EURAMET Project 'Report'

1	**Report**	☐ progress report ☒ final report	2	**Reference No**:	1249
3	**Subject Field**	T - Temperature			
4	**Type of collaboration**	Comparison of Measurement Standards			
4A	**In the case of a comparison** Registered as Key comparison (KC) or Supplementary Comparison (SC) in the KCDB: ☒no ☐ yes If yes: No. of KC/SC:				
5	**Coordinator** Institute/Country: Metrology Institute of the Republic of Slovenia/University of Ljubljana-Faculty of Electrical Engineering/Laboratory of Metrology and Quality (MIRS/UL-FE/LMK) Name: Jovan Bojkovski Phone: +386 1 4768 798 E-mail: jovan.bojkovski@fe.uni-lj.si				
6	**Participating Partners**				
6A	EURAMET members or associates (Institute's standard acronym with country code in brackets) as registered on EURAMET website. • MBM (ME) • MIRS/UL-FE/LMK (SI)				
6B	Institutes not being EURAMET members or associates (Institute's full name and country in brackets)				
6C	Change of projects partners: (Please indicate here changes of project partners compared to the previous report) New project partners Removed project partners				
7	**Title of project** Comparison of the calibration of liquid in glass thermometers in the range -30 °C to 150 °C				
8	**Progress/Final** Number of national metrology institutes, including Metrology Institute of the Republic of Slovenia/University of Ljubljana-Faculty of Electrical Engineering/Laboratory of Metrology and Quality (MIRS/UL-FE/LMK) and Bureau of Metrology (MBM), offer calibration services for these thermometers among the Calibration Measurement Capabilities (CMC) of Appendix C of the BIPM Key Comparison Database. MIRS/UL-FE/LMK and MBM organized a bilateral comparison of a set of LIGT in the range from -30 °C to 150 °C. The bilateral comparison itself was divided in three phases. In the first phase (performed in June 2012), three mercury-in-glass thermometers were selected and calibrated at MIRS/UL-FE/LMK (SI) by comparison in liquid baths (alcohol, water and light viscosity silicon oil bath). In the second phase (performed in the September 2012), the same measurements were performed by MBM (ME).				

After its return, the three mercury-in-glass thermometers were recalibrated (measurements performed in December 2012) at MIRS/UL-FE/LMK (SI). The values of temperature corrections were compared.
It was recommended that the participants use their standard procedure during the temperature calibration and if possible avoid making extra time-consuming measurements.

The circulating items were the three liquid in glass thermometers, manufactured by Thermo Schneider. The resolution of circulated thermometers was 0.1 °C. With special set-up, the resolution could be decreased to 1/5 of the scale division. The first thermometer was covering range from -30 °C to 10 °C (serial number 991289), the second range from 0 °C to 50 °C (serial number 9710425) and the third 100 °C to 150 °C (serial number 991308). The diameter of the thermometers was Ø 5 mm. All of them are total immersion liquid in glass thermometers.
After receiving thermometers, they were carefully checked for any mechanical damage as consequence of the transport. Next check included check for broken column of liquid (mercury). All of the separated mercury had to be reunited with the main column before the thermometer can be calibrated. In the next step, all three thermometers were measured in the ice-point thus allowing checking for any change as a consequence of a transport between laboratories.
After that, thermometers were calibrated by comparison in liquid baths. The procedure for calibration of LiGTs was relatively simple in comparison to the other types of thermometers. The LiGT and the reference thermometer were placed in the calibration bath and their readings were compared. Differences of readings at several temperature points were fitted to a polynomial function and the uncertainty of calibration was calculated.
The uncertainty sources included repeatability of measurements u1, inhomogeneity of the calibration bath u2, the uncertainty of reference thermometer u3and uncertainty of reading u4. Total uncertainty u was calculated as the geometric sum of all uncertainty contributions.
In the MIRS/UL-FE/LMK calibrations were performed in the alcohol bath Fluke HartScientific 7100 with methanol as working liquid in the range from -30 °C to 10 °C, the water bath Kambič OB 50 in the range 10 °C to 50 °C and the light viscosity oil bath Kambič OB 50 in the range 100 °C to 150 °C . As the reference thermometer, Fluke 5681 quartz sheathed thermometer standard platinum resistance thermometer calibrated at fixed points at MIRS/UL-FE/LMK was used. As a resistance measurement system, automatic AC resistance bridge ASL F700 in combination with reference resistor was used.
In the MBM calibrations were performed in the alcohol bath Fluke Hart Scientific 7080 with ethanol as working liquid in the range from -30 °C to 10 °C, the water bath Fluke Hart Scientific 7341 in the range from 10 °C to 50 °C and oil bath Fluke Hart Scientific 6331 in the range from 100 °C to 150 °C. As the reference thermometer Fluke 5681-S, standard platinum resistance thermometer, calibrated at fixed points in CMI, was used. As a resistance measurement system was used Fluke BLACK STACK 1560 System.
During the course of comparison, no significant technical problems occurred. The results obtained show that LIGT are stable enough for the comparison. The results of the comparison that all 18 pairs of measurement performed by the participating laboratories agree within declared uncertainties and thus supporting declared capabilities by MIRS/UL-FE/LMK and MBM. Results of this interlaboratory comparison can be used to support entries to BIPM KCDC Annex C (CMC).

Nominal temperature (°C)	Correction determined by MIRS/UL-FE/LMK (°C)	Uncertainty of MIRS/UL-FE/LMK (°C)	Correction determined by MBM (°C)	Uncertainty of MBM (°C)
-30	-0.04	0.05	-0.11	0.1
-20	-0.03	0.05	-0.12	0.1
-10	-0.04	0.05	-0.13	0.1
0	-0.02	0.05	-0.10	0.1
10.0	-0.05	0.05	-0.12	0.1

Uncertainty source				
Uncertainty contribution (K) MIRS/UL-FE/LMK				
Uncertainty contribution (K) MBM				
LIGT repeatability	0.01	0.012		
Uncertainty of reference thermometer			0.001	0.0013
Uncertainty due to drift of reference thermometer			0.0005	0.00014
Uncertainty of resistance meter		0.00025		0.0015
Uncertainty due to drift of resistance meter			0.0001	0.0015
Uncertainty due to stability of the bath			0.0005	0.0037
Uncertainty due to homogeniety of the bath			0.001	0.004
Uncertainty due to resoultion of the LIGT			0.012	0.014
Combined uncertainty		0.016	0.052	
Expanded (rounded) uncertainty		0.05	0.1	

Further details are avaiable in paper Comparison of the Calibration of the Liquid in Glass Thermometers in the Range from -30 °C to 150 °C, J.Bojkovski and T.Vukicevic, presented at TEMPMEKO 2013 and submitted for publication in IJT

9	**In the case of a KC/SC comparison & final report** Final report sent to the appropriate CC WG ☒no ☐ yes Report endorsed by the CC WG ☒no ☐ yes	
10	**Expected completion date** 2013-06-01	11 **Date** 2014-03-21

Notes for completion of the form overleaf