EURAMET Project 'Report'

Document: G-OPS-TMP-025 Version: 2.0
Approved: Head of Secretariat 2012-02-01

EURAMET European Association of National Metrology Institutes

1 **Report** ☐ progress report ☒ final report	2 **Reference No**: 1251
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**
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6 **Participating Partners**

6A EURAMET members or associates (Institute's standard acronym with country code in brackets) as registered on EURAMET website.
- BoM (MK)
- DMDM (RS)
- DPM (AL)
- IMBiH (BA)
- MBM (ME)
- MIRS/UL-FE/LMK (SI)
- UME (TR)

6B Institutes not being EURAMET members or associates (Institute's full name and country in brackets)
KDM (International/Regional Organisation)

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 standard platinum resistance thermometers in the range -80 °C to 300 °C by comparison

8 **Progress/Final**
The interlaboratory comparison itself, for the practical and transport reason, was divided in two loops. In the first loop measurements were performed in following laboratories, in order as they are named here: LMK, DMDM, BOM, KDM, MBM, DPM, IMBiH and LMK. In the second loop measurements at LMK and UME were performed. The whole comparison measurements started in September 2012 and ended in September 2013.

The circulating items were two stable 25 Ω standard platinum resistance thermometers, serial numbers: Fluke 370 (metal sheath) and Tinsley 279428 (quartz sheath). The interlaboratory comparison included eleven measuring points in the range between -80 °C and 300 °C (-80 °C, -60 °C, -50 °C, -30 °C, 0 °C, 50 °C, 100 °C, 150 °C, 200 °C, 250 °C and 300 °C). Some of the laboratories also performed measurement at the triple point of water (0.01 °C). It also has to be noted, that some participants didn't have equipment to perform measurements in the whole range of interlaboratory comparison.

The diameter of the metal sheath probe was Ø 5.6 mm and of quartz sheath was 7 mm. The immersion of both thermometers was at least 150 mm.

It was recommended that the participants use their standard procedure and follow the protocol during the temperature calibration. If possible making extra time-consuming measurements was avoided.

After receiving thermometers, they were carefully checked for any mechanical damage as consequence of the transport. In the next step, both thermometers were measured in the triple point of water or ice-point thus allowing checking for any change as a consequence of a transport between laboratories. Also, current used for the comparison was prescribed at 1mA.The hysteresis was also measured in midpoint of calibration range but values were in order of 0.5 mK absolute difference.

Immediately after measuring hysteresis, thermometers were calibrated by comparison, mostly in liquid baths. The reporting of results depended on the fact if laboratory performed measurements in the TPW or not. In case that measurement at TPW was performed, $W=R(t_{90})/R(TPW)$ was calculated for each measured temperature and reported together with its uncertainty. In case that measurement at ice-point was performed, first correction of resistance from actual temperature at ice-point to temperature of TPW (0.01 °C) was performed following by $W=R(t_{90})/R(TPW)$ for each measured temperature.

For calculation of ITS-90 coefficients measurements bellow TPW (a,b) and measurements above TPW (a,b and c) were used. In case of measurements above TPW, coefficients of a,b and c are used in case that calibration is performed up to the freezing point of zinc (420 °C). Up to the freezing point of tin (232 °C), only coefficients a and b are used. Within this comparison, also difference between using c coefficient in ITS-90 equation above TPW was evaluated.

Since SPRTs are usually calibrated at fixed points, it is quite easy to compare values (temperature is the same, simply W values are compared).In our case each laboratory nominally measured at same temperatures, but actually, these temperatures differ significantly. As a result, it was not possible directly to compare results of W. So, based on the sent ITS90 coefficients a,b and a,b,(c), we have calculated W at nominal temperatures of comparison and compared those W values together with their uncertainties.

As agreed among participants, the reference W value at each temperature was calculated as weighted mean of measurements LMK1-3, UME and DMDM. This is because these three laboratories do have their CMCs in BIPM KCDB annex C. Uncertainty of the reference value also included stability of W at each temperature as measured by the pilot laboratory.

The uncertainty sources included repeatability of measurements, inhomogeneity and stability of the calibration bath, the uncertainty of reference temperature measurement system and its drift, uncertainty of reading of SPRT, uncertainty due to hysteresis and uncertainty due to fit of ITS90 equation. 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 -80 °C to 10 °C, the water bath Kambič OB 50 in the range 10 °C to 70 °C, the low temperature silicon oil bath Kambič OB 50 in the range 100 °C to 150 °C and the high temperature silicon oil bath Kambič OB 50 in the range from 150 °C to 300 °C. In all the baths, equalizing blocks were used in order to provide increase stability and homogeneity. 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 270 °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.

In the TUBITAK UME calibrations were performed in the alcohol bath Fluke art Scientific 7100 with ethanol as working liquid in the range from -80 °C to 0 °C, the HETO water bath in the range 10 °C to 50 °C, the Fluke Hart Scientific oil bath in the range 100 °C to 250 °C and the Fluke Hart Scientific salt bath at the 300 °C. As the reference thermometer, Tinsley quartz sheathed thermometer and Fluke metal sheated standard platinum resistance thermometer calibrated at fixed points was used. As a resistance measurement system, automatic Fluke Superthermometer 1590 was used.

In the BoM calibrations were performed in the alcohol bath Fluke HartScientific 7080 with ethanol as working liquid in the range from -30 °C to 10 °C, the water bath Fluke HartScientific 7080 in the range 10 °C to 50 °C and the oil bath Fluke HartScientific 6020 in the range 100 °C to 150 °C . As the reference thermometer, Fluke 5683 quartz sheathed thermometer standard platinum resistance thermometer calibrated at fixed points was used. As a resistance measurement system, Fluke HartScientific Super thermometer 1590 in combination with reference resistor was used.

In the DMDM calibrations were performed in the low temperature bath Fluke Hart Scientific 7080 with halocarbon as working liquid in the range from -80°C to -30 °C, the water bath Fluke Hart Scientific 7341 in the range 10 °C to 80 °C, oil bath Fluke Hart Scientific 6020 in the range 80 °C to 250 °C and salt bath Fluke Hart Scientific 6050H in the range 250 °C to 550 °C. Two reference thermometers standard platinum resistance thermometer, Fluke 5699 metal sheathed and Isotech 670 quartz sheathed, both calibrated at fixed points were used. As a resistance measurement system, resistance bridge ASL F18 in combination with reference resistor at 23 °C was used.

In the IMBIH Laboratory for temperature calibrations were performed in the alcohol bath ISOTECH NEPTUNE 915LW with ethanol as working liquid in the range from -40 °C to 10 °C and the oil bath ISOTECH NEPTUNE 915H in the range from 50 °C to 250°C. As the reference thermometer, ISOTECH 670SQ quartz sheathed standard platinum resistance thermometer calibrated at fixed points was used. As a resistance measurement system, F900 Primary Standard AC Resistance Bridge in combination with reference resistor was used.

In DPM Albania, the SPRT’s were calibrated by using an ethanol bath (Hart Scientific, model 7381), water bath , Hart Scientific model 7321 and a stirred oil bath (Hart Scientific, model 6331). The temperature in baths and in ice-point is monitored by one standard platinum resistance thermometer (Fluke 5681), traceable to ITS 90. The thermometer resistance was measured by an AC resistance temperature bridge, F700B. A standard resistor of 100 ohm nominal value was used for comparison purposes, maintained in air bath. The measurement current used was 1 mA.

In the KMD calibrations were performed in the ethanol bath Kambic OB-50/2 LT in the range from -60 °C to 10 °C, the water bath Kambič OB-35/2 in the range 10 °C to 80 °C and the silicon oil bath Isotech 796H in the range from 80 °C to 300 °C. No equilizing blocks were used. As the reference thermometer, Isotech 909H metal sheathed standard platinum resistance thermometer calibrated by comparison was used. As a resistance measurement system, Isotech MicroK 800 with internal resistor was used.

Measurements of W at each temperature together with its uncertainties

Nominal temp. (°C)	Reference W value	U(W) of ref. value	LMK1 W	U(W) of LMK1	DMDM W	U(W) of DMDM	BOM W	U(W) of BOM
-80	0.67681378	5.8974E-05	0.67684027	2.46E-05	0.67683622	4.10E-05		
-60	0.75843075	3.16099E-05	0.75844430	2.44E-05	0.75844022	4.07E-05	0.75843511	4.47E-05

-50	0.79901716	2.34098E-05	0.79902606	2.43E-05	0.79902227	4.05E-05	0.79901510	4.46E-05
-40	0.83946460	1.77429E-05	0.83946990	2.42E-05	0.83946657	4.04E-05	0.83945865	4.04E-05
-30	0.87977860	1.37962E-05	0.87978129	2.42E-05	0.87977859	3.62E-05	0.87977108	4.03E-05
-10	0.96002365	1.07081E-05	0.96002377	2.40E-05	0.96002274	3.60E-05	0.96001927	4.00E-05
0	0.99996013	5.95934E-07	0.99996011	2.39E-05	0.99996011	7.98E-06	0.99996011	1.60E-05
50	1.19783893	1.31085E-05	1.19782909	2.36E-05	1.19784689	2.75E-05	1.19781359	3.14E-05
100	1.39270244	1.3076E-05	1.39269521	2.32E-05	1.39270294	3.48E-05	1.39266907	4.64E-05
150	1.58458389	1.08386E-05	1.58458406	2.29E-05	1.58456961	4.19E-05	1.58455263	4.57E-05
200	1.77351054	1.28443E-05	1.77351922	2.25E-05	1.77348490	4.88E-05	1.77348828	4.88E-05
250	1.95950915	1.64703E-05	1.95952503	2.22E-05	1.95948627	4.06E-05	1.95950072	4.80E-05
300	2.14260855	1.76612E-05	2.14262272	2.18E-05	2.14260686	4.36E-05	2.14261152	5.09E-05

Nominal temp. (°C)	DMK W	U(W) of DMK	MBM W	U(W) of MBM	DPM W	U(W) of DPM	IMBiH W	U(W) of IMBiH
-80		0.67675197	8.19E-05	0.67684653	1.21E-04			
-60	0.75836296	2.03E-04	0.75836740	8.13E-05	0.75844248	1.08E-04		
-50	0.79894979	2.03E-04	0.79895792	8.10E-05	0.79902207	9.83E-05		
-40	0.83940249	2.02E-04	0.83941234	8.08E-05	0.83946484	9.80E-05	0.83947357	6.50E-05
-30	0.87972618	2.01E-04	0.87973595	8.05E-05	0.87977617	8.86E-05	0.87977976	6.48E-05
-10	0.96000259	2.00E-04	0.96000731	8.00E-05	0.96002125	8.80E-05	0.96002062	6.44E-05
0	0.99996009	1.99E-04	0.99996010	7.98E-05	0.99996011	6.38E-05	0.99996011	5.54E-05
50	1.19791926	1.96E-04	1.19783094	7.86E-05	1.19783511	8.54E-05	1.1978616	9.39E-05
100	1.3927419	1.93E-04	1.39269399	7.74E-05	1.39270012	9.33E-05	1.39274375	9.05E-05
150	1.58452938	1.90E-04	1.58457757	7.62E-05	1.58458341	1.03E-04	1.58463524	9.45E-05
200	1.77337439	1.88E-04	1.77350773	7.50E-05	1.77351103	1.13E-04	1.77356252	1.04E-04
250	1.95936424	3.69E-04	1.95951111	7.38E-05	1.95950959	1.21E-04	1.9595526	9.12E-05
300	2.14257746	3.63E-04	2.14261098	7.27E-05				

Nominal temp. (°C)	LMK2 W	U(W) of LMK2	UME W	U(W) of UME	DPM LMK3	U(W) of LMK3
-80	0.67675339	2.46E-05	0.67675103	2.87E-05	0.67684572	2.46E-05

-60	0.75839423	2.44E-05	0.75841810	2.85E-05	0.75844467	2.44E-05
-50	0.79899006	2.43E-05	0.79901968	2.84E-05	0.79902496	2.43E-05
-40	0.83944543	2.42E-05	0.83947648	2.83E-05	0.83946796	2.42E-05
-30	0.87976602	2.42E-05	0.87979451	2.82E-05	0.87977908	2.42E-05
-10	0.96002058	2.40E-05	0.96003330	2.80E-05	0.96002257	2.40E-05
0	0.99996011	2.39E-05	0.99996013	5.98E-07	0.99996011	2.39E-05
50	1.19783388	2.36E-05	1.19784252	2.75E-05	1.19784361	2.36E-05
100	1.39269888	2.32E-05	1.39270894	3.87E-05	1.39270850	2.32E-05
150	1.58458338	2.29E-05	1.58458793	3.81E-05	1.58458738	2.29E-05
200	1.77351341	2.25E-05	1.77350579	3.75E-05	1.77351022	2.25E-05
250	1.95951558	2.22E-05	1.95948937	3.69E-05	1.95950721	2.22E-05
300	2.14261313	2.18E-05	2.14256221	7.27E-05	2.14260488	2.18E-05

Further details are avaiable in paper Comparison of the Calibration of Standard Platinum Thermometers by Comparison in the Range From -80 °C to 300 °C J.Bojkovski, N. Arifovic, N. Hodzic, M. Hoxha, M. Misini, O. Petrusova, S.Simic, T.Vukicevic and J. Drnovsek, 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**

2014-02-14

11 **Date**

2014-03-21

Notes for completion of the form overleaf