Comparison of the calibration of noble metal thermocouple from 0 ºC up to 1200 ºC

SADCMET ILC/TEM – 002/2019

Prepared by

Dr Efrem K Ejigu / B Chibaya

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1. INTRODUCTION

SADCMET temperature technical committee has decided to organise an inter comparison in different temperature parameters. One of the parameters is thermocouple where members show a great interest in participating.

The objective of this comparison is to establish a degree of equivalence between the participants for the calibration of noble metal thermocouple by comparison from 0 ºC up to 1200 ºC.

Scientific and Industrial Research and Development Centre's National Metrology Institute (SIRDC-NMI) has shown interest to pilot this comparison and was agreed by the members at the workshop held in Botswana in February 2019.

The Comparison project is funded by PTB

2. PARTICIPANTS

The responsibility of the pilot laboratory which is SIRDC-NMI is to collect the measurement information from all participants and perform the analysis of the comparison data and elaborate the reports four months after the last participant report was received.

The National Metrology Institute of South Africa (NMISA) will assist to

- Organize to buy a stable noble metal thermocouple (Type R or S) with the following characteristics from PTB fund to perform the measurements:
    i. length of the alumina sheath: 700 mm
    ii. length of the thermoelements: 2000 mm
    iii. maximum outer diameter: 7 mm
- The National Metrology Institute of South Africa (NMISA) will assist to prepare the protocol, perform the initial and final measurement of the thermocouple to provide a reference value and give advice when the pilot prepares the report

Each participant laboratory should:

- perform the measurements according to the rules of this protocol and their own calibration procedure,
- Air or hand-carry the thermocouple to the next participant in due time,
- send to the pilot laboratory a report using the forms included in the annex one month after the completion of its measurements.

Table 1. shows the contact details of the comparison participants.

INSTITUTE	COUNTRY	Contact Person	e-mail/Phone	Address
NMISA	SOUTH AFRICA	Dr. Efrem K. Ejigu Ms Regina Mnguni	eejigu@nmisa.org rmnguni@nmisa.org	Meiring Naudé Road Brummeria Pretoria South Africa
OCC	DRC	Ms Mpiana Kaja Nady	nadyocpe@gmail.com	
Eswatini Standards Authority)	Kingdom of Eswatini	Ms Cebsile Bhembe	cbhembe@swasa.co.sz	
NMI-SIRDC	Zimbabwe	Blessing Chibaya	bchibaya@sirdc.ac.zw |bchibaya@gmail.com	1574 Alpes Road, Technology Drive Hatcliffe P.O. Box 6640 Harare
ZMA	Zambia	Ms Careen Mutembo	karenmutembo@gmail.com	Lechwe House, Freedom Way P.O. Box 50259 Lusaka
DSQA	Lesotho	Ms Qenehelo Lenka	Qenehelo2008@yahoo.com	Ministry of Trade and industry, LNDC Building, Kingways Road, Lesotho
TBS	Tanzania	Adam Ziagi	adam.ziagi@tbs.go.tz	
BOBS	Botswana	Tebogo Kajane Mr Nkgare Mr Kagiso Tshaila	kajane@bobstandards.bw nkgare@bobstandards.bw tshaila@bobstandards.bw	Private Bag B0 48 Gaborone
Qualidade-INNOQ	Mozambique	Mr Elves Emilio Djedje	elvesdjedje@gmail.com	Av. Moçambique, Parcela 7168/D1/7,| Bairro do Zimpeto,| C.P: 2983; Maputo - Moçambique
MSB	Mauritius	Mr Christian Ng Ha Kwong	jchrisng@gmail.com	Mauritius Standards Bureau, Villa Road. Moka, Republic of Mauritius
NSI	Namibia	Mr Simasiku Matali	Matalis@nsi.com.na	
MBS	Malawi	Mr Crighton Marorongwe	crightonmarorongwe@mbsmw.org	

SBS	Seychelles	Mr Fabien Duval	fabienduval86@gmail.com	SBS, Standards House, Providence, Mahe, Seychelles

3. ARTEFACT

The following artefact is purchased and will be used in the comparisons

Thermometer	S/N	Model	Manufacturer	TYPE	Diameter (mm)
THERMOCOUPLE				R	

4. COMPARISON SCHEDULE

The proposed start date is May 2019. Table 2 presents the schedule. Each participant counts on 2 months to perform the measurements.

Table 2. Comparison schedule

Institute	Planned date	Actual date
NMISA South Africa	May 2019	May 2019
SIRDC-NMI Zimbabwe	June 2019	June 2019
Botswana	July 2019	
Namibia	August 2019	
Zambia	September 2019	
Tanzania	October 2019	
Malawi	November 2019	
Mozambique	December 2019	
Mauritius	January 2020	
Seychelles	February 2020	
South Africa	March 2020	
Zimbabwe	April 2020	

5. PROCEDURE

5.1. Initial inspection

As soon as the equipment is delivered and the thermocouple unpacked and inspected, the participant should inform the coordinator by e-mail. If the equipment has any visible damage due to transportation, this must be reported to the pilot before the calibration begins using the form attached in the appendix.

5.2. Thermocouple homogeneity tests

Before starting the calibration, each participant should determine the thermocouple homogeneity:

- Immersion test in an oil bath at 150 - 200 ºC. Particular care should be taken to avoid contamination of the wires. The thermocouple will be introduced in an appropriate protective alumina sheath in order to avoid direct contact with the liquid and cleaned with alcohol and distilled water after the test.

5.3. Measurements

The participating laboratory should not dismantle the thermocouple and the thermocouple should not be subject to any further annealing before or after the calibration. Additionally, participants should not perform any heat treatment to the thermocouple. To maintain its thermoelectric stability, the exposure at high temperatures must be as short as possible.

Conduct measurement at the following temperatures by using comparison method: 200 ºC, 400 ºC, 600 ºC, 800 ºC, 1000 ºC and 1200 ºC

6. Reference Value

The comparison reference value will be the average of the initial and final measurements by NMISA.

Each participants measurement performance can be assessed based on the En values. En values can help to identify discrepancies amongst participant's measurement data which is aimed at fulfilling one of MRA requirements. Usually En values that are above 1 indicate the discrepancy. The normalized error En can be calculated by the following equation.

$$E_n = \frac{\Delta T_{NMI-CRV}}{u_{NMI-CRV}(k=2)}$$

$$\Delta T_{NMI-CRV} = \Delta T_{NMI} - \Delta T_{CRV}$$

$$u_{NMI-CRV}(k=2) = \sqrt{(u(\Delta T_{NMI})^2 + u(\Delta T_{CRV})^2)}$$

$$\Delta T_{CRV} = \Delta T_{REFERNCE\ NMI}$$

$$u(\Delta T_{CRV}) = u\left(\Delta T_{REFRENCE\ NMI}\right)$$

7. UNCERTAINTIES

The laboratory should perform the uncertainties estimation according to its usual procedures, however at least the following sources of uncertainty will be taken into account:

- t_{CP}: uncertainty due to the temperature determination of the calibration point.
- E_{vc}: uncertainty due to the voltmeter calibration.
- E_{vr}: uncertainty due to the voltmeter resolution.
- E_{vd}: uncertainty due to the voltmeter drift.
- t_{0C}: uncertainty due to the thermocouple cold junction.
- E_{Homo}: uncertainty due to the thermocouple homogeneity.

Any other source of uncertainty, like the influence of the isothermal enclosure and/or the heat flux along the thermocouple wires, should be added to the uncertainty budget with a brief explanation of their admission.

8. REPORTING OF DATA

The participating laboratories should send the following measurement results and information to the coordinator:

- details of instrumentation
- temperature profiles of furnaces used at the highest calibration point by comparison
- results of the thermocouple homogeneity tests
- measured emfs at the calibration points
- uncertainty budget of the measurements

The information should be reported using the excel sheet formats in the format given in Appendices A & B.

9. REFERENCES

[1] CIPM MRA-D-05 Version 1.3.
http://www.bipm.org/utils/common/CIPM_MRA/CIPM_MRA-D-05.pdf

[2] AFRIMETS TS-7 protocol

[3] APMP-T-S3-03 protocol

Appendix A

ARTEFACT DISPACHED

To: Thermometry Department Fax No. :

Comparison of Thermocouple S/No. _____

The Thermocouple was dispatched from ……

On:…../……. /……..

The condition when it was dispatched was

( ) in good physical and working order

( ) damaged (please explain)…….

Participating Laboratory:

Contact Person:

Tel:
Fax:

In order to monitor the comparison, we kindly ask each participating laboratory, upon dispatching of the artefact, to fill in this confirmation form and return it to:

Mr. Blessing Chibaya

SIRDC-NMI
Thermometry Department
1574 Alpes Road, Technology Drive Hatcliffe
P.O. Box 6640
Harare

Mobile Phone : +263772107300
Telephone Number: +263242860346
Fax : +263242860350
E-mail: bchibaya@sirdc.ac.zw or bchibaya@gmail.com

Appendix B

ARTIFACT RECEIVED

To: Thermometry Department Fax No. :

Comparison of Thermocouple S/No. _____

The Thermocouple was received at……

On:…../……. /……..

The condition when it was received was

( ) in good physical and working order

( ) damaged (please explain)…….

Participating Laboratory:

Contact Person:

Tel:

Fax:

In order to monitor the comparison, we kindly ask each participating laboratory, upon arrival of the artefact, to fill in this confirmation form and return it to:

Mr. Blessing Chibaya

SIRDC-NMI
Thermometry Department
1574 Alpes Road, Technology Drive Hatcliffe
P.O. Box 6640
Harare

Mobile Phone : +263772107300
Telephone Number: +263242860346
Fax : +263242860350
E-mail: bchibaya@sirdc.ac.zw or bchibaya@gmail.com

Appendix C: Measuring equipment and standards used in the comparison

Laboratory Name: _____

Device	Type	Manufacturer	Serial number	Description	Immersion (mm)
Standard used for reference temperature					
AC bridge/DVM for SPRT measurements					
Ice-Point used					
DVM for Test TC					
Scanner (if used)					
Enclosure used					

* Note: Please write about the traceability of the standard used

Appendix D: Calibration Data of the Thermocouple

Serial Number _____ Inhomogeneity _____
Name of the Laboratory:_____

Temperature/°C	**E_{ref}/ µV**	**E/ µV**	**E - E_{ref} / µV**	**Uncertainty/°C**
0				
200				
400				
600				
800				
1000				
1200				

*** E_{ref} is the reference emf given by IEC or ASTM**