**AFRIMETS.L-S6 Supplementary Comparison**

**Comparison on Hand Instruments**

**(50mm Micrometer setting piece, 0-25mm and 50-75mm External Micrometers)**

# Final Report

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## Table of Contents



## 0. Document Control

Draft A.1 Issued October 2022

Draft A.2 Report Issued March 2023

*Key Changes*

- *Correction of artefacts resolution in table 3, Correction of NSI Acronym, Removal of NSI data points measured on wrong nominal values based on information and request from Sheehama Pandulo, NSI*
- *Addition of information to the conclusion, recommendation and acknowledgement sections according to comments from Oelof Kruger, NMISA*

# 1 Introduction

## 1.1 Background

Following the decision of a Southern African Development Community in Measurement Traceability (SADCMET) meeting held in South Africa in 2018 as per SADCMET strategic plan, Zimbabwe's Scientific and Industrial Research and Development Centre's National Metrology Institute (SIRDC-NMI) hosted a Dimensional Interlaboratory Comparison training workshop from the 11th to the 13th of February 2019. The workshop was sponsored by Physikalisch Technische Bundesanstalt (PTB), Germany [1]. It is during this period that the SADCMET Technical Committee for Length agreed to start comparisons in different parameters and artifacts.

The parameters chosen included Hand instruments (External Micrometers). Two micrometers were chosen in order to cover the accreditation range of most of the participating National Metrology Institutes (NMIs). It was further agreed that the intercomparison be upgraded to AFRIMETS level in order for one of the objectives, registration of Calibration and Measurement Capabilities (CMCs) in the International Bureau of Weights and Measures Key Comparison Data Base (BIPM KCDB) to be fulfilled. The comparison was registered in the KCDB as AFRIMETS.L-S6.

The technical protocol for the comparison was drafted in consultation with the participants following the guidelines established by the BIPM [2, 3]. The comparison project was funded by PTB.

## 1.2 Objectives

The objectives of the comparison were to:

- Assess the equivalence of the hand instruments (External Micrometers) calibration among the participants and to underpin the relevant claim of the Calibration and Measurement Capability in the International Bureau of Weights and Measures Key Comparison Data Base (BIPM KCDB).
- Enable the participating NMIs to meet the requirements of ISO17025:2017 international accreditation
- Serve as a tool for procedure and method validation and to
- Ensure harmonization of standards and demonstrate measurement uniformity of SADC NMIs.

# 2 Organisation

## 2.1 Participants

Zimbabwe's Scientific and Industrial Research and Development Centre National Metrology Institute (SIRDC-NMI) acted as the pilot laboratory among the participants in the comparison. The participating institutes were Zimbabwe (SIRDC NMI), National Metrology Institute of South Africa (NMISA), Zambia Metrology Agency (ZMA), Malawi Bureau of Standards (MBS), Namibian Standards Institution (NSI), Mauritius Standards Bureau (MSB), Botswana Bureau of Standards (BOBS), Tanzania Bureau of Standards (TBS), Mozambique Instituto Nacional de Normalizacao e Qualidade (INNOQ)[1]. All the participants were supposed to demonstrate traceability to an independent realization of the SI unit of length, the meter or make clear the route of traceability to SI unit, the meter via another named laboratory [1, 2]. The laboratories accepted the general instructions written down in the technical protocol SADCMET ILC/LEN-003/2019. Later changes to the protocol such as the change in schedule due to COVID 19 pandemic was made with prior agreement of all the participants. A closing workshop organized by SADCMET RC and sponsored by PTB was held from 8-11 August 2022 in Dar es Salaam to discuss the analysis of the Intercomparison results.

**Table 1 : List of participating laboratories**

| | Participant | Correspondence | E-mail Address<br>Phone number | Address |
|---|---|---|---|---|
| 1 | SIRDC (Zimbabwe) (Pilot) | Burnhard Panda Gandah | Email: bgandah@sirdc.ac.zw / burnhardg@gmail.com<br>Tel:+263242860346/ +263778330014 | SIRDC National Metrology Institute, 1574 Alpes Road, Hatcliffe, Harare |
| 2 | NMISA (South Africa) | Oelof Kruger (AFRIMETS TCL Chair)<br>Zanele Nzimande | Email: okruger@nmisa.org<br>Email: znzimande@nmisa.org<br>Tel: 012 841 3057 | NMISA, Bldg 5, CSIR, Meiring Naude Road - South Africa |
| 3 | MBS (Malawi) | Truwe Munkhondya | Email: truwemunkhondya@mbsmw.org<br>+265993202760 | Malawi Bureau of Standards, Blantyre, Malawi |
| 4 | MSB (Mauritius) | Tomeswar Pryam | Email: T_Pryam@ msbmu.onmicrosoft.com<br>Tel: +23057689595 | Mauritius Standards Bureau<br>Villa Road, Moka |
| 5 | INNOQ (Mozambique) | Emidio Mulchande | Email: emulcha@gmail.com<br>Tel:+258 21 344 600 / | Av. de Moçambique, Parcela 7168/D1/7 Bairro, Zimpeto, Maputo, Mozambique |
| 6 | NSI (Namibia) | Sheehama Pandulo | Email: PanduloS@nsi.com.na | 205 Gold Street, Windhoek, Namibia |
| 7 | TBS (Tanzania) | Angela K Charles | Email: angela.charles@tbs.go.tz<br>Tel: +255714215038 | Tanzania bureau of standards, Ubungo, Sam Nujoma – Morogoro road junction, Dar es salaam |
| 8 | ZMA (Zambia) | Natasha Sichone | Email: sichonenatasha@gmail.com<br>Tel: +260968862190 | HQ Plot #2387 Longo-longo Road P.O BOX 30989 Lusaka, Zambia |
| 9 | BOBS (Botswana) | Ntima Pamidzani | Email: ntima@bobstandards.bw<br>+26772607660 | BOBS, Botswana Bureau of Standards, Private Bag BO48, Main Airport Road, Plot No. 55745, Gaborone - Botswana |

## 2.2 Form of comparison

The comparison was primarily carried out through calibration of the artifacts which are 2 external micrometers (range: 0-25 mm and 50-75mm). The sequence of measurements was as in table 2. The comparison consisted of one round. Every Laboratory was to have a period of one month in which to i) receive the artifact ii) perform measurements and iii) send the artifacts to the next participant. However there were some changes to the schedule due to covid-19 protocols.

## 2.3 Time Schedule

The commencement date of the intercomparison was July 2019 when NMISA took the first measurements. Malawi was the last laboratory in the loop to take measurements. After all laboratories had taken measurements, the artefacts were send to NMISA for measurements to check the stability of the artefacts. During the Virtual AFRIMETS TCL meeting held in 2021, it was further agreed that participants should start submitting results to the pilot lab soon after the participant had taken measurements. When measurements were completed participants were given deadline date for submitting the results.

**Table 2: Actual Schedule of Comparison**

| **COUNTRY/ LAB** | **DATE** |
|---|---|
| South Africa (NMISA) | 08/07/2019 |
| Mauritius (MSB) | 16/09/2019 |
| Tanzania (TBS) | 09/10/2019 |
| Zambia (ZMA) | 24/01/2020 |
| Zimbabwe (SIRDC) | 30/05/2020 |
| Botswana (BOBS) | 30/06/2020 |
| Namibia (NSI) | 07/10/2020 |
| Mozambique (INNOQ) | 13/04/2021 |
| Malawi (MBS) | 07/07/2021 |
| South Africa (NMISA) | 13/01/2022 |

## 3 Description of Artefacts

PTB sponsored the purchase of artifacts. NMISA was tasked to source for the artefacts. The artefacts were 2 external micrometers shown in figure 1.1 and figure 1.2, and a 50mm micrometer setting piece shown in Figure 1.2.

**Figure 1.1** : Photograph of the 0-25mm micrometer

**Figure 1.2** : Photograph of the 50-75 mm micrometer.


Table 3 shows the range, resolution as well as the thermal expansion coefficient of the artifacts

| **Artefact** | **Make** | **Serial Number** | **Range (mm)** | **Resolution (mm)** | **Expansion Coefficient ($10^{-6}$/K)** |
|---|---|---|---|---|---|
| Micrometer | ESMET | 0207124456 | 50-75mm | 0.01 | 11.5±1.0 |
| Micrometer | ESMET | 161202229 | 0-25mm | 0.001 | 11.5±1.0 |
| Micrometer setting piece | ESMET | - | 50mm | - | 11.5±1.0 |

## 4 Measurement Instructions

### 4.1 Measurand

The Calibration was performed on the length scale of the external micrometer (Consultative Committee for length (CCL) category 6.1.1 so that the error of indicated size is measured [4].

### 4.2 Calibration Instruction

***0-25mm Micrometer:***

Screw thread Error of indicated size at the prescribed positions was determined by measuring 10 Gauge blocks which have the lengths in mm of (2.5, 5.1, 7.7, 10.3, 12.9, 15, 17.6, 20.2, 22.8 and 25 mm). Micrometer was to be zeroed before measurement. Zero reading was to be recorded after zeroing. Repeatability was measured at 15mm.

***50-75mm Micrometer:***

Screw thread Error of indicated length at the prescribed positions was determined by measuring Gauge blocks which have the lengths in mm of (50, 60, 70 and 75 mm). The Origin was to be set to 50 mm and recorded after being set. Repeatability was measured at 60mm.

***50mm Micrometer setting piece:***

Centre length of the micrometer setting piece was to be measured in a horizontal or vertical orientation.

## 5 Methods used

### 5.1 External Micrometers (0-25mm and 50-75mm)

All participants used the comparison with gauge blocks method to calibrate the two micrometers as stated in the measurements instruction section of the protocol. For the 50-75mm micrometer, the measurement instructions did not specify whether the Origin was to be set to 50mm using the provided setting rod or the participants' own equipment. All participants however indicated that they used a 50mm gauge block to set the origin. This might have been because this had been discussed during the 2019 intercomparison training workshop.

### 5.2 Micrometer setting piece (50mm)

The use of different equipment and techniques for measuring the micrometer setting piece resulted in participants having different uncertainties. Table 4 shows equipment used.

**Table 4:** Methods and equipment used for measuring micrometer setting piece

| Metrology Institute | Method/Equipment used |
|---|---|
| BOBS (Botswana) | Gauge blocks and Trimos Universal Machine |
| ZMA (Zambia) | Height Measuring Machine |
| SIRDC-NMI (Zimbabwe) | Gauge blocks and Dial comparator |
| TBS (Tanzania) | Universal Length Machine |
| NMISA (South Africa) | Labmaster Universal measuring machine |
| MSB (Mauritius) | Gauge blocks and Micrometer |
| MBS (Malawi) | Did not measure setting rod |
| NSI (Namibia) | Digital Calipers |
| INNOQ (Mozambique) | Vernier Calipers |

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## 6 Results

The measurements results for the micrometers and setting piece are presented in tables 5 to 7 and Fig. 2.1 to Fig. 4.

**Table 5: 0-25mm Micrometer results**

| | Micrometer measured length (X) /mm | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Nominal (mm)** | **NSI** | **SIRDC-NMI** | **INNOQ** | **BOBS** | **MSB** | **ZMA** | **TBS** | **NMISA** | **MBS** |
| 2.500 | 2.501 | 2.501 | **2.490** | 2.500 | 2.501 | 2.500 | 2.500 | 2.501 | 2.500 |
| 5.100 | - | 5.101 | **5.090** | 5.100 | 5.101 | 5.101 | 5.100 | 5.101 | 5.104 |
| 7.700 | - | 7.701 | **7.697** | 7.700 | 7.700 | 7.701 | 7.700 | 7.701 | 7.701 |
| 10.300 | - | 10.301 | **10.300** | 10.300 | 10.301 | 10.302 | 10.300 | 10.301 | 10.300 |
| 12.900 | - | 12.900 | **12.900** | 12.900 | 12.901 | 12.901 | 12.900 | 12.900 | 12.900 |
| 15.000 | 15.001 | 15.001 | **14.997** | 15.000 | 15.001 | 15.000 | 15.000 | 15.000 | 15.002 |
| 17.600 | - | 17.602 | **17.597** | 17.600 | 17.600 | 17.601 | 17.600 | 17.600 | 17.600 |
| 20.200 | - | 20.201 | **20.020** | 20.200 | 20.202 | 20.201 | 20.200 | 20.200 | 20.200 |
| 22.800 | - | 22.800 | **22.800** | 22.800 | 22.802 | 22.801 | 22.799 | 22.800 | 22.802 |
| 25.000 | 25.001 | 25.001 | **24.993** | 25.000 | 25.002 | 25.000 | 25.000 | 25.000 | 25.001 |
| | **Reported Uncertainties of Measurement (U)/mm** | | | | | | | | |
| **Nominal (mm)** | **NSI** | **SIRDC** | **INNOQ** | **BOBS** | **MSB** | **ZMA** | **TBS** | **NMISA** | **MBS** |
| 0 to 25.000 | 0.001 | 0.002 | - | 0.0048 | 0.002 | 0.001 | 0.006 | 0.0013 | 0.003 |

NB: INNOQ did not provide a valid uncertainty budget to support stated uncertainties

**Table 6: 50-75mm Micrometer results**

| | Micrometer measured length (X) /mm | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Nominal (mm)** | **NSI** | **SIRDC-NMI** | **INNOQ** | **BOBS** | **MSB** | **ZMA** | **TBS** | **NMISA** | **MBS** |
| 50.000 | 50.000 | 50.000 | **50.000** | 50.000 | 50.000 | 50.000 | 50.000 | 50.000 | 50.030 |
| 60.000 | 60.000 | 60.000 | **60.000** | 60.000 | 60.002 | 60.000 | 60.000 | 60.000 | 60.000 |
| 70.000 | 70.000 | 70.000 | **70.000** | 70.000 | 70.002 | 70.000 | 70.000 | 70.000 | 70.000 |
| 75.000 | 75.000 | 75.000 | **75.000** | 75.000 | 75.002 | 75.000 | 75.000 | 75.000 | 75.000 |
| | **Reported Uncertainties of Measurement (U)/mm** | | | | | | | | |
| **Nominal (mm)** | **NSI** | **SIRDC** | **INNOQ** | **BOBS** | **MSB** | **ZMA** | **TBS** | **NMISA** | **MBS** |
| 50 to 75 | 0.010 | 0.007 | - | 0.008 | 0.004 | 0.010 | 0.006 | 0.012 | 0.010 |

NB: INNOQ did not provide a valid uncertainty budget to support stated uncertainties

**Table 7: 50mm setting piece**

| | Micrometer setting Piece measured length (X) /mm | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Nominal (mm)** | **NSI** | **SIRDC-NMI** | **INNOQ** | **BOBS** | **MSB** | **ZMA** | **TBS** | **NMISA** | **MBS** |
| 50.000 | 50.010 | 50.002 | **50.050** | 50.000 | 50.000 | 50.000 | 50.000 | 50.001 | NA |
| | **Reported Uncertainties of Measurement (U)/mm** | | | | | | | | |
| **Nominal (mm)** | **NSI** | **SIRDC** | **INNOQ** | **BOBS** | **MSB** | **ZMA** | **TBS** | **NMISA** | **MBS** |
| 50.000 | **0.003** | 0.004 | - | 0.008 | 0.004 | 0.03 | 0.002 | 0.0005 | NA |

NB: INNOQ did not provide a valid uncertainty budget to support stated uncertainties. NSI reported uncertainty did not take into account contribution of the Caliper used to measure the setting piece.

## 7 Analysis

### 7.1 Calculation of reference values

The weighted mean of the participants' results was used for the calculation of reference values after elimination of outliers.

The reference value being

$$x_{ref} = \frac{\sum u_{x_i}^{-2} . x_i}{\sum u_{x_i}^{-2}} \qquad (1)$$

Combined uncertainty of reference value

$$u_{c_{ref}} = \frac{1}{\sqrt{\sum u_{x_i}^{-2}}} \qquad (2)$$

Expanded uncertainty

$$u_{exp_{ref}} = 2\frac{1}{\sqrt{\sum u_{x_i}^{-2}}} \qquad (3)$$

The weighted mean method requires that reference value be calculated after elimination of outliers using the remaining consistent data set [5]. Any result with an $E_n$ value > 1 with respect to the reference value is excluded and the reference value and $E_n$ value ratio recalculated using the remaining results. For a case where more than one laboratory result was to be excluded the test was performed one at a time [5, 6]. Another way of checking for consistency of a data set is to use the Birge ratio [5]. A data set is consistent if the Birge ratio is less than the Birge Criterion.

The Birge ratio $R_B$ is derived from the least squares algorithms and the $\chi^2$-test

$$R_B = \frac{U_{ext}}{U_{int}} \qquad (4)$$

Where $u_{int}$ = $u_{cref}$ is the propagated internal uncertainty and $u_{ext}$ is the external standard deviation

$$u_{ext} = \sqrt{\frac{1}{(n-1)} \cdot \frac{\sum_{i=1}^{n}\left(\left(x_i - \bar{x}_{ref}\right)^2 \cdot \frac{1}{u^2(x_i)}\right)}{\sum_{i=1}^{n} u^{-2}(x_i)}} \qquad (5)$$

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

$$R_B < \sqrt{1 + \sqrt{\frac{8}{(n-1)}}} \qquad (6)$$

where $n$ is the number of laboratories. [5]

Equations (2), (4), (5) and (6) were used to check data used for reference value calculation for statistical consistency.

NSI data set for the 0-25mm micrometer were excluded from calculation of reference values because some measurements were not taken at the nominal values stated in the protocol.

INNOQ data sets were excluded from calculation of reference values because of the uncertainties which ranged from 0.001 to 11.112mm for micrometers and 28.896 mm for the micrometer setting Piece which were not explained.

MBS was excluded in reference value calculations for 50 mm position for the 50-75 mm micrometer, $E_n$ value >1 during first iteration of the weighted mean method. It was also expected from the protocol that the origin be set at 50mm. No explanation was provided by the laboratory for the result at 50mm. Remaining statistically consistent data sets were used for the calculation of reference values for all artefacts. The internal consistency of the remaining datasets used was also confirmed by the Birge ratio test.

**Table 8: 0-25mm reference values.**

| Excluding values for NSI and INNOQ | | | | | | |
|---|---|---|---|---|---|---|
| Reference values | | | | Subset consistency check | | |
| Xref | Combined Uref | Expanded Uref exp | | U external | Birge Ratio | Birge Criterion |
| 2.5005 | 0.0007 | 0.0014 | | 0.00020 | 0.31 | 1.47 |
| 5.1011 | 0.0007 | 0.0014 | | 0.00028 | 0.42 | 1.47 |
| 7.7009 | 0.0007 | 0.0014 | | 0.00014 | 0.21 | 1.47 |
| 10.3014 | 0.0007 | 0.0014 | | 0.00026 | 0.38 | 1.47 |
| 12.9006 | 0.0007 | 0.0014 | | 0.00020 | 0.31 | 1.47 |
| 15.0003 | 0.0007 | 0.0014 | | 0.00023 | 0.35 | 1.47 |
| 17.6007 | 0.0007 | 0.0014 | | 0.00027 | 0.41 | 1.47 |
| 20.2008 | 0.0007 | 0.0014 | | 0.00026 | 0.39 | 1.47 |
| 22.8008 | 0.0007 | 0.0014 | | 0.00030 | 0.45 | 1.47 |
| 25.0004 | 0.0007 | 0.0014 | | 0.00028 | 0.42 | 1.47 |

**Table 9: 50-75mm reference values**

| Excluding INNOQ and (MBS 50mm position) | | | | | | |
|---|---|---|---|---|---|---|
| Reference Values | | | | Data consistency Check | | |
| Xref | Combined Uref | Expanded Uref | | External Uext | Birge Ratio | Birge Criterion |
| 50.0000 | 0.0026 | 0.0051 | | 0.00000 | 0.00 | 1.47 |
| 60.0008 | 0.0025 | 0.0050 | | 0.00037 | 0.15 | 1.44 |
| 70.0008 | 0.0025 | 0.0050 | | 0.00037 | 0.15 | 1.44 |
| 75.0008 | 0.0025 | 0.0050 | | 0.00037 | 0.15 | 1.44 |

**Table 10: 50mm Setting piece reference values.**

| Excluding INNOQ, NSI and (MBS did not measure setting piece) | | | | | | |
|---|---|---|---|---|---|---|
| Reference Values | | | | Data consistency Check | | |
| Xref | Combined Uref | Expanded Uref | | External Uext | Birge Ratio | Birge Criterion |
| 50.0007 | 0.0005 | 0.0010 | | 0.000087 | 0.18 | 1.50 |

## 7.2 Calculation of Degrees of Equivalence

Normalised error ($E_n$) values were used to calculate the degree of equivalence among participants.

$$E_n = \frac{x - x_{ref}}{2 \cdot \sqrt{\left(u_{x_c}^2 - u_{c_{ref}}^2\right)}} \qquad (7)$$

$$E_n = \frac{x - x_{ref}}{\sqrt{\left(u_{x_{exp}}^2 + u_{ref_{exp}}^2\right)}} \qquad (8)$$

Where
$x_{ref}$ is the reference value
and $u_{ref\,exp}$ is the reference expanded uncertainty.
and $u_{c\,ref}$ is the reference combined uncertainty.
$x$ and $u_{x\ exp}$ are the reported value and expanded uncertainty, respectively, for a participating laboratory.

For laboratories that contributed to the calculation of reference values, the $E_n$ value formula with a minus in the denominator was used to account for the correlation of the uncertainties. $E_n$ value with a plus sign was used for the labs excluded from reference value calculation.

**Table 11: 0-25mm Micrometer normalized Errors ($E_n$) values for the participants**

| | **En Values** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Nominal (mm) | **NSI** | **SIRDC-NMI** | **INNOQ** | **BOBS** | **MSB** | **ZMA** | **TBS** | **NMISA** | **MBS** |
| 2.500 | 0.22 | 0.14 | - | -0.05 | 0.14 | -0.32 | -0.04 | 0.23 | -0.08 |
| 5.100 | - | -0.03 | - | -0.12 | -0.03 | -0.08 | -0.09 | -0.05 | 0.49 |
| 7.700 | - | 0.04 | - | -0.09 | -0.23 | 0.09 | -0.07 | 0.06 | 0.02 |
| 10.300 | - | -0.10 | - | -0.14 | -0.10 | 0.43 | -0.11 | -0.16 | -0.23 |
| 12.900 | - | -0.15 | - | -0.06 | 0.12 | 0.30 | -0.05 | -0.25 | -0.09 |
| 15.000 | 0.28 | 0.18 | - | -0.03 | 0.18 | -0.21 | -0.03 | -0.14 | 0.29 |
| 17.600 | - | 0.36 | - | -0.07 | -0.17 | 0.23 | -0.06 | -0.30 | -0.11 |
| 20.200 | - | 0.06 | - | -0.08 | 0.33 | 0.15 | -0.06 | -0.34 | -0.13 |
| 22.800 | - | -0.20 | - | -0.08 | 0.33 | 0.17 | -0.15 | -0.33 | 0.21 |
| 25.000 | 0.26 | 0.16 | - | -0.04 | 0.43 | -0.25 | -0.03 | -0.17 | 0.11 |

**Table 12: 50-75mm Micrometer $E_n$ values for the participants**

| | En Values | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Nominal (mm)** | **NSI** | **SIRDC-NMI** | **INNOQ** | **BOBS** | **MSB** | **ZMA** | **TBS** | **NMISA** | **MBS** |
| 50.000 | 0.00 | 0.00 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **1.45** |
| 60.000 | -0.04 | -0.06 | - | -0.05 | 0.20 | -0.04 | -0.07 | -0.03 | -0.04 |
| 70.000 | -0.04 | -0.06 | - | -0.05 | 0.20 | -0.04 | -0.07 | -0.03 | -0.04 |
| 75.000 | -0.04 | -0.06 | - | -0.05 | 0.20 | -0.04 | -0.07 | -0.03 | -0.04 |

**Table 13: 50mm Micrometer Setting Piece $E_n$ values for the participants**

| | En Values | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Nominal (mm) | NSI | SIRDC-NMI | INNOQ | BOBS | MSB | ZMA | TBS | NMISA | MBS |
| 50.000 | **1.52** | 0.159 | - | -0.046 | -0.093 | -0.012 | -0.062 | 0.001 | N/A |

## 8 Graphical Summary of results

### 0-25mm Micrometer

**Fig. 2.1:** Nominal Length 2.5mm

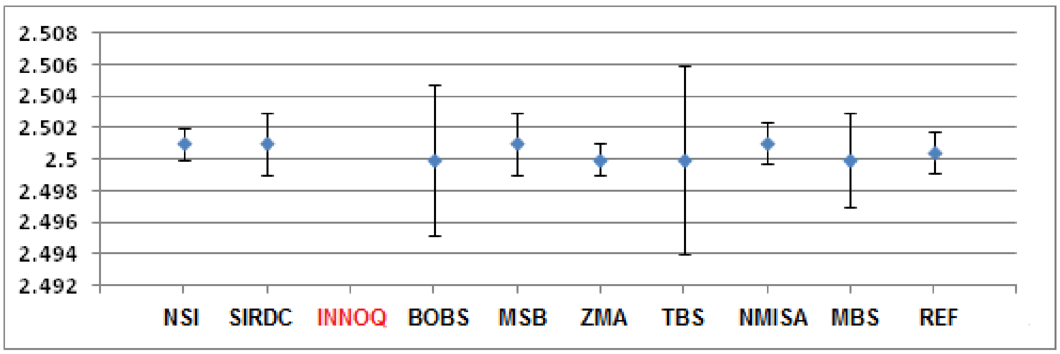



**Fig. 2.2:** Nominal Length 5.1mm

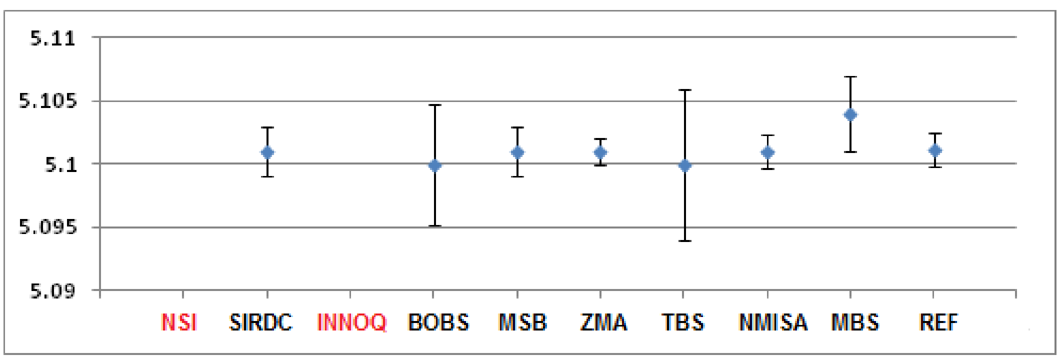


**Fig. 2.3:** Nominal length 7.7mm

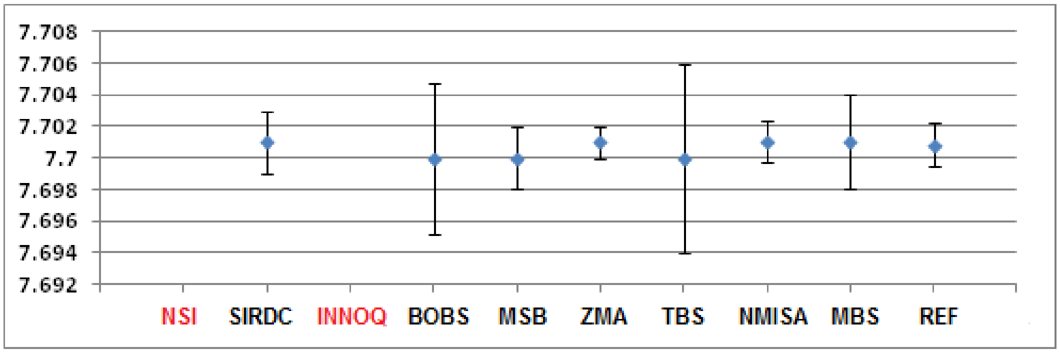



**Fig. 2.4:** Nominal length 10.3 mm

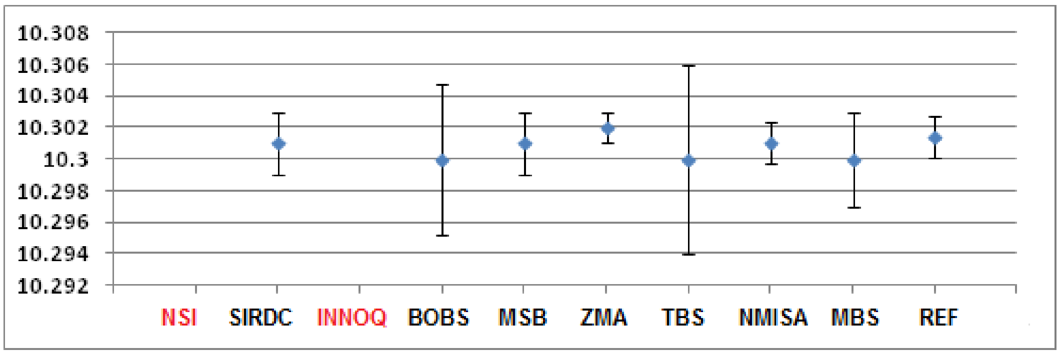



**Fig. 2.5:** Nominal Length 12.9mm

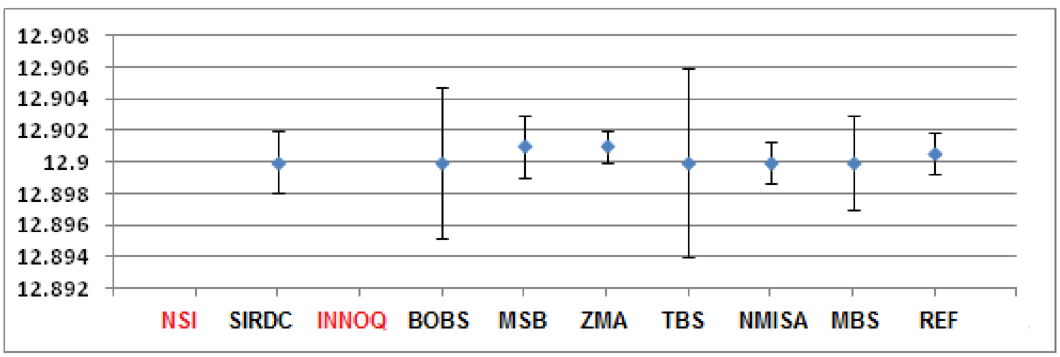


**Fig. 2.6:** Nominal Length 15mm

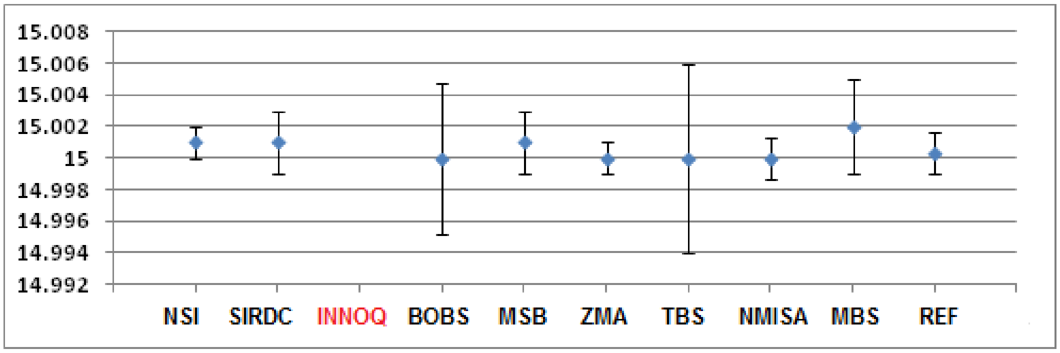



**Fig. 2.7:** Nominal length 17.6mm

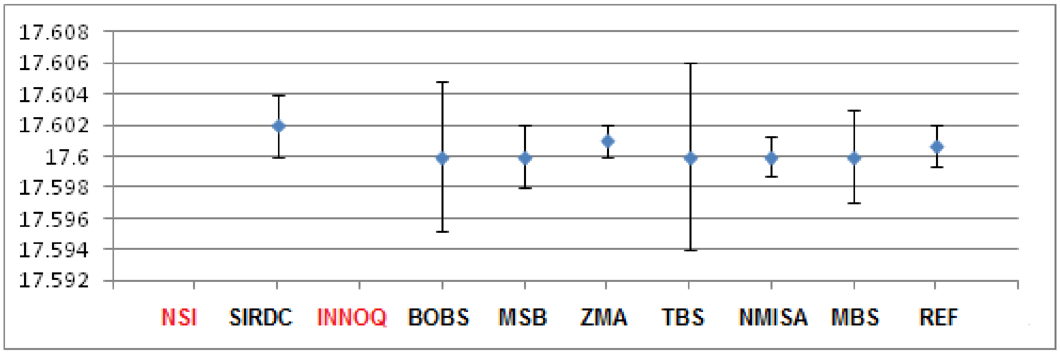



**Fig. 2.8:** Nominal Length 20.2 mm

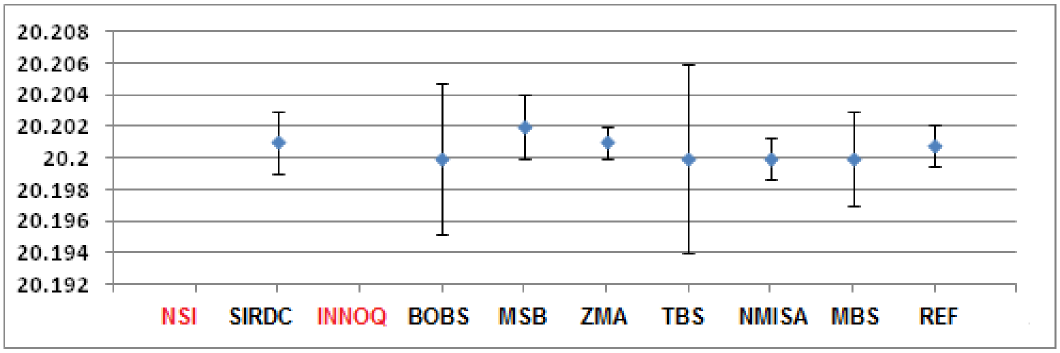


**Fig. 2.9**: Nominal Length 22.8mm

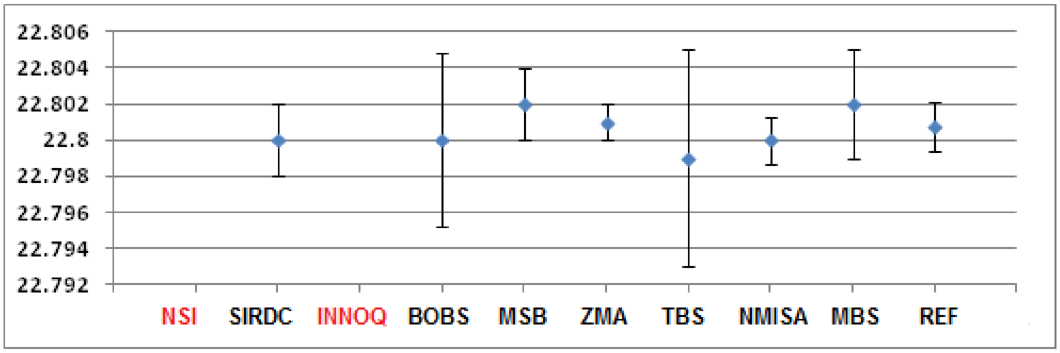
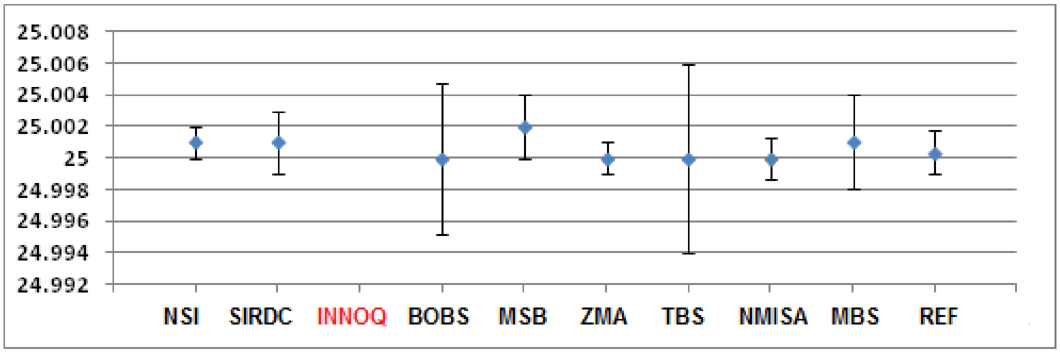



**Fig. 2.10:** Nominal Length 25mm




**50-75mm Micrometer**

**Fig. 3.1:** Nominal length 50mm

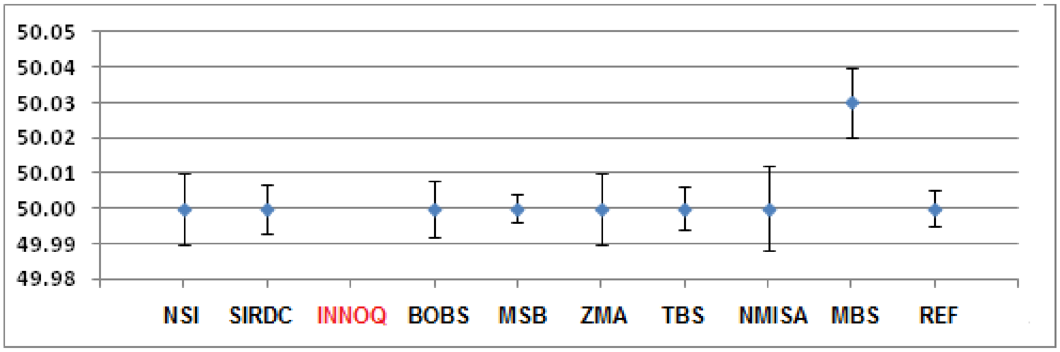


**Fig. 3.2**: Nominal length 60mm

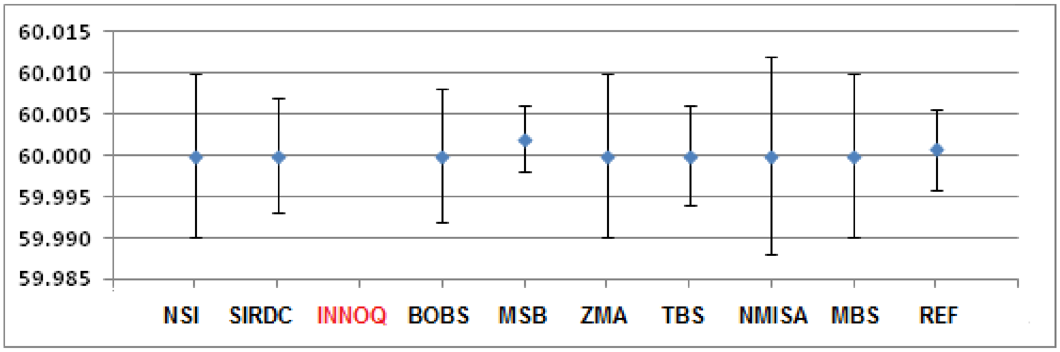



**Fig. 3.3:** Nominal Length 70mm

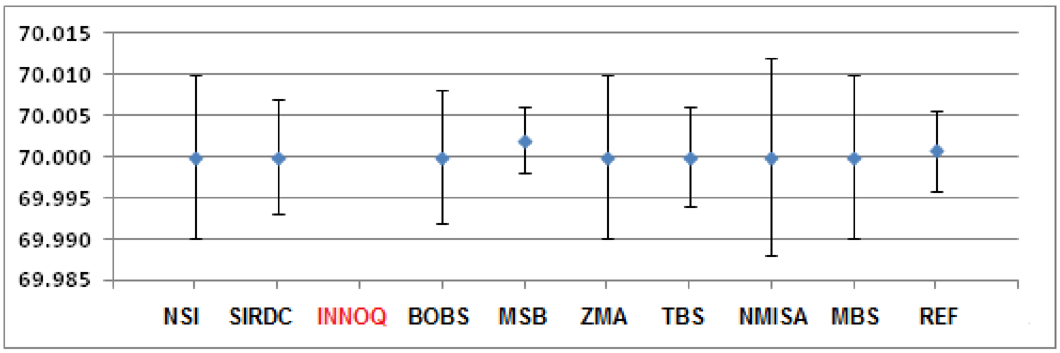
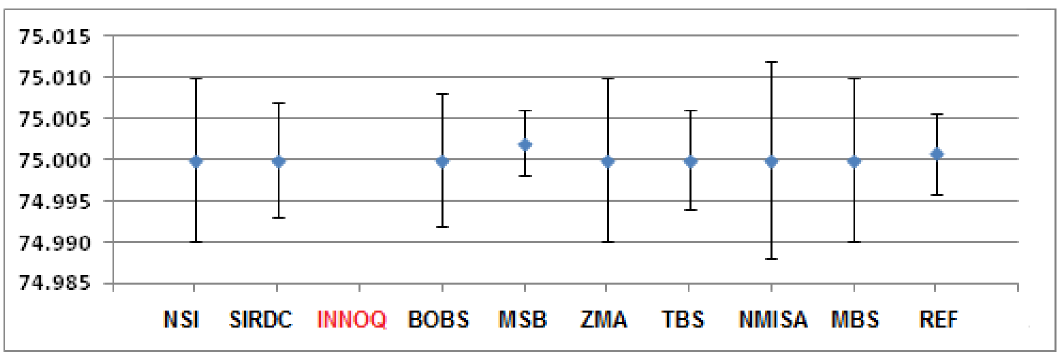
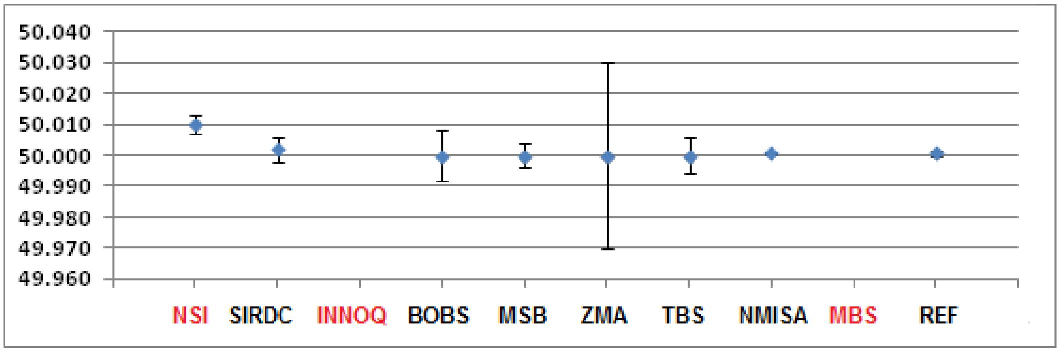



**Fig. 3.4**: Nominal Length 75mm



**Micrometer setting piece**

**Fig. 4:** Nominal length 50mm




## 9 Conclusion

Nine African National Metrology Institutes participated in the PTB sponsored AFRIMETS.L-S6 External micrometers and setting rod interlaboratory comparison during the period 2019 to 2022. Due to covid-19 pandemic travel restrictions, artefacts had to be couriered in some cases instead of being hand carried as per initial plan. This resulted in some minor delays in the movement of artefacts due to customs clearance formalities. No damages to the artefacts were observed during the comparison. Overall the Interlaboratory comparison was successfully completed.

Measurements by one participant which were taken on nominal positions not stated in the protocol (for the 0-25mm Micrometer) were not included in the report. Results for another participant with uncertainties that were not supported by uncertainty budgets were not used in reference value calculation. One result at the 50mm position by one participant for the 50-75mm micrometer with En value greater than 1 during first iteration of the weighted mean method was not used in the calculation of reference values. At that position participants were expected to have set the origin to 50mm.

## 10 Recommendations

Laboratories with $|En|$ values less than one may use their results to demonstrate competence in their calibration measuring capabilities while those with $E_n$ values outside the acceptable range can investigate the root cause of the disagreement with the view of making corrective actions.

It is recommended that protocols and reports be properly reviewed to ensure that all measurement requirements are understood. NMIs are also encouraged to report and send results in the same format for easier analysis by the pilot laboratory.

## 11 Acknowledgement

The SADCMET TCL acknowledges with thanks

a. PTB for continued funding of the Dimensional interlaboratory comparisons and trainings.
b. SIRDC and TBS for hosting the initial and closing workshops
c. All NMIs for participating in the ILC

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