V2 and DraftB. Technical experts will easily understand MSL's technical competence as well as good corrective action for quality system.
[apmp.l-k1: 00014] (Re:00013)	Nick	CSIRO	(1) CCL had a similar situation in CCL K1 where two participants did not apply phase corrections The pilot, Ruedi Thalmann wrote: A2.4 Exclusion of results contributing to the reference values Before calculating the reference values, it must be assured, that there are no "outliers" or erroneous results which may significantly bias the reference value. Looking at the graphical representations in figures 4 and 5 and the histograms in figure 8, no single value can be identified to be clearly outlying. The results of VNIIM for the tungsten carbide gauge blocks show an average deviation of -30.8 nm with respect to the mean of the other laboratories. The physical reason is the phase correction, which has not been applied, although quartz platens were used to wring the tungsten carbide gauge blocks. The CCL Working Group Dimensional Metrology (WGDM) pointed out, that this procedure did not comply with the technical protocol and the requirements of the international standard ISO 3650 and that a non-corrected value represents a different measurand. According to chapter 5, phase corrections were also not applied by VNIIM for stee although with a much smaller effect on the results, since the material of the platens used was the same. The WGDM therefore decided, that these laboratories were consequently to be excluded from the determination of the reference value for both materials.	Thanks for the good comment. CCL-K1's example is very similar. So, the pilot has made a proposal mentioned above for MSL's case.
			(2) So I think the correct course would be to exclude MSL from the reference value, but publish their results as reported and explain that they did not apply the phase correction. I don't think MSL's results are disastrous, and they can ask the technical assessor to take their correct results into account when being assessed. He will obviously be interested in their corrective actions!	The pilot agrees with the comment.
			(3) If IRL had discovered this error before Draft A was circulated they are allowed to make corrections. There is scope for the pilot to alert them if their results look anomalous, and I think we should ask our pilots to be a bit more proactive and warn people as soon as they have any suspicions. In this case the results were not obviously odd so I guess no action was taken.	The pilot did not warn MSL for the offsets because the offsets were not so large. The pilot warned four NMI's, which did not include MSL, for their anomalous values.

			(4) It would be nice to simply correct their results and include an explanation, but this hasn't been the practise in the past. The MRA allows participants to withdraw results if there is a "clear failure of the standard". See section 9 of the MRA guidelines: If, on examination of the complete set of results, the pilot institute finds results that appear to be anomalous, the corresponding institutes are invited to check their results for numerical errors but without being informed as to the magnitude or sign of the apparent anomaly. If no numerical error is found the result stands and the complete set of results is sent to all participants. Note that once all participants have been informed of the results, individual values and uncertainties may be changed or removed, or the complete comparison abandoned, only with the agreement of all participants and on the basis of a clear failure of the travelling standard or some other phenomenon that renders the comparison or part of it invalid.	The pilot has made a proposal as mentioned above.
			(5) I hope that helps! We at NML have had our own errors and mishaps in KCs and have looked carefully at this side of things. If there is a strong feeling that the "clear failure of the standard" is too severe then we should discuss this at the next WGDM meeting.	There would be some discussion at the next WGDM meeting.
[apmp.l-k1: 00016]	Ahmad	SIRIM	(1) I have checked SIRIM measurement result and found all of them entered correctedly. As you can see from the SIRIM intercomparison result, the En values calculated for length 100 mm(steel gb) and 80, 90 and 100 mm (ceramic gb) are larger than one. Based on the interferometer software, for gauge less than 200 mm, the interferometer software which I used previously calculated the central length based on temperature reading of the platen. This setting may be correct when difference between gauge and air temperature in chamber is very small. Upon checking my raw data, I realised that the temperature difference between the gauge block and air are significantly large particularly when measuring ceramic gb. For gauge block of length 80,90,100 mm, such large temperature difference between gauge and air might introduce temperature gradient along the gauge length, and platen temperature may not be sufficient for calculating gauge length. I think that could be the main reason for such large En. (Note: We experience Air Cond problem during measurement)	Thanks for your explanations. Your situation is understood very well. Your explanations will be included in DraftA-V2 and DraftB.
			(2) I think bilateral/trilateral intercomparison is neccessary for economies that found their En exceeding one. Any lab willing to participate?	The pilot will arrange a follow-up comparison on request.
[apmp.l-k1: 00018]	Gao	NIM	(1) There are some difference between the formulae and the uncertainty reported with the central lengths in our report. The reason is that the effection for variation in length of gauge block is depending on its nominal length. But it is not linear. Your report use its maximum length(L=100mm) in the formulae. The uncertainty of results reported by us is calculated in individual value. We think it is more reasonable then using maximum length.	Your explanation is added in the excel worksheet of "Uncertainty" of Appendix B.