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SUBSEQUENT BILATERAL COMPARISON TO CCT-K3:

COMPARISON OF REALIZATIONS OF THE ITS-90 OVER THE RANGE 273.16 K TO 302.9146 K BETWEEN THE BIPM AND THE LNE-INM

CIPM Key Comparison CCT-K3.1

PROTOCOL 1.0

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ABSTRACT

This comparison protocol outlines the procedure to be followed for the comparison of the calibration of two standard platinum resistance thermometers at two fixed points of the ITS-90: the triple point of water (T = 273.16 K) and the melting point of gallium (T = 302.9146 K).

This bilateral comparison is a subsequent comparison to the CIPM Key comparison CCT.K3, and is to be carried out between: the Bureau International des Poids et Mesures (BIPM), which acts as the pilot laboratory, and the Laboratoire National de métrologie et d'Essais – Institut National de Métrologie (LNE-INM).

CONTENTS

1. OBJECTIVES

Temperature calibrations of standard platinum resistance thermometers (SPRTs) in the range of ambient laboratory temperature ceased at the Bureau International des Poids et Mesures (BIPM) in 2006. However, the BIPM still needs calibrated high precision thermometers in several applications. To have a flexible service for temperature calibrations between the water triple point and the gallium melting point temperatures at the required uncertainties, it was decided to re-introduce the calibration activity in 2009 using the existing apparatus on site but applied exclusively to the needs of the BIPM.

As thermometers have not been calibrated at the BIPM since 2005 and staff needed to be trained to take on this work, the activity was re-started by testing the performance and conformity of the experimental apparatus. It is also necessary to confirm the re-establishment of the former quality of calibrations. The objective of this comparison with the LNE-INM is to demonstrate the re-establishment and quality level of SPRT calibrations at the BIPM. The result will be represented by the temperature difference ΔT between the two laboratories and its associated uncertainty.

This comparison protocol is based on the protocol of the CIPM Key Comparison CCT-K3 [1].

2. PARTICIPANTS

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The BIPM is acting as the pilot laboratory.

3. REALIZATION

The comparison requires that the participating laboratories perform calibrations of two specific SPRTs at two fixed points of the ITS-90; the water triple point WTP (T_{WTP} = 273.16 K) and the melting point of gallium (T_m(Ga) = 302.9146 K), according to the respective laboratory specific quality system procedures.

The result is represented by the temperature difference ΔT attributed to a measurement at the gallium melting point and its associated uncertainty [2], in form of

$$\Delta T_{BIPM-INM} = \frac{\frac{1}{2}(W_{BIPM,ThA} - W_{INM,ThA}) + \frac{1}{2}(W_{BIPM,ThB} - W_{INM,ThB})}{dW_r / dT}, \quad (1)$$

where $W_{i,j}$ represents the resistance fraction $R(T_m(\mathrm{Ga}))/R(T_{WTP})$ for the laboratory i and thermometer j. The denominator dW_r/dT refers to the reference function [3]. In the present case, dW_r/dT = 0.003952. The associated uncertainty is

$$u_c(\Delta T_{BIPM-INM}) = \sqrt{\frac{S^2_{A_{BIPM}}}{4n_{BIPM,ThA}} + \frac{S^2_{A_{INM}}}{4n_{INM,ThA}} + S^2_{B_{BIPM}} + \frac{S^2_{A_{BIPM}}}{4n_{BIPM,ThB}} + \frac{S^2_{A_{INM}}}{4n_{INM,ThB}} + S^2_{B_{INM}} + \frac{u^2_{ThA}}{4} + \frac{u^2_{ThB}}{4}}, \quad (2)$$

where S_A and S_B represent the type A and type B uncertainties [4]. In the present case n = 5 (c.f. 5.2.). The uncertainty component $u_j \neq 0$ if a significant change in the thermometer response is observed after transport [2].

For transparency, the resistances measured at the water triple point and gallium melting point, $R(T_{WTP})$ and $R(T_m(\mathrm{Ga}))$ should also be given with their estimated associated uncertainties for each thermometer.

4. TRANSFER INSTRUMENTS

The transfer instruments selected for the comparison are two thermometers belonging to the BIPM as detailed in Table 1.

Table 1.

Manufacturer	model	Serial number	Length/mm	Diam/mm
Leeds and Northrup	8167	# 439	465	7.3
Leeds and Northrup	8167	# 442	465	7.3

The thermometers are fragile. They must be handled with extreme care, and should be placed in their specific compartment in the transport box when not in use. In view of the comparatively short geographical distance between the participating laboratories, the pilot laboratory will arrange for the transport of the thermometers by car.

5. COMPARISON PROCEDURE

The Leeds and Northrup thermometer 8167 # 439 is identified as Th-A, and the Leeds and Northrup thermometer 8167 # 440 is identified as Th-B below

5.1. Each participant checks that the geometry of the chosen thermometers is compatible with the laboratory apparatus, i.e that the dimensions of the thermometer well of the cells is comparable with the dimensions of the SPRTs.

5.2. The calibration of Th-A and Th-B is first performed at the BIPM - following their internal technical procedure, validated within the BIPM Quality System. The number of measurements is limited to five cycles, where one cycle consists of consecutive measurements at T_{WTP}, T_m(Ga)[1] and at T_{WTP} again.

5.3. The thermometers are transported to the LNE-INM.

5.4. The thermometers are calibrated at the LNE-INM following the LNE-INM internal technical procedure. The number of measurements is limited to five cycles as above.

5.5. The thermometers are returned to the BIPM.

5.6. A second calibration of the thermometers Th-A and Th-B is made at the BIPM. The number of measurements is again limited to five cycles.

5.7. Each laboratory analyses their measurement data. The method of analysis and corrections should be clearly indicated. A detailed uncertainty budget should be established for each measurement.

5.8. The LNE-INM report should be sent to the CCT Executive Secretary one month after the completion of its measurements. Once the BIPM has sent its results to the CCT

[1] The BIPM will do the measurement at T_m(Ga) for two gallium cells at each cycle, as usual.

Executive Secretary, one month after the completion of its measurements, the CCT Executive Secretary will communicate the LNE-INM report to the BIPM.

5.9. A Draft-A report will be issued by the BIPM within two months after the completion of the comparison. It will be sent to the LNE-INM for discussion and approval.

5.10. The Draft-B will be submitted to the CCT-WG7 for approval.

6. COMPARISON SCHEDULE

Step	To be executed by
5.1. and 5.2.	Friday 25 September 2009
5.3.	Monday 28 September 2009
5.4.	Friday 9 October 2009
5.5.	Monday 12 October 2009
5.6.	Friday 23 October 2009
5.7. and 5.8.	Friday 20 November 2009
5.9.	Draft A: Friday 18 December 2009
5.10.	Draft B: Friday 22 January 2010

7. PRECAUTIONS FOR UNEXPECTED EVENTS

7.1. The thermometers should be jointly inspected at the LNE-INM by the participants on arrival and before departure.

7.2. If a thermometer shows an unexpected behaviour during measurements, the reason for this should be reported and preferably analysed and.

7.3. If a delay occurs, the collaborating laboratory should be informed as soon as possible.

REFERENCES

[1] Mangum B W, Strouse G F, Guthrie W F 2002 CCT-K3: Key comparison of realizations of the ITS-90 over the over the range 83.8058 K to 933.473 K *NIST Technical Note* **1450** 385 p.

[2] Mangum B W, Strouse G F, Guthrie W F, Pello R, Stock M, Renaot E, Hermier Y, Bonnier G, Marcarino P, Gam K S, Kang K H, Kim Y-G, Nicholas J V, White D R, Dransfield T D, Duan Y, Qu Y, Connolly J, Rusby R L, Gray J, Sutton G J M, Head D I, Hill K D, Steele A, Nara K, Tehler E, Noatsch U, Heyer D, Fellmuth B, Thiele-Krivoj B, Duris S, Pokhodun A I, Moiseeva N P, Ivanova A G, de Groot M J and Dubbeldam J F 2002 Summary of comparison of realizations of the ITS-90 over the over the range 83.8058 K to 933.473 K: CCT Key Comparison CCT-K3 *Metrologia* **39** 179-208

[3] Preston-Thomas H 1990 The International Temperature Scale of 1990 (ITS-90) *Metrologia* **27** 3-10; Erratum 1990 *Metrologia* **27** 107

[4] *Guide to the Expression of Uncertainty in measurement*, 1st ed., Geneva, International Organization for Standardization, 1995, 101 p.