FINAL REPORT
GULFMET.T-S3
Supplementary Comparison on a Platinum Resistance Thermometer Calibration from -70 ºC to 250 ºC

Pilot Lab:

EMIRATES METROLOGY INSTITUTE

U.A.E. National Metrology Institute

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Contents

1. Introduction

This is the final report of the GULFMET T-S3 supplementary comparison on the calibration of Platinum Resistance Thermometers between the metrology institutes of GULFMET. The comparison was performed by measuring the electrical resistance of two Platinum Resistance Thermometer for a set of reference temperatures: -70 ºC, -35 ºC, 0.01 ºC, 50 ºC, 100 ºC, 200 ºC, 250 ºC.
Emirates Metrology Institute (EMI) in United Arab Emirates, was the pilot institute of this comparison. The travelling standards were provided by the pilot laboratory. EMI was responsible for monitoring the performance of the standards during the circulation and the evaluation and reporting of the comparison results.
The purpose of comparison is to demonstrate the degree of equivalence between institutes and support CMCs.
The comparison was carried out in accordance with the “Measurement Comparisons in the CIPM MRA” and “EURAMET Guide on Comparisons” [1, 2].

2. Travelling Standards

The traveling standards were the two platinum resistance thermometers shown in Table 1.

Table 1. Travelling standards

Thermometer 1	Thermometer 2
Manufacturer: Hart Scientific Model: 5615-9 Serial No: 906541 Range: -200 to 420 ºC R(0.0 ºC) = 100 Ω Suggested measuring current = 1 mA Leads: 4 wires Sheath length: 229 mm Sheath diameter: 4.75 mm Sheath material: Inconel 600 Sensor length: 28 mm Sensor location: 6.9 mm ± 3.3 mm from tip	Manufacturer: Hart Scientific Model: 5615-12 Serial No: 883912 Range: -200 to 420 ºC R(0.0 ºC) = 100 Ω Suggested measuring current = 1 mA Leads: 4 wires Sheath length: 305 mm Sheath diameter: 6.35 mm Sheath material: Inconel 600 Sensor length: 28 mm Sensor location: 6.9 mm ± 3.3 mm from tip

3. Participating Institutes

The pilot and coordinator institute for this comparison is Emirates Metrology Institute (UAE). The participating institutes and contact persons with their addresses are given in Table 2.

Table 2. Participating Institutes

Country	Institute	Acronym	Shipping Address	Contact Person
United Arab Emirates	Emirates Metrology Institute (pilot lab)	EMI	Now: Kryptolabs building, Masdar city, PO Box 853, Abu Dhabi, United Arab Emirates During the comparison: Block H, CERT Technology Park, 881, Sultan Bin Zayed The First Street, PO Box 853, Abu Dhabi, United Arab Emirates	Dr. Miltiadis Anagnostou miltiadis.anagnostou@qcc.gov.ae Tel :+97124035981
Turkey	TÜBİTAK Ulusal Metroloji Enstitüsü	TÜBİTAK UME	TÜBİTAK Ulusal Metroloji Enstitüsü (UME) TÜBİTAK Gebze Yerleşkesi Barış Mah. Dr. Zeki Acar Cad. No:1 41470 Gebze-Kocaeli, TURKEY	Dr. Murat Kalemci murat.kalemci@tubitak.gov.tr
Saudi Arabia	SASO The National Measurement and Calibration Center	SASO NMCC	Saudi Standards, Metrology and Quality Organization of The Kingdom of Saudi Arabia (SASO) Riyadh 11471, P.O. Box 3437 KINGDOM of SAUDI ARABIA	Eng. Oqab N. Alotaibi Tel: +966 11 2529737 and Eng. Rakan O. AlNefaie r.nefaie@saso.gov.sa Tel: +966 11 2529767
Qatar	Qatar Standards	QGOSM	Qatar General Organization for standardization Industrial area Rd., Abu Hamour, P.O. Box 23277 Doha	Mrs. Aisha Al Suwaidi amsuwaidi@mm.gov.qa amsuwaidi@qs.gov.qa

4. Time Schedule

The time schedule for the measurements of the comparison is given in Table 3 below:

Table 3. Time Schedule

Acronym of Institute	**Country**	**Starting Date**	**Finishing Date**
EMI	United Arab Emirates	14.04.2019	13.06.2019
SASO NMCC	Saudi Arabia	27.10.2019	26.11.2019
TÜBİTAK UME	Turkey	23.12.2019	03.01.2020
QGOSM	Qatar	20.01.2020	22.04.2020
EMI	United Arab Emirates	24.08.2020	14.02.2021

5. Transportation of Travelling Standards

The travelling standards were packed in a carton box of size (50 x 20 x 20) cm and total weight of 3 kg. The transport box could be easily opened for customs inspection.
Each participant was responsible for the transportation of the travelling standards to the next participant.
Any participant had to notify the pilot lab upon receiving the thermometers and report their resistance at the ice / water triple point and their general condition.
Stability of the instruments during the comparison was monitored from the resistance measurements of the participating labs at the ice point / triple point of water.

6. Measurement Quantities and Points

Main quantity which was measured is the electrical resistance of the PRTs at the reference temperatures of the comparison.
The measurement temperature points of the comparison are:

0.01 °C, -70 °C, -35 °C, 0.01 °C, 50 °C, 100 °C, 200 °C, 250 °C, 100 °C, 0.01 °C

The electrical resistance measurements were performed with four terminals using 1mA current and the self-heating was determined.
An initial ice / water triple point resistance measurement was performed and communicated to the pilot lab. The pilot lab was deciding whether an annealing of the thermometer is necessary or not. If an annealing was decided, it was done for 4 hours at 260 °C and followed by an ice / water triple point of the thermometers. Equivalent change of the thermometers should be less than 10 mK. If change is larger than this number, then the annealing had to be repeated.
Every lab calibrated the thermometers in comparison with its own reference thermometers using baths or block calibrators. The measurements were performed from the lower to the higher temperatures and then down to 100 °C and 0.01 °C to account for the hysteresis of the thermometers. At each set-point, and after the stability of the temperature has been reached, at least 10 measurements were taken in a period of 10 to 20 minutes for the reference temperature and the electrical resistance of the test thermometers. The mean and standard deviation of these measurements were determined and reported.
If the scope/capability of a laboratory was not covering the whole range of this comparison, the laboratory was allowed to limit measurement values according to its capability. In this case, the Pilot institute (EMI, UAE) was informed by the participant laboratory.

7. Measurement Equipment Used

The labs have used the equipment shown in Table 4 below to perform their measurements.

Table 4. Reference standards and calibration equipment used by the laboratories.

Institute:	EMI Manuf./Type/SN	UME Manuf./Type/SN	SASO NMCC Manuf./Type/SN	QGOSM Manuf./Type/SN
Thermometers:	Fluke/5681/1790 Quartz sheath, SPRT 25.5 ohm	Hart Sc./5680/1140 Metal sheath, SPRT 25.5 ohm	Fluke/5681/1989 Quartz sheath, SPRT 25.5 ohm	Fluke/5628/- Metal sheath, 25.5 ohm
		Hart Sc./5680/1141 Metal sheath, SPRT 25.5 ohm	Fluke/5682/1096 Metal sheath, PRT 100 ohm	
		Hart Sc./5683/4029 Quartz sheath, SPRT 25.5 ohm		
		Isotech/670SL/033 Metal sheath		
Instruments:	Fluke /1595A/B2B108	Hart Sc./1590/-	Bridge: ASL/F18/004879-01	Fluke/1595A/-
			Ref Resistor 100 ohm: Tinsley/5685A/1307-01	
			Fluke/1595A/B66233	
Baths:	Alcohol bath: Fluke/7080/B2C145	Alcohol bath: Heto/CB217/-	Alcohol bath: Isotech/798L/261643-2	Block Calibrator: Fluke/9170/-
	Water bath: Fluke/7080/B2B147	Water bath: Isotech/796m/-	Water bath: Fluke/7312/A94219	Block Calibrator: Fluke/9144/-
	Oil bath: Fluke/6020/B2B368	Oil Bath: Hart Sc./6020/-	Oil bath: Fluke/6331/A94275	Oil Bath: Fluke/6020/-
	Water bath: Fluke/7312/B2B328		Salt bath: Fluke/6055/A27070	
Water Triple Point Cells:	Fluke/5901-Q/AQ5073	UME/Long Cell/2014-01	UME/Zero4/2013	Ice point
Traceability:	EMI uses fixed-point cells to calibrate the reference SPRT thermometer. The electrical instrument is calibrated in EMI.	UME uses fixed-point cells to calibrate the reference thermometers. UME has registered SPRT CMCs at the KCDB. The electrical instrument is calibrated in UME.	SASO-NMCC uses fixed-point cells to calibrate the reference thermometer 5682. Thermometer 5681 has traceability to UME. The electrical instruments are calibrated in SASO-NMCC.	QGOSM standards are traceable to NIST (USA).

8. Measurement Uncertainty

The uncertainty of measurement was calculated according to the JCGM 100 “Guide to the Expression of Uncertainty in Measurement” [3] for the coverage probability of approximately 95%.
All contributions to the measurement uncertainty were listed in the report submitted by each participant.
Even though the contributions to the uncertainty are specific to the measurement method used, laboratories were advised to consider the list of uncertainty sources given below.

1. The Type A standard uncertainty of reference temperature and PRT resistance output.
2. The estimated uncertainty of the reference temperature including calibration and drift of reference thermometer also calibration, drift and resolution of the reading instrument used to read reference thermometer.
3. The estimated uncertainty term from the bath instability.
4. The estimated uncertainty term from the bath inhomogeneity.
5. The estimated uncertainty relating to the short-term stability of the travelling standard at the time of measurement.
6. The estimated uncertainty relating to the hysteresis of the travelling standard (Difference between measurements in ascending and descending order).

This was not a complete list, and it could be extended with uncertainty contributions that are specific for the participant's measurement system. The labs could get advice for the uncertainty terms required from the guideline DKD-R 5-1 [4].
Uncertainty terms related to electrical resistance were converted to equivalent temperature terms using the corresponding sensitivity of the reference or test PRT.
Each participant submitted detailed analyses of uncertainty for their standards. A list of all significant components of the uncertainty budget was given to support the quoted uncertainties. A template for reporting uncertainty of measurement was given in Appendix 1 of the measurement protocol.

9. Participant Results

The results should be sent to the pilot institute at the latest six (6) weeks after completing the measurements. The labs reported their results using four tables given in the Appendix 1 of the protocol.

- In Table A. "MEASUREMENT RESULTS", participants reported the actual mean of their reference temperatures and the standard deviation of these measurements, also they reported the actual mean of the PRT resistance values at these temperatures and their standard deviation.
- In Table B. "RESULTS REDUCED TO NOMINAL TEMPERATURES", participants calculated, using their measurements, and reported the PRT resistance values at the exact nominal points of the comparison. This will help us compare the results of the labs, since during calibration every lab measures at a slightly different temperature, close to the nominal value. In the same page, an average sensitivity dR/dt of the resistance vs temperature curve is given, calculated from the respective curves of both thermometers. These values can be used by the participants to calculate the PRT resistance values at the exact nominal points of the comparison. Also, the participants have to calculate the combined standard uncertainty of their measurements and report in this table (last column).
- In Table C. "UNCERTAINTY CALCULATION", participants presented an analytical evaluation of their uncertainty. If the uncertainty is not the same in all measurement points, they provided more than one tables covering the whole range of measurements.
- In Table D. "EQUIPMENT INFORMATION", participants provided information for their equipment used and its traceability.

We present in Tables 5, 6 and 7 below the Table B compilation of the results submitted by the laboratories for the two thermometers.

Table 5. PRT 906541 resistance values, reduced to the nominal temperatures and the standard uncertainty related to them, reported by the participant labs.

Institute:	EMI Initial		TUBITAK UME		SASO-NMCC		QGOSM		EMI Second	
Nominal Temperature (°C)	PRT Res. (ohm)	Std. Unc. (°C)	PRT Res. (ohm)	Std. Unc. (°C)	PRT Res. (ohm)	Std. Unc. (°C)	PRT Res. (ohm)	Std. Unc. (°C)	PRT Res. (ohm)	Std. Unc. (°C)
0.01	100.0103	0.004	100.0106	0.004	100.0108	0.002	100.0104	0.005	100.0104	0.004
-70	71.7922	0.006	71.7959	0.005	71.7948	0.012	not meas.	not meas.	71.7965	0.006
-35	85.9788	0.006	85.9802	0.005	85.9790	0.006	85.9812	0.007	85.9780	0.006
0.01	not meas.	not meas.	100.0105	0.004	100.0105	0.002	100.0103	0.005	not meas.	not meas.
50	119.7829	0.006	119.7848	0.005	119.7823	0.009	119.7869	0.007	119.7841	0.006
100	139.2602	0.007	139.2620	0.006	139.2588	0.009	139.2573	0.011	139.2613	0.007
200	177.3220	0.009	177.3256	0.006	177.3156	0.009	177.3106	0.016	177.2990	0.009
250	195.9128	0.009	195.9141	0.006	195.9091	0.012	195.8978	0.027	195.8794	0.009
100	139.2607	0.007	139.2592	0.006	139.2592	0.009	139.2585	0.011	139.2614	0.007
0.01	100.0102	0.004	100.0104	0.004	100.0104	0.002	100.0102	0.005	100.0065	0.004

The PRT 906541 thermometer was stable during the circulation to the labs and when it came back to EMI its water triple point (WTP) was as before. But during the second measurement at EMI, it showed unstable behaviour, when it was at 200 °C and 250 °C and by the end of the second calibration its triple point of water was shifted to a lower value by about 10 mK. EMI continued studying and calibrating the thermometer, its insulation resistance was measured and found OK (greater than 100 Mohm). After a third calibration cycle its WTP was about 17 mK below the comparison value but it was still unstable. An annealing was performed at 420 °C for three hours, without having any drastic effect on the WTP. After the annealing a fourth calibration was performed which gave good results in respect to the stability of the thermometer and the W ratios, but its WTP remained about 17 mK lower than the value during circulation. The data of this fourth calibration will be considered as the EMI final measurement, see Table 6.

Table 6. PRT 906541 resistance values, reduced to the nominal temperatures and the standard uncertainty related to them, reported by the EMI as the final measurement for this thermometer.

EMI final, after annealing at 420 ºC for 3 hours		
Nominal Temperature (°C)	**PRT Res. (ohm)**	**Std. Unc. (°C)**
0.01	100.0029	0.004
-70	71.7887	0.006
-35	85.9730	0.006
0.01	100.0027	0.004
50	119.7757	0.006
100	139.2514	0.007
200	177.3117	0.009
250	195.8997	0.009
100	139.2518	0.007
0.01	100.0035	0.004

Table 7. PRT 883912 resistance values, reduced to the nominal temperatures and the standard uncertainty related to them, reported by the participant labs.

Institute:	**EMI Initial**		**TUBITAK UME**		**SASO-NMCC**		**QGOSM**		**EMI Final**	
Nominal Temperature (°C)	**PRT Res. (ohm)**	**Std. Unc. (°C)**	**PRT Res. (ohm)**	**Std. Unc. (°C)**	**PRT Res. (ohm)**	**Std. Unc. (°C)**	**PRT Res. (ohm)**	**Std. Unc. (°C)**	**PRT Res. (ohm)**	**Std. Unc. (°C)**
0.01	100.0439	0.002	100.0439	0.002	100.0437	0.002	100.0437	0.005	100.0438	0.002
-70	71.8182	0.004	71.8205	0.003	71.8200	0.012	not meas.	not meas.	71.8211	0.004
-35	86.0078	0.004	86.0092	0.003	86.0078	0.006	85.9975	0.007	86.0100	0.004
0.01	not meas.	not meas.	100.0433	0.002	100.0436	0.002	100.0433	0.005	not meas.	not meas.
50	119.8236	0.004	119.8238	0.004	119.8228	0.009	119.8247	0.007	119.8234	0.004
100	139.3065	0.006	139.3075	0.004	139.3039	0.009	139.2937	0.010	139.3061	0.006
200	177.3782	0.008	177.3787	0.005	177.3755	0.009	177.3700	0.016	177.3787	0.008
250	195.9733	0.008	195.9752	0.005	195.9742	0.012	195.9627	0.027	195.9754	0.008
100	139.3055	0.006	139.3065	0.004	139.3042	0.009	139.2954	0.010	139.3064	0.006
0.01	100.0437	0.002	100.0444	0.002	100.0436	0.002	100.0438	0.005	100.0437	0.002

As we see from the results, the PRT 883912 thermometer was quite stable during the comparison.

10. Calculation of the Comparison Reference Values

The resistance ratio $W_{lab}(t) = \frac{R(t)}{R(0.01\,^oC)}$ of each thermometer, for every lab, is compared with the weighted mean value calculated from all labs:

$$W_{wmean}(t) = \frac{\left[\frac{1}{u(W_{lab1}(t))^2}\right]*W_{lab1}(t)+\left[\frac{1}{u(W_{lab2}(t))^2}\right]*W_{lab2}(t)+\cdots}{\left[\frac{1}{u(W_{lab1}(t))^2}\right]+\left[\frac{1}{u(W_{lab2}(t))^2}\right]+\cdots} \qquad (1)$$

The uncertainty of this weighted mean was evaluated using the equation:

$$[u(W_{wmean}(t))]^2 = \frac{1}{\left[\frac{1}{u\left(W_{lab1}(t)\right)^2}\right]+\left[\frac{1}{u\left(W_{lab2}(t)\right)^2}\right]+\cdots} \qquad (2)$$

The *R(t)* value for every lab is the average of the resistance value of the ascending measurements reported by the lab for every nominal temperature set point (Table B in the Appendix 1.). The *R(0.01 ^oC)* value for every lab, is the average of the three WTP values reported by the lab in Table B, Appendix 1. The standard uncertainty of W_{lab} was calculated combining the standard uncertainties of *R(t)* and *R(0.01 ^oC)* reported by the labs.
The deviation of $W_{lab}(t)$ values from the $W_{wmean}(t)$ is calculated using equation 3:

$$\Delta W_{lab}(t) = W_{lab}(t) - W_{wmean}(t) \qquad (3)$$

The pilot made the assessment of the drift in the travelling standards during the comparison. The assessment was based on initial and final measurements done by the pilot. The drift found, was taken into account in the uncertainty of the reference value of the comparison u_{drift}.
The normalized deviation for every lab was calculated using the following formula:

$$E_{n-lab} = \frac{\Delta W_{lab}(t)}{2*\sqrt{u(W_{lab}(t))^2 - u\left(W_{wmean}(t)\right)^2 + u_{drift}^2}} \qquad (4)$$

Note that this comparison is an RMO supplementary comparison so the W_{wmean} values generated are used only as a baseline for reporting the results, and they have no particular meaning of reference values in the sense of the key comparisons.
A similar approach was used to evaluate the results of the laboratories in respect to the resistance of the thermometers at the triple point of water *R(0.01 ^oC)*. This was done following a comment from a reviewer of the CCT Key Comparison Working Group for the Draft B of the comparison.

10.1 Thermometer 1 data evaluation

In this Section the Thermometer 1 (SN: 906541) data are processed and presented in tables and graphs.
The W ratio values of the PRT 906541 and its standard uncertainty are given for the labs in Table 8.

Table 8. PRT 906541 W ratio values, reduced to the nominal temperatures and the standard uncertainty associated to them, calculated using the lab results.

	$W_{EMI\ (average)}$		W_{UME}		$W_{SASO\ NMCC}$		W_{QGOSM}	
Nom. Temp. (°C)	**W PRT**	**u(W)**	**W PRT**	**u(W)**	**W PRT**	**u(W)**	**W PRT**	**u(W)**
-70	0.717857	0.000026	0.717883	0.000024	0.717872	0.000049	-	-
-35	0.859702	0.000027	0.859712	0.000025	0.859699	0.000025	0.859723	0.000034
50	1.197714	0.000030	1.197722	0.000029	1.197696	0.000037	1.197746	0.000037
100	1.392465	0.000037	1.392474	0.000033	1.392441	0.000037	1.392429	0.000049
200	1.773051	0.000045	1.773070	0.000039	1.772968	0.000037	1.772923	0.000069
250	1.958932	0.000048	1.958936	0.000042	1.958884	0.000047	1.958776	0.000107

The drift of the PRT 906541 thermometer determined by its change of W ratio from the pilot measurements, the W_{wmean} and its standard uncertainty are given in Table 9.

Table 9. PRT 906541 W ratio drift, weighted mean, standard uncertainty of the weighted mean, calculated using the submitted results.

Nom. Temp. (°C)	**W_{drift}= $W_{EMI\ change}/\sqrt{3}$**	**W_{wmean}**	**u(W_{wmean})**
-70	0.000010	0.717871	0.000016
-35	0.000002	0.859707	0.000014
50	0.000008	1.197719	0.000016
100	0.000007	1.392456	0.000019
200	0.000014	1.773014	0.000022
250	0.000006	1.958911	0.000025

The W ratio deviation from the weighted mean is given in Table 10.

Table 10. PRT 906541, W ratio deviation for all labs from the W_{wmean}

Nom. Temp. (°C)	W_{EMI}-W_{wmean}	W_{UME}-W_{wmean}	$W_{SASO\ NMCC}$-W_{wmean}	W_{QGOSM}-W_{wmean}
-70	-0.000014	0.000012	0.000001	-
-35	-0.000006	0.000005	-0.000009	0.000016
50	-0.000005	0.000003	-0.000023	0.000027
100	0.000009	0.000018	-0.000015	-0.000027
200	0.000036	0.000056	-0.000046	-0.000091
250	0.000022	0.000025	-0.000026	-0.000135

The expanded uncertainties of W_{wmean} and W_{lab}-W_{wmean} are given in Table 11.

Table 11. PRT 906541, expanded uncertainty of W_{wmean} and W_{lab}-W_{wmean}.

Nom. Temp. (°C)	$U(W_{wmean})$	$U(W_{EMI}$-$W_{mean})$	$U(W_{UME}$-$W_{wmean})$	$U(W_{SASO\ NMCC}$-$W_{wmean})$	$U(W_{QGOSM}$-$W_{wmean})$
-70	0.000033	0.000044	0.000040	0.000095	-
-35	0.000027	0.000046	0.000043	0.000043	0.000062
50	0.000033	0.000053	0.000051	0.000067	0.000069
100	0.000038	0.000065	0.000056	0.000064	0.000091
200	0.000044	0.000085	0.000072	0.000065	0.000134
250	0.000051	0.000083	0.000067	0.000080	0.000208

The En values for all labs are given in Table 12.

Table 12. PRT 906541, The En values for all labs.

Nom. Temp. (°C)	$E_{n\text{-}EMI}$	$E_{n\text{-}UME}$	$E_{n\text{-}SASO\ NMCC}$	$E_{n\text{-}QGOSM}$
-70	-0.329	0.313	0.007	-
-35	-0.121	0.112	-0.202	0.255
50	-0.100	0.064	-0.342	0.389
100	0.139	0.313	-0.234	-0.299
200	0.427	0.783	-0.705	-0.683
250	0.260	0.376	-0.331	-0.648

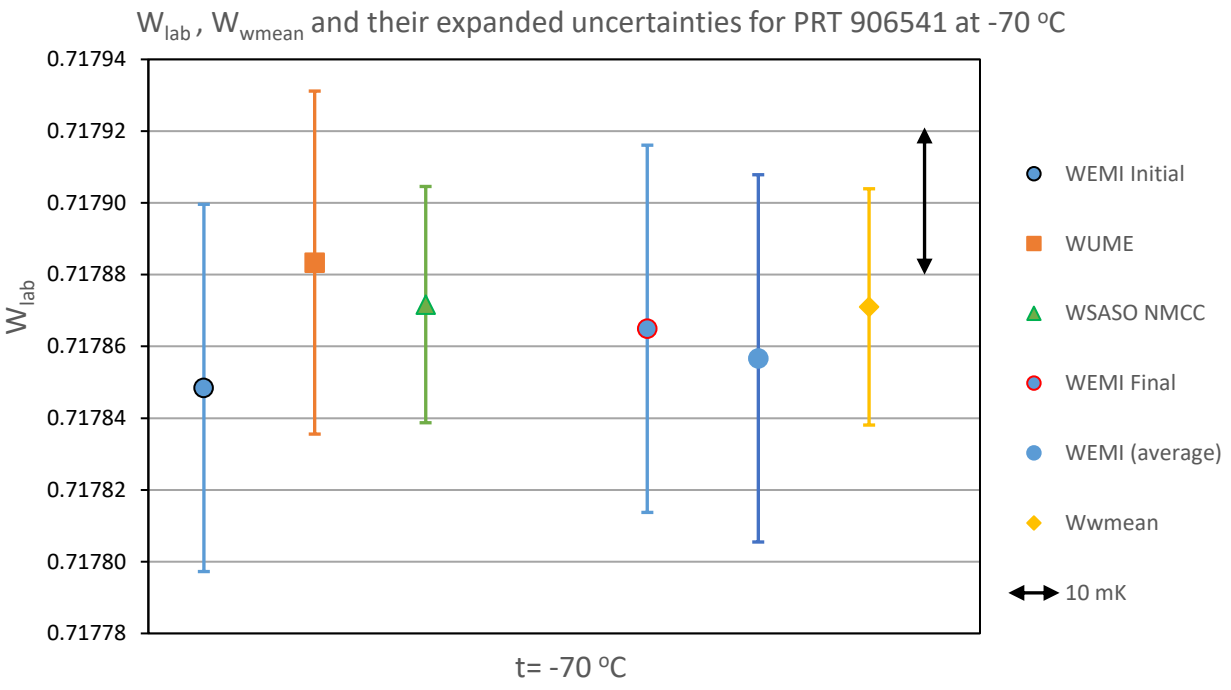
The respective results of the laboratories for the triple point of water $R_{0.01}$ resistance value of the PRT 906541 are presented in Table 13.

Table 13. PRT 906541 $R_{0.01}$ average value, its standard uncertainty in ^{o}C and ohms, drift, weighted mean, standard uncertainty of the weighted mean, deviation from weighted mean, expanded uncertainty of the deviation and En value for all labs.

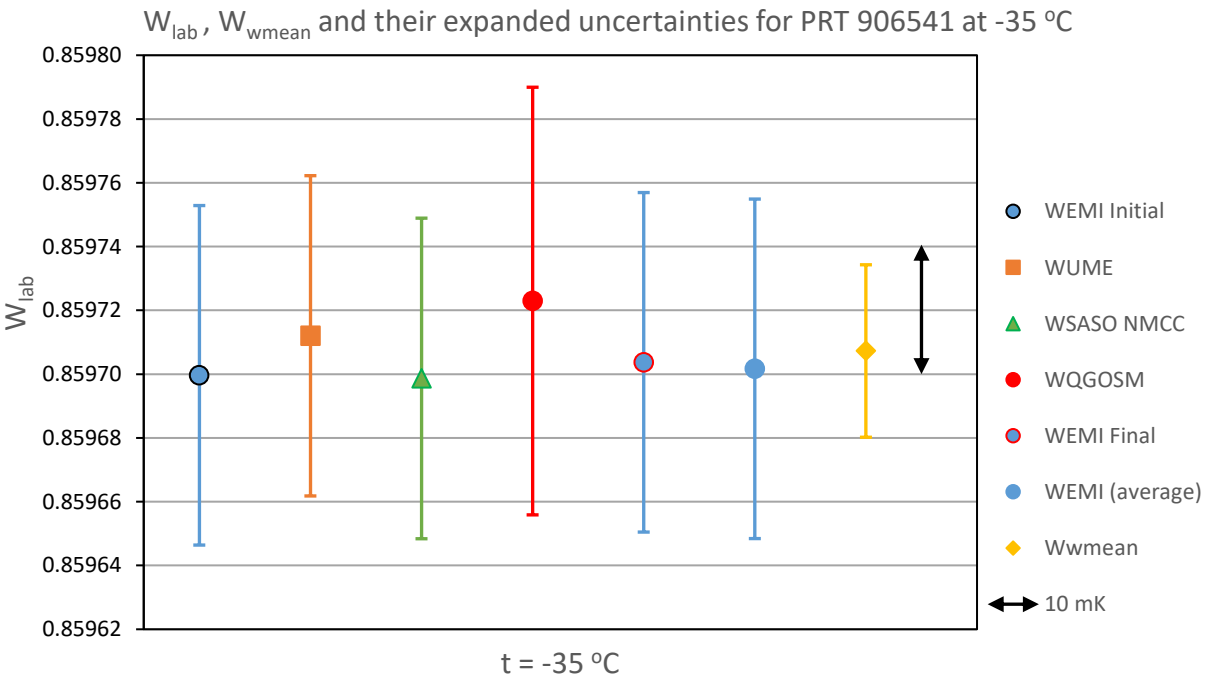
	$R_{0.01}$ (ohm)	$u(R_{0.01})$ (^{o}C)	$u(R_{0.01})$ (ohm)	$R_{lab}-R_{wmean}$ (ohm)	$U(R_{lab}-R_{wmean})$ (ohm)	$E_{n\text{-}lab}$, $R_{0.01}$
EMI Initial	100.0102	0.004	0.0017	-0.0003	0.0032	-0.080
UME	100.0105	0.004	0.0018	0.0000	0.0033	-0.005
SASO-NMCC	100.0106	0.002	0.0008	0.0001	0.0010	0.071
QGOSM	100.0103	0.005	0.0020	-0.0002	0.0037	-0.050
EMI* Second	100.0104	0.004	0.0017	-0.0001	0.0032	-0.023
EMI Average	100.0103	0.004	0.0017	-0.0002	0.0032	-0.052
Rwmean	100.0105	0.002	0.0006			
$R_{0.01}$ drift= R change/√3	-0.0001					

*The EMI Second value before the shift of the thermometer's triple point of water was used in this evaluation.

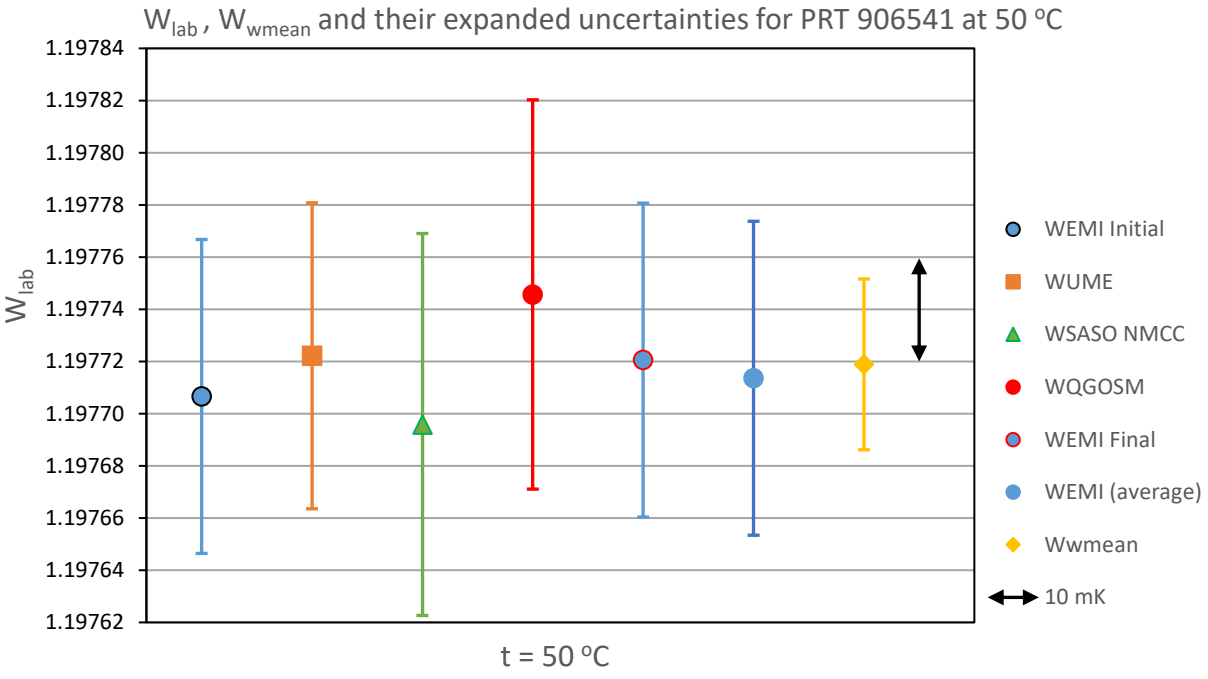
The data given in Tables 8, 9, 10, 11, 12 and 13 are pictured in the graphs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11 that follow for thermometer PRT 906541.



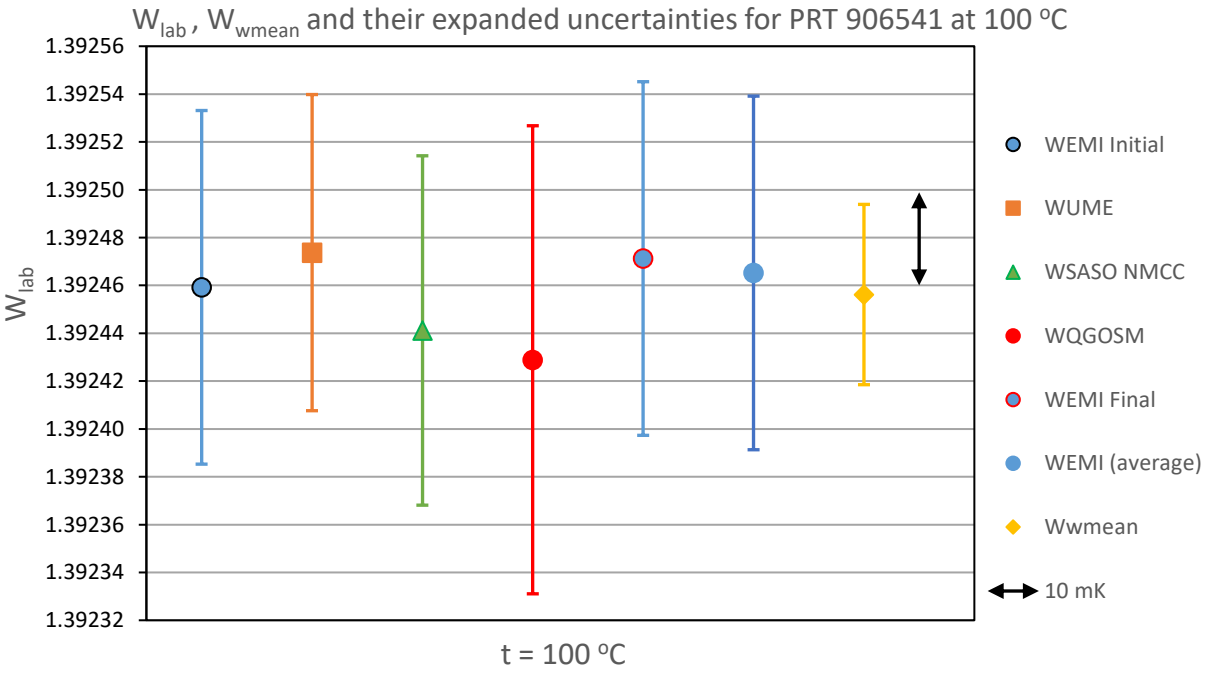
Graph 1. PRT 906541, W_{lab} , W_{wmean} and their expanded uncertainties at t = -70 °C for all labs.



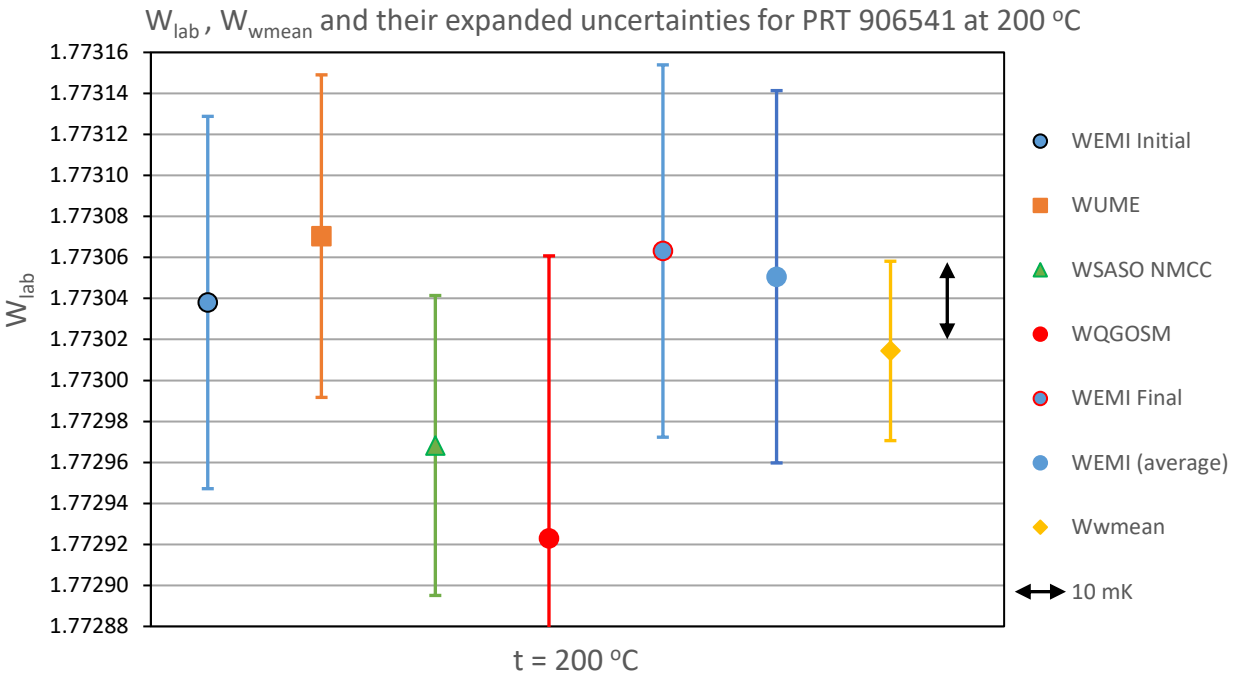
Graph 2. PRT 906541, W_{lab} , W_{wmean} and their expanded uncertainties at t = -35 °C for all labs.



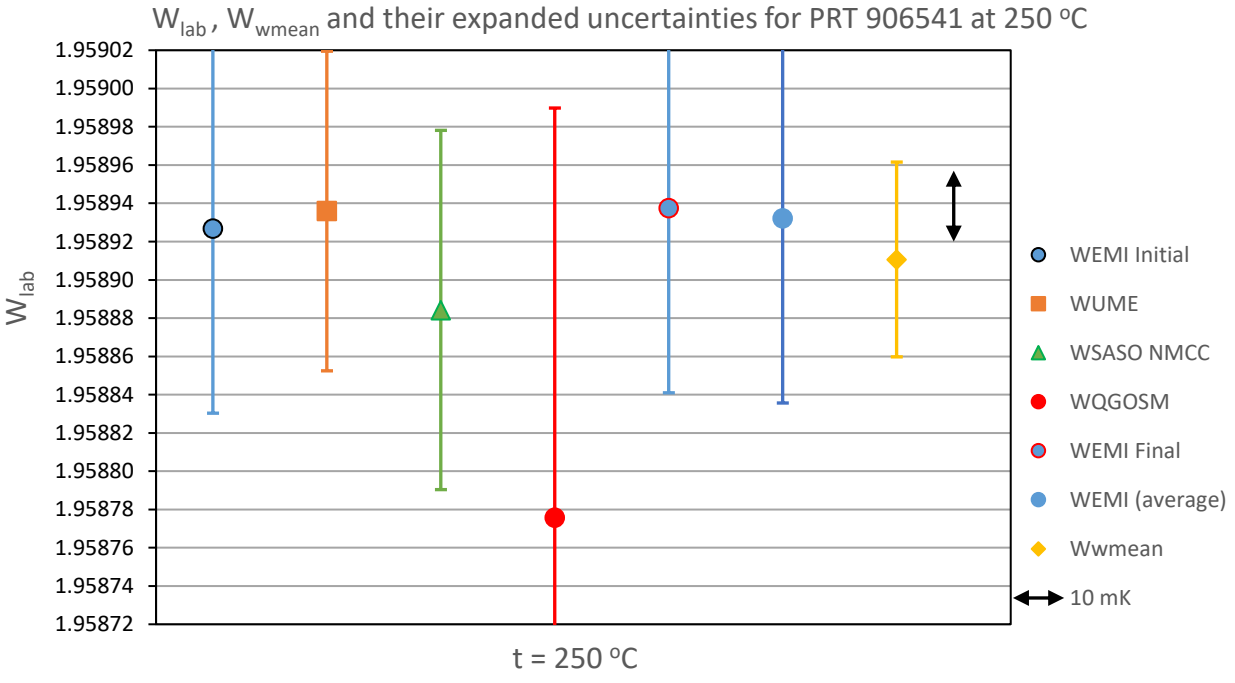
Graph 3. PRT 906541, W_{lab} , W_{wmean} and their expanded uncertainties at t = 50 °C for all labs.



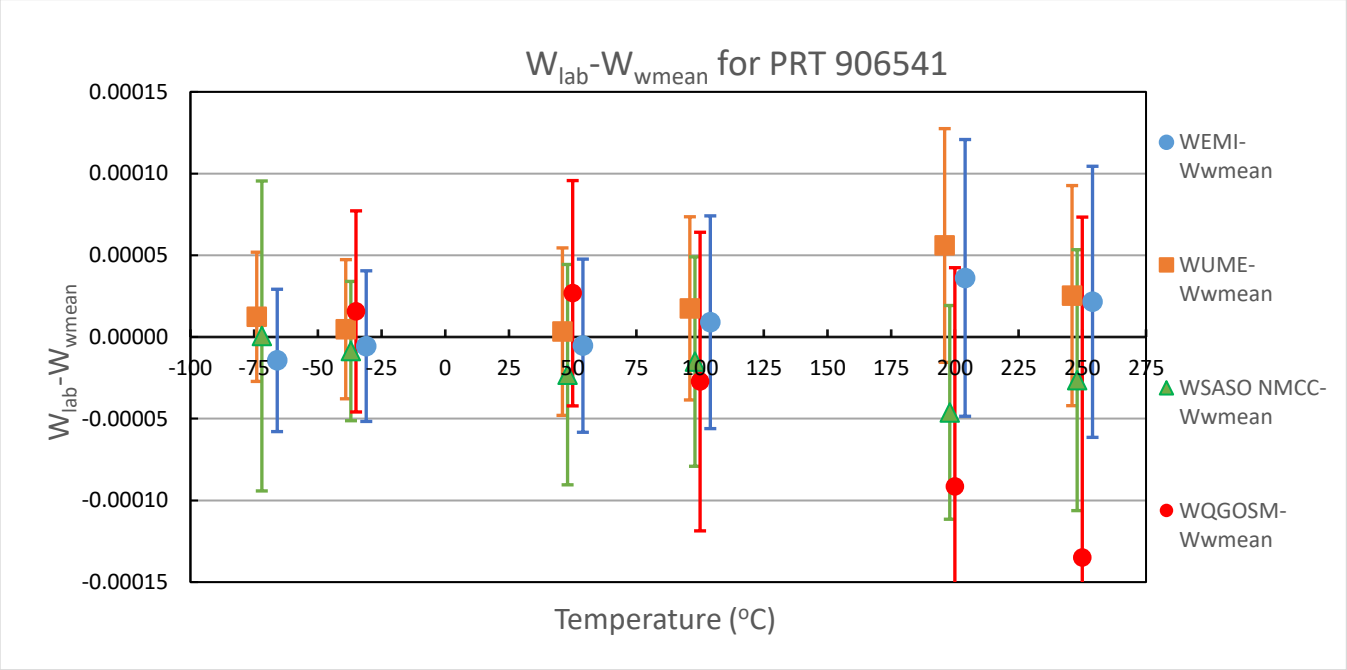
Graph 4. PRT 906541, W_{lab} , W_{wmean} and their expanded uncertainties at t = 100 °C for all labs.



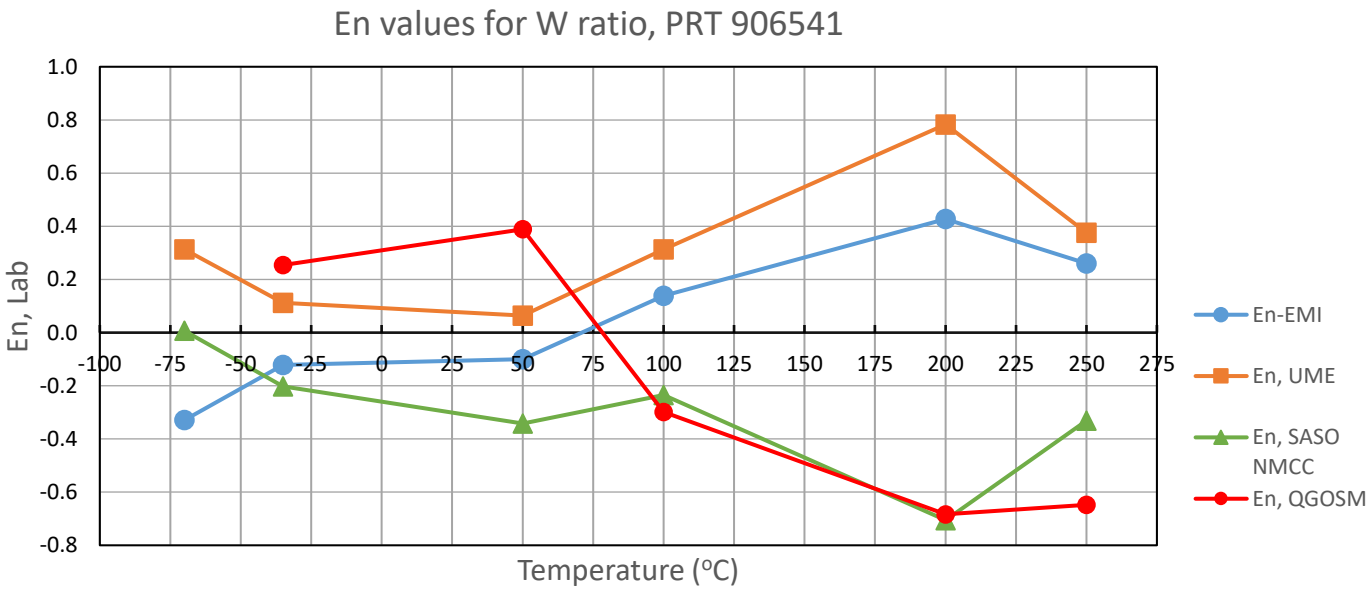
Graph 5. PRT 906541, W_{lab} , W_{wmean} and their expanded uncertainties at t = 200 °C for all labs.



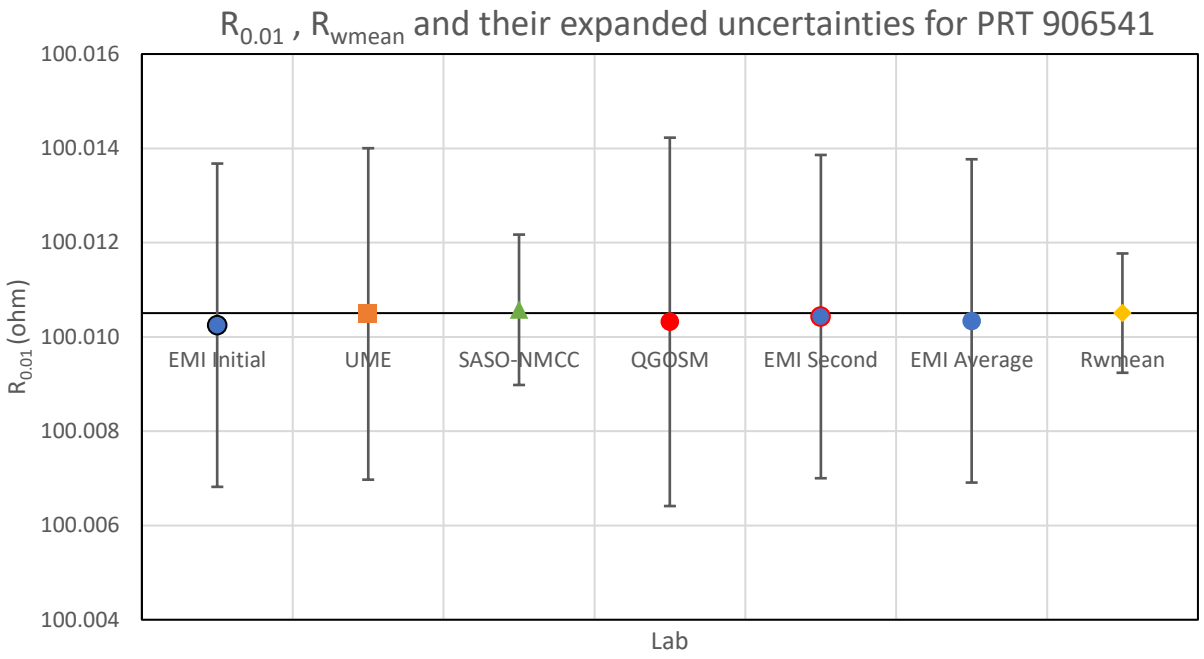
Graph 6. PRT 906541, W_{lab} , W_{wmean} and their expanded uncertainties at t = 250 °C for all labs.



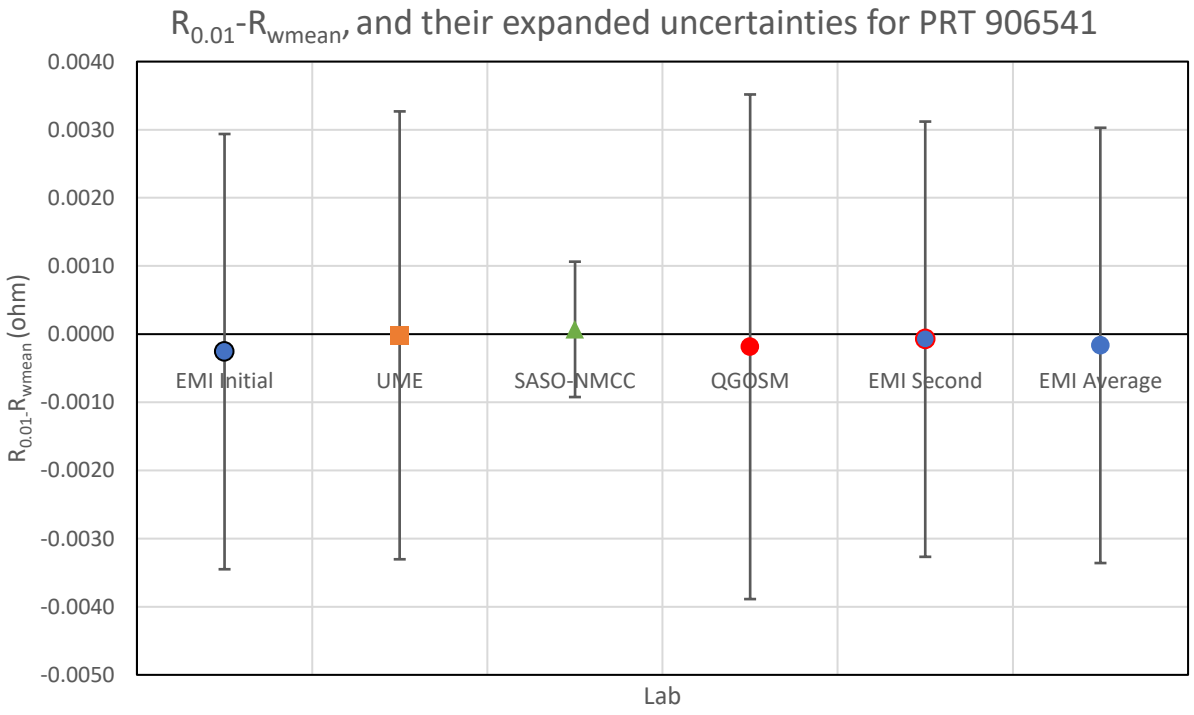
Graph 7. PRT 906541, W_{lab}-W_{wmean} and its expanded uncertainty for all labs and set-points.



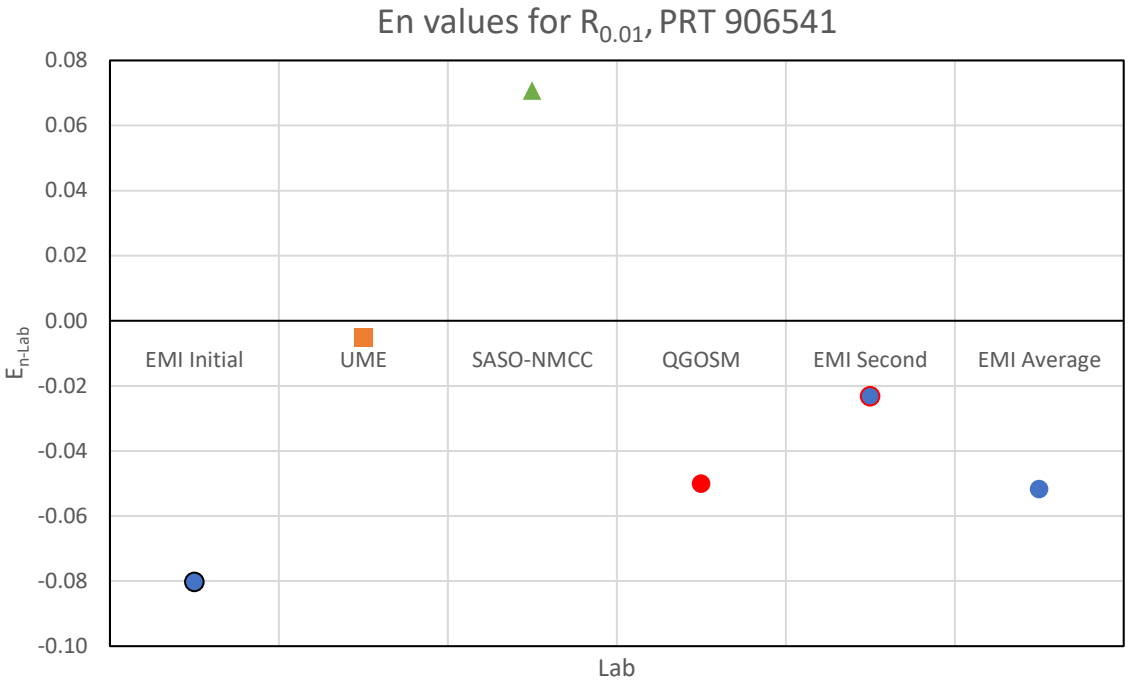
Graph 8. PRT 906541, En value for all labs and set-points.



Graph 9. PRT 906541, water triple point $R_{0.01}$ for all labs, and R_{wmean} along with their expanded uncertainties.



Graph 10. PRT 906541, $R_{0.01}$ - R_{wmean} for all labs and their expanded uncertainties.



Graph 11. PRT 906541, E_n values for $R_{0.01}$ measurements for all labs.

10.2 Thermometer 2 data evaluation

In this Section the Thermometer 2 (SN: 883912) data are processed and presented in tables and graphs.
The W ratio values of the PRT 883912 and its standard uncertainty is given for the labs in Table 14.

Table 14. PRT 883912 W ratio values, reduced to the nominal temperatures and the standard uncertainty associated to them, calculated using the lab results.

	$W_{EMI\ (average)}$		W_{UME}		$W_{SASO\ NMCC}$		W_{QGOSM}	
Nom. Temp. (°C)	**W PRT**	**u(W)**	**W PRT**	**u(W)**	**W PRT**	**u(W)**	**W PRT**	**u(W)**
-70	0.717882	0.000017	0.717890	0.000015	0.717886	0.000049	-	-
-35	0.859713	0.000017	0.859715	0.000015	0.859703	0.000025	0.859600	0.000034
50	1.197711	0.000018	1.197712	0.000018	1.197706	0.000037	1.197725	0.000037
100	1.392453	0.000026	1.392464	0.000021	1.392431	0.000037	1.392329	0.000049
200	1.773008	0.000033	1.773010	0.000025	1.772981	0.000037	1.772927	0.000069
250	1.958886	0.000034	1.958893	0.000026	1.958887	0.000047	1.958772	0.000106

The drift of the PRT 883912 thermometer determined by its change of W ratio from the pilot measurements, the W_{wmean} and its standard uncertainty are given in Table 15.

Table 15. PRT 883912 W ratio drift, weighted mean, standard uncertainty of the weighted mean, calculated using the submitted results.

Nom. Temp. (°C)	$W_{drift} = W_{EMI\ change}/\sqrt{3}$	W_{wmean}	$u(W_{wmean})$
-70	0.000017	0.717887	0.000011
-35	0.000013	0.859702	0.000010
50	-0.000001	1.197712	0.000011
100	-0.000002	1.392444	0.000014
200	0.000003	1.772998	0.000017
250	0.000012	1.958886	0.000019

The W ratio deviation from the weighted mean is given in Table 16.

Table 16. PRT 883912, W ratio deviation for all labs from the W_{wmean}

Nom. Temp. (°C)	W_{EMI}-W_{wmean}	W_{UME}-W_{wmean}	$W_{SASO\ NMCC}$-W_{wmean}	W_{QGOSM}-W_{wmean}
-70	-0.000005	0.000003	-0.000001	-
-35	0.000011	0.000012	0.000001	-0.000103
50	-0.000001	0.000000	-0.000007	0.000013
100	0.000009	0.000020	-0.000014	-0.000115
200	0.000010	0.000011	-0.000017	-0.000071
250	0.000000	0.000007	0.000000	-0.000114

The expanded uncertainties of W_{wmean} and W_{lab}-W_{wmean} are given in Table 17.

Table 17. PRT 883912, expanded uncertainty of W_{wmean} and W_{lab}-W_{wmean}.

Nom. Temp. (°C)	$U(W_{wmean})$	$U(W_{EMI}-W_{wmean})$	$U(W_{UME}-W_{wmean})$	$U(W_{SASO\ NMCC}-W_{wmean})$	$U(W_{QGOSM}-W_{wmean})$
-70	0.000022	0.000043	0.000038	0.000102	-
-35	0.000020	0.000039	0.000034	0.000053	0.000069
50	0.000023	0.000028	0.000027	0.000070	0.000071
100	0.000028	0.000043	0.000031	0.000067	0.000093
200	0.000034	0.000057	0.000037	0.000065	0.000134
250	0.000037	0.000062	0.000043	0.000089	0.000210

The En values for all the labs are given in Table 18.

Table 18. PRT 883912, The En values for the W ratio for all labs.

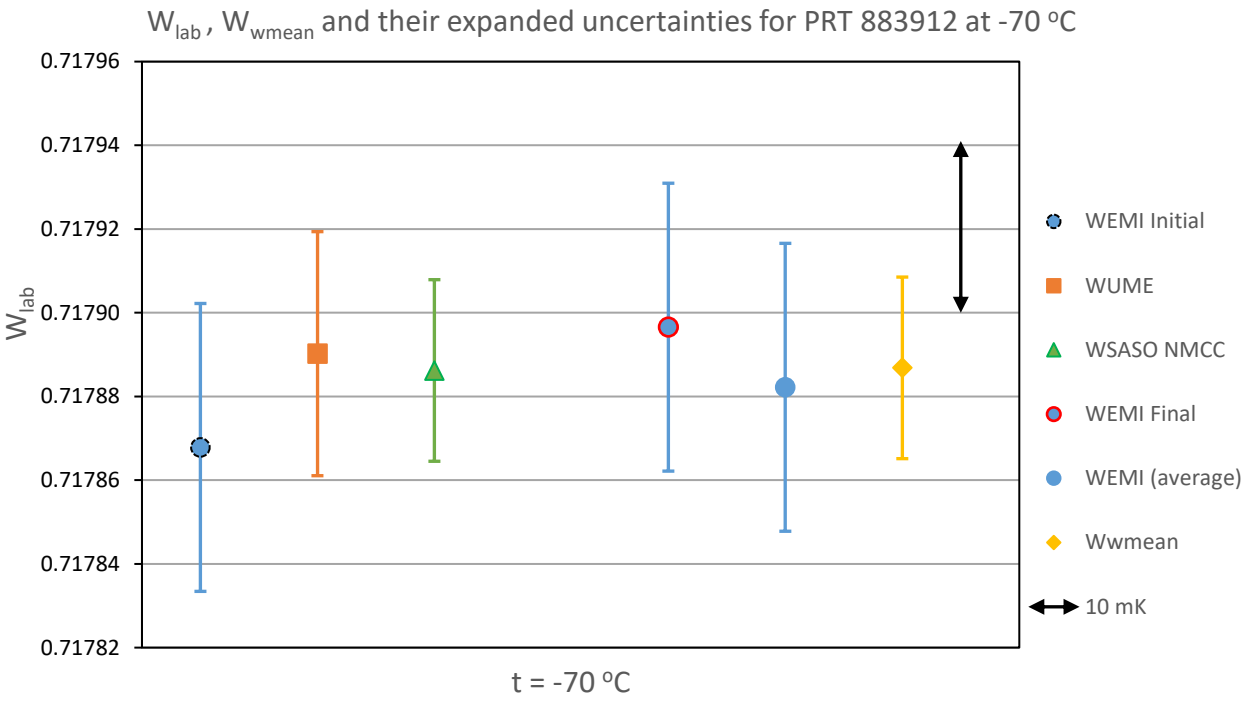
Nom. Temp. (°C)	E_{n-EMI}	E_{n-UME}	$E_{n-SASO\ NMCC}$	$E_{n-QGOSM}$
-70	-0.109	0.080	-0.006	-
-35	0.278	0.322	0.012	-1.485
50	-0.052	0.004	-0.096	0.177
100	0.206	0.454	-0.201	-1.240
200	0.181	0.200	-0.260	-0.534
250	-0.002	0.110	0.000	-0.544

The respective results of the laboratories for the triple point of water $R_{0.01}$ resistance value of the PRT 883912 are presented in Table 19.

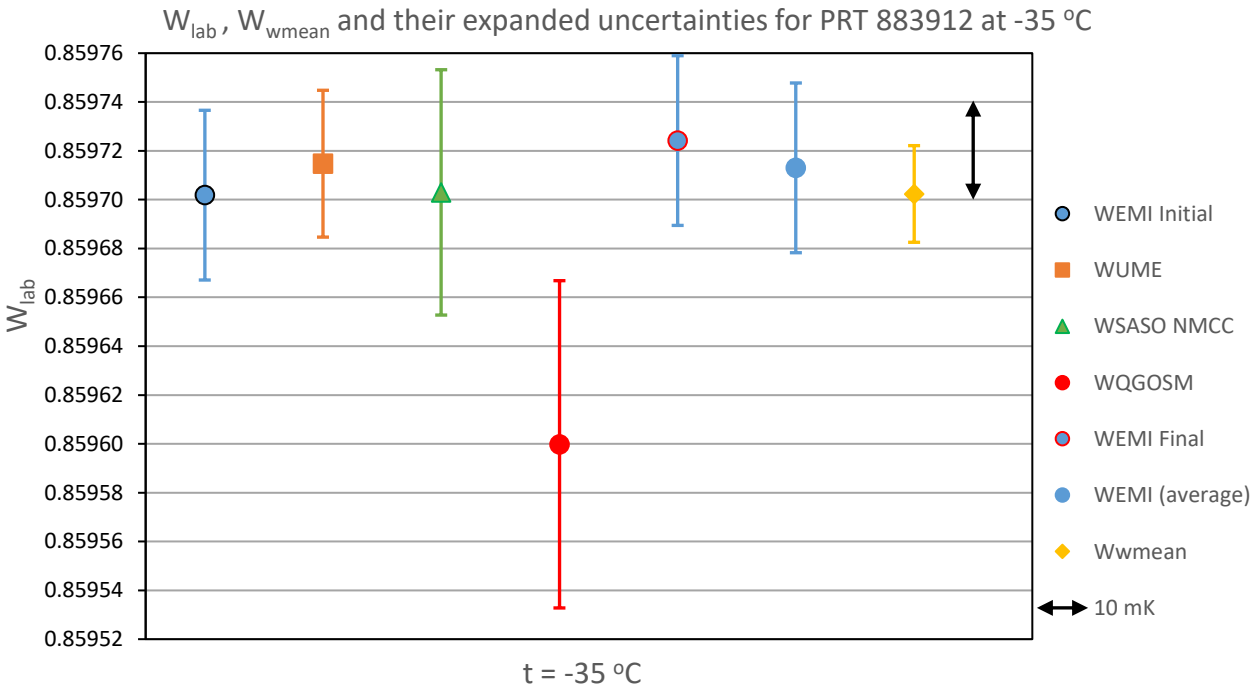
Table 19. PRT 883912 $R_{0.01}$ value, its standard uncertainty in ^oC and ohms, drift, weighted mean, standard uncertainty of the weighted mean, deviation from weighted mean, expanded uncertainty of the deviation and En value for all labs.

	$R_{0.01}$ (ohm)	**$u(R_{0.01})$ (^oC)**	**$u(R_{0.01})$ (ohm)**	**$R_{lab}-R_{wmean}$ (ohm)**	**$U(R_{lab}-R_{wmean})$ (ohm)**	**E_{n-lab}, $R_{0.01}$**
EMI Initial	100.0438	0.002	0.0008	0.0000	0.0012	0.022
UME	100.0439	0.002	0.0009	0.0001	0.0015	0.073
SASO-NMCC	100.0436	0.002	0.0008	-0.0001	0.0013	-0.068
QGOSM	100.0436	0.005	0.0020	-0.0001	0.0038	-0.029
EMI Final	100.0437	0.002	0.0008	0.0000	0.0012	0.005
EMI Average	100.0438	0.002	0.0008	0.0000	0.0012	0.014
Rwmean	100.0437	0.001	0.0005			
$R_{0.01}$ drift= R change/√3	0.00001					

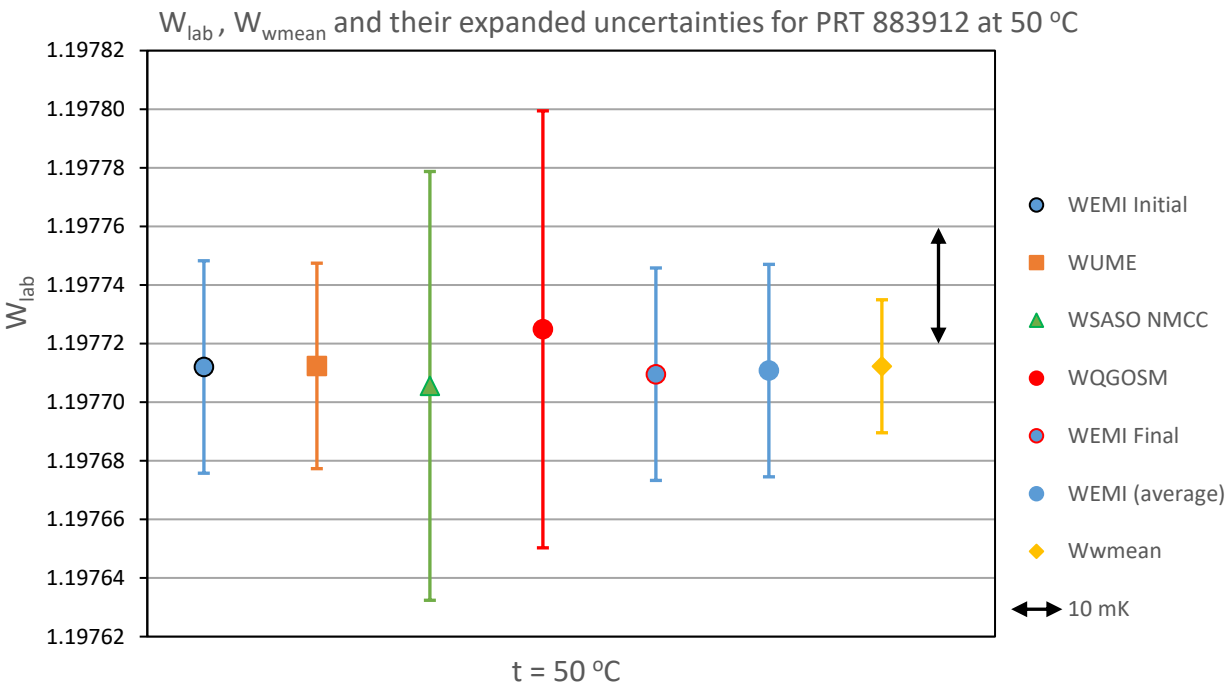
The data given in tables 14, 15, 16, 17, 18 and 19 are pictured in the graphs 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 and 22 that follow for thermometer PRT 883912.



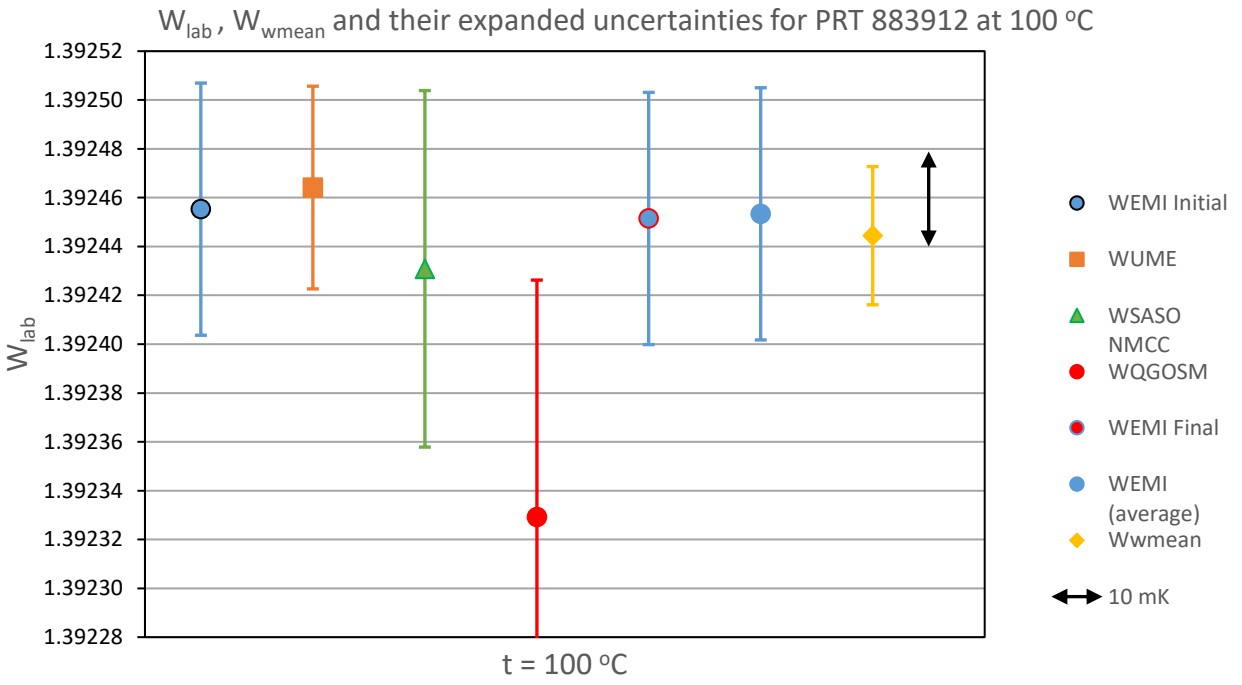
Graph 12. PRT 883912, W_{lab} , W_{wmean} and their expanded uncertainties at t = -70 °C for all labs.



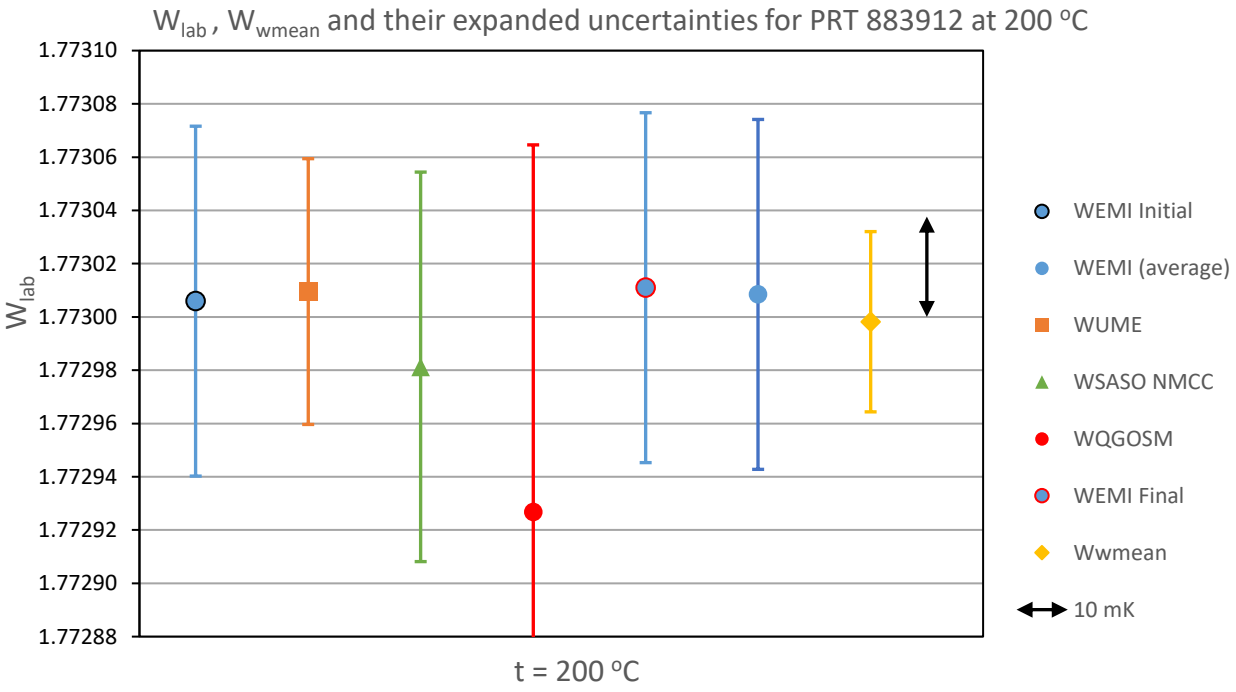
Graph 13. PRT 883912, W_{lab} , W_{wmean} and their expanded uncertainties at t = -35 °C for all labs.



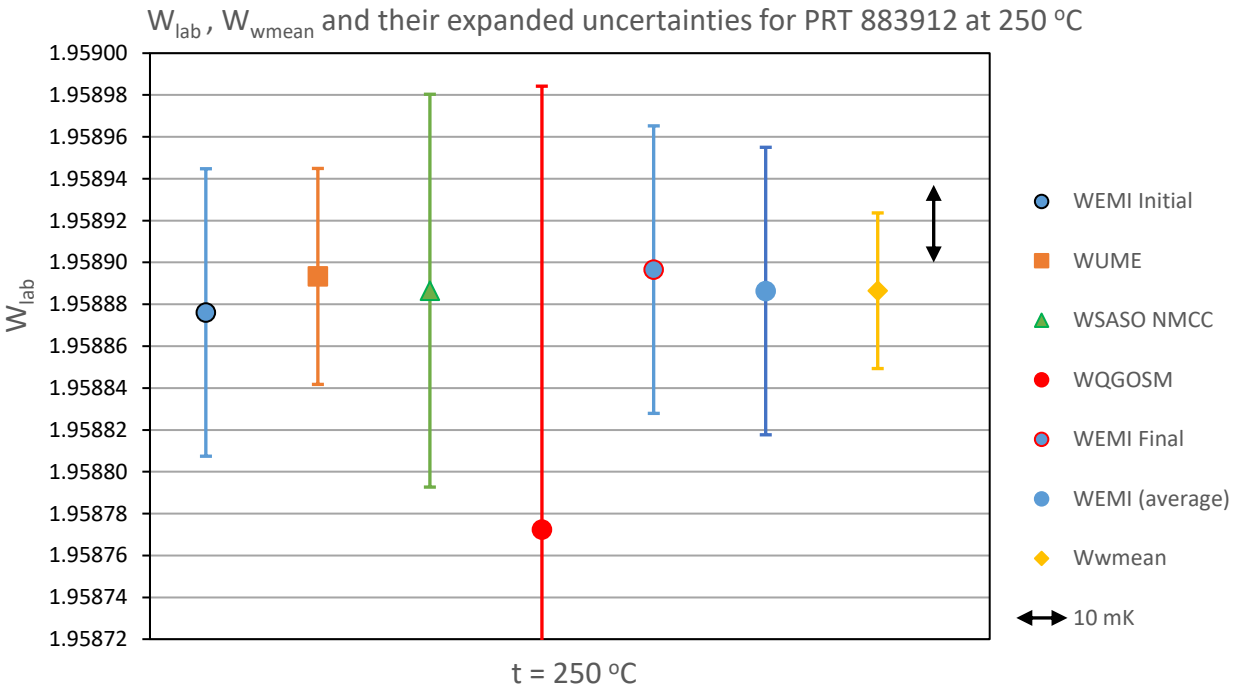
Graph 14. PRT 883912, W_{lab} , W_{wmean} and their expanded uncertainties at t = 50 °C for all labs.



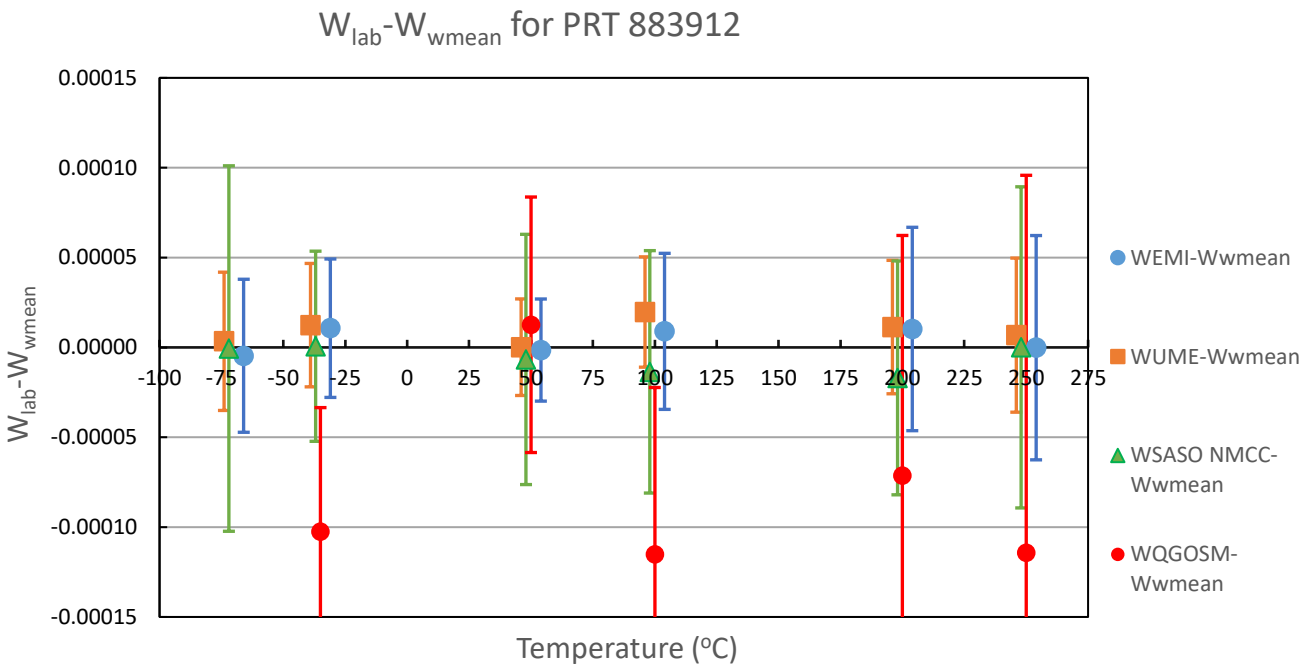
Graph 15. PRT 883912, W_{lab} , W_{wmean} and their expanded uncertainties at t = 100 °C for all labs.



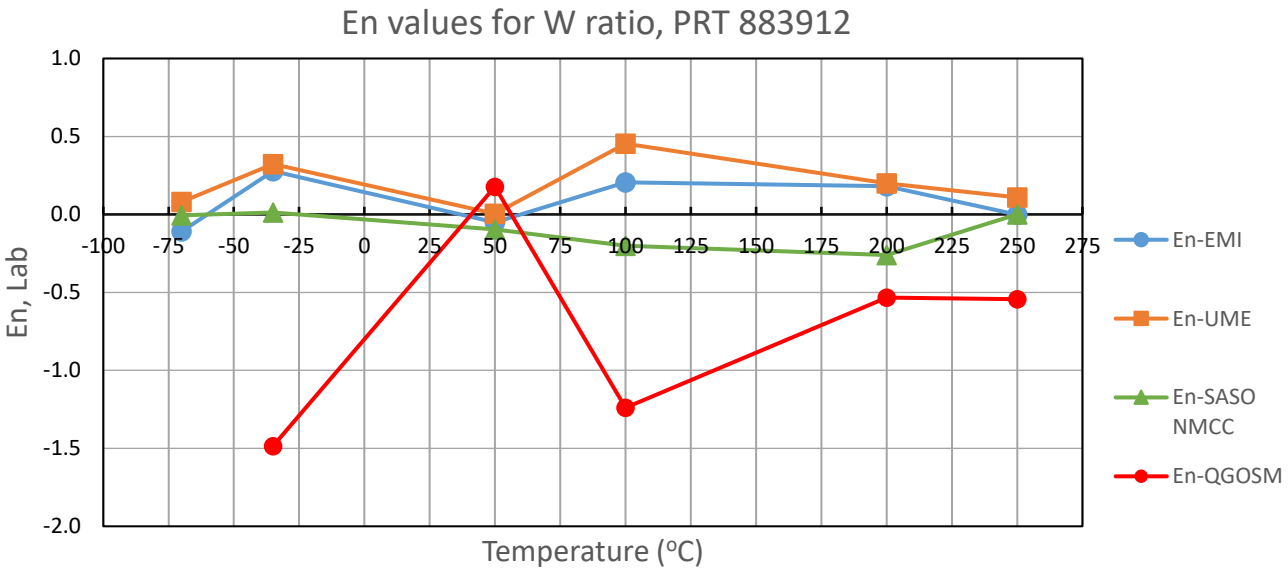
Graph 16. PRT 883912, W_{lab} , W_{wmean} and their expanded uncertainties at t = 200 °C for all labs.



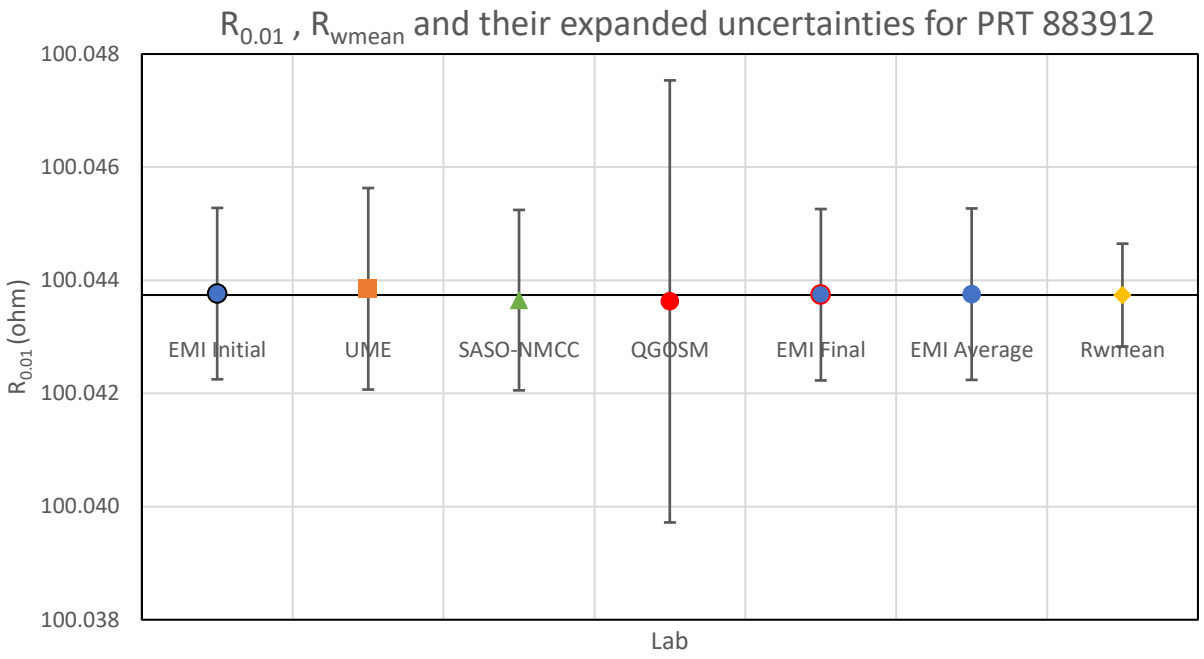
Graph 17. PRT 883912, W_{lab} , W_{wmean} and their expanded uncertainties at t = 250 °C for all labs.



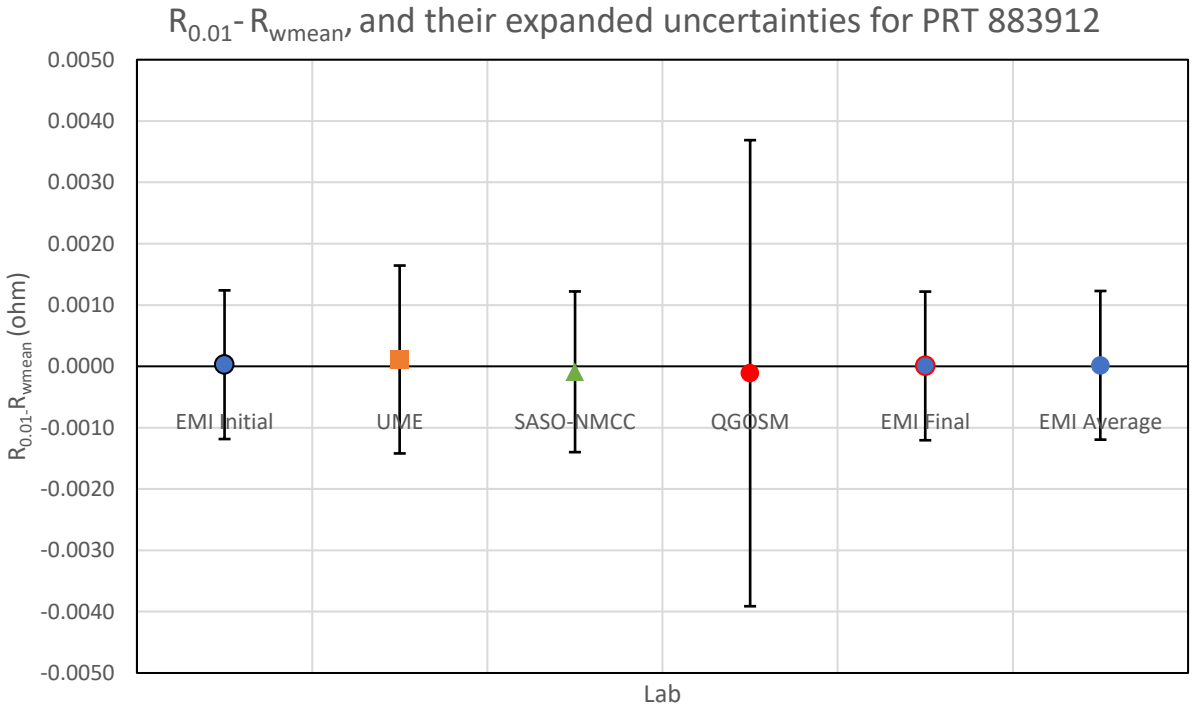
Graph 18. PRT 883912, W_{lab}-W_{wmean} and its expanded uncertainty for all labs and set-points.



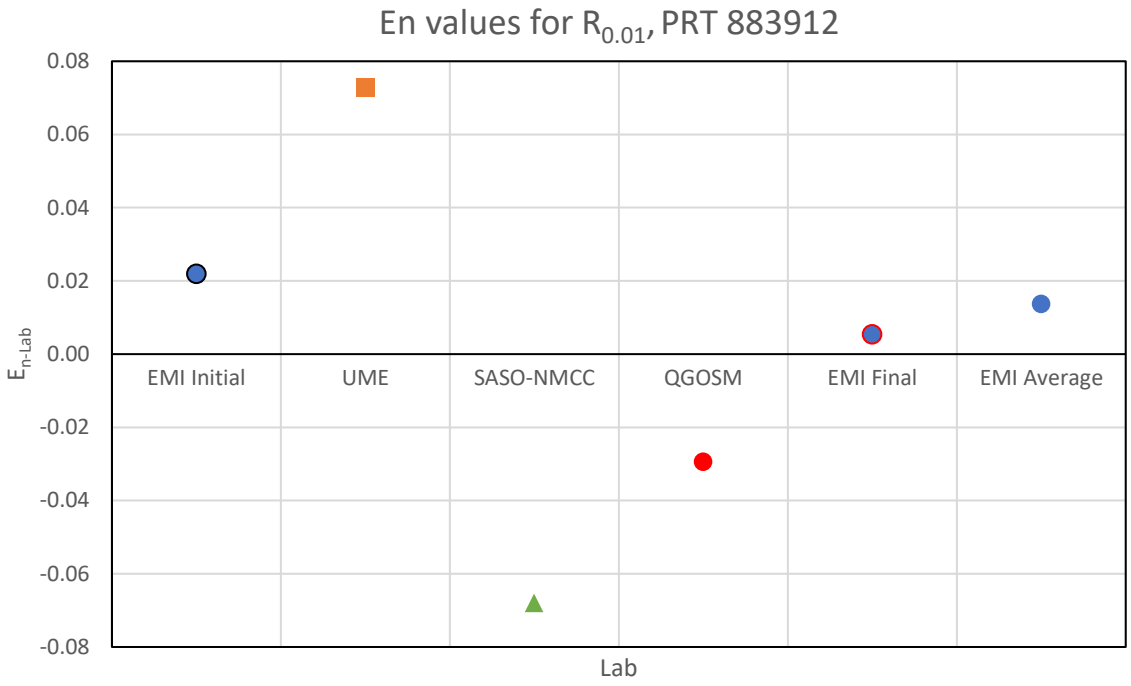
Graph 19. PRT 883912, En value for all labs and set-points.



Graph 20. PRT 883912, water triple point $R_{0.01}$ for all labs, and R_{wmean} and their expanded uncertainties.



Graph 21. PRT 883912, $R_{0.01}$ - R_{wmean} for all labs and their expanded uncertainties.



Graph 22. PRT 883912, E_n values for $R_{0.01}$ measurements for all labs.

11. Conclusions

This supplementary comparison was about the calibration of platinum resistance thermometer sensors in the range of -70 to 250 ºC. Four laboratories participated in the comparison: Emirates Metrology Institute (EMI) from United Arab Emirates, SASO-NMCC from Saudi Arabia, QGOSM from Qatar and Tubitak UME from Turkey. These Institutes are full or associated (Tubitak UME) members of the Gulfmet Regional Metrology Organization.

The pilot institute was Emirates Metrology Institute, and the transfer instruments are belonging to this institute.

The measurements of the comparison performed between April 2019 and February 2021 and the circulation of the instruments was without particular problems, except for a delay of four months between the labs QGOSM and EMI due to the Corona virus pandemic.

The weighted mean of the measurements from all labs was used to produce the reference values of the comparison and no laboratory was excluded from this weighted mean. Note that this comparison is an RMO supplementary comparison, so the W_{wmean} values generated are used only as a baseline for reporting the results, and they have no particular meaning of reference values in the sense of the key comparisons.

The results show a satisfactory agreement between the participant laboratories (En < 1), with the exception of two set-points: -35 ºC and 100 ºC, for one of the two thermometers (SN: 883912), for the Qatar laboratory (QGOSM).

12. References

[1] Measurement Comparisons in the CIPM MRA, MRA-D-05, V1.6

[2] EURAMET Guide on Comparisons, EURAMET Guide No. 4, V1.0 (05/2016)

[3] JCGM 100, “Guide to the Expression of Uncertainty in Measurement” (GUM), First edition, September 2008 (available on the BIPM website: http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf).

[4] Guideline DKD-R 5-1, “Calibration of Resistance Thermometers”, Edition 10/2003, English translation 02/2009. The guideline was withdrawn on December 31, 2009 and replaced by: Richtlinie DAkkS- DKD-R 5-1, Kalibrierung von Widerstandsthermometern, Neuauflage 2010, in German language.

APPENDIX 1. TEMPLATES for SUBMISSION of RESULTS

A. MEASUREMENT RESULTS

Name of the Laboratory: **Date of Measurements:** **Thermometer:**

Reference temperature (°C)	Standard deviation of ref. temp. measurements (°C)	PRT Resistance (ohm)	Standard deviation of PRT resistance measurements (ohm)	Number of Measurements

Current: **.....** mA Self-heating at 0 °C: **.....** mK

Immersion during measurements: …….. cm

B. RESULTS REDUCED TO NOMINAL TEMPERATURE

Name of the Laboratory: **Thermometer:**

Nominal temperature (°C)	PRT Resistance at the nominal temperature (ohm)	Standard uncertainty (°C)
0.01		
-70		
-35		
0.01		
50		
100		
200		
250		
100		
0.01		

Resistance results must be reduced to the exact (nominal) temperatures points of the comparison (first column).

The table below is giving an average slope of the R vs t curve for the two thermometers at the different set points of the comparison. The slope can be used to reduce the resistance results of the participants to the exact (nominal) temperature points of the comparison.

Nominal temperature (°C)	**dR/dt (ohm / °C)**
-70	0.4080
-35	0.4030
0.01	0.3987
50	0.3926
100	0.3866
200	0.3748
250	0.3689

C. UNCERTAINTY CALCULATION

Name of the Laboratory: *Points of calibration:*

Quantity X_i	Estimation of the quantity x_i	Unit	Probability Distribution	Standard Uncertainty	Sensitivity coefficient c_i	Unit	Contribution to the combined uncertainty $u(x_i)$ [°C]

Combined uncertainty: u=
Expanded uncertainty for k=2: U=

D. EQUIPMENT INFORMATION

Name of the Laboratory:

Equipment	Description	Manufacturer	Type	Traceability
Standard Thermometers				
Measuring Instruments				
Isothermal Media				

APPENDIX 2. EXAMPLES OF UNCERTAINTY EVALUATION SUBMITTED BY THE PARTICIPANTS

EMI, PRT 883912, Uncertainty at TPW

	Name of the Laboratory: EMI									
	Platinum Resistance Thermometer	Water triple Point measurement						Calibration Temperature:		0.01 °C
	Quantity Xi	Estimation of the quantity xi	Uncert. of xi	Probability Distribution	Divisor	Standard Uncertainty u(xi)	Unit	Sensitivity coefficient ci	Unit	Contribution to the combined uncertainty $u_i(y)$ [°C]
Measurement system	Water Triple Point Cell reference temperature, t_N	0.01	0.0001	Normal	1	0.0001	°C	1	-	0.0001
	Calibration of reference cell, δt_{cal}	0	0.0002	Normal	2	0.0001	°C	1	-	0.0001
UUT	Reading of the test thermometer, R_N	100.04387	0.000001	Normal	1	0.000001	Ω	2.5	°C/ Ω	0.000003
	Calibration of the resistance bridge, $\delta R_{Br\ cal}$	0	0.00040	Normal	2	0.00020	Ω	2.5	°C/ Ω	0.0005
	Drift of the resistance bridge, $\delta R_{Br\ drift}$	0	0.00050	Rectangular	1.73	0.00029	Ω	2.5	°C/ Ω	0.0007
	Resolution of the resistance bridge, $\delta R_{Br\ res}$	0	0.00004	Rectangular	3.46	0.00001	Ω	2.5	°C/ Ω	0.00003
	Repeatability of the UUT, $\delta R_{UUT\ rep}$	0	0.00021	Rectangular	1.73	0.00012	Ω	2.5	°C/ Ω	0.0003
	Hysteresis of the UUT, $\delta R_{UUT\ hyst}$	0	0.00100	Rectangular	1.73	0.00058	Ω	2.5	°C/ Ω	0.0014
	Immersion error of UUT, $\delta R_{UUT\ Ims}$	0	0.00040	Rectangular	1.73	0.00023	Ω	2.5	°C/ Ω	0.0006
Comparison medium	Temp. stability of bath, δt_{sta}	0	0.0001	Normal	1	0.0001	°C	1	-	0.0001
	Temp. uniformity of the bath, δt_{uni}	0	0.0020	Rectangular	3.46	0.0006	°C	1	-	0.0006
								Combined Standard Uncertainty:		0.002
								Expanded Uncertainty:		0.004

EMI, PRT 883912, Uncertainty at -70 ºC

	Platinum Resistance Thermometer							Calibration Temperature:		-70 °C
	Quantity Xi	Estimation of the quantity xi	Uncert. of xi	Probability Distribution	Divisor	Standard Uncertainty u(xi)	Unit	Sensitivity coefficient ci	Unit	Contribution to the combined uncertainty $u_i(y)$ [°C]
Measurement system	Reference temperature, t_N	-70.835	0.0001	Normal	1	0.0001	°C	1	-	0.0001
	Calibration of reference SPRT, δt_{cal}	0	0.0026	Normal	2	0.0013	°C	1	-	0.0013
	Drift of the reference SPRT, δt_{drift}	0	0.0020	Rectangular	1.73	0.0012	°C	1	-	0.0012
	Calibration of the resistance bridge, $\delta t_{Br\ cal}$	0	0.0010	Normal	2	0.0005	°C	1	-	0.0005
	Drift of the resistance bridge, $\delta t_{Br\ drift}$	0	0.0010	Rectangular	1.73	0.0006	°C	1	-	0.0006
	Resolution of the resistance bridge, $\delta t_{Br\ res}$	0	0.0001	Rectangular	3.46	0.00003	°C	1	-	0.00003
UUT	Reading of the test thermometer, R_N	71.47753	0.00002	Normal	1	0.00002	Ω	2.5	°C/ Ω	0.00004
	Calibration of the resistance bridge, $\delta R_{Br\ cal}$	0	0.00040	Normal	2	0.00020	Ω	2.5	°C/ Ω	0.0005
	Drift of the resistance bridge, $\delta R_{Br\ drift}$	0	0.00050	Rectangular	1.73	0.00029	Ω	2.5	°C/ Ω	0.0007
	Resolution of the resistance bridge, $\delta R_{Br\ res}$	0	0.00004	Rectangular	3.46	0.00001	Ω	2.5	°C/ Ω	0.00003
	Repeatability of the UUT, $\delta R_{UUT\ rep}$	0	0.00015	Rectangular	1.73	0.00009	Ω	2.5	°C/ Ω	0.0002
	Hysteresis of the UUT, $\delta R_{UUT\ hyst}$	0	0.00100	Rectangular	1.73	0.00058	Ω	2.5	°C/ Ω	0.0014
	Immersion error of UUT, $\delta R_{UUT\ Ims}$	0	0.00040	Rectangular	1.73	0.00023	Ω	2.5	°C/ Ω	0.0006
Comparison medium	Temp. stability of bath, δt_{sta}	0	0.0020	Normal	1	0.0020	°C	1	-	0.0020
	Temp. uniformity of the bath, δt_{uni}	0	0.0080	Rectangular	3.46	0.0023	°C	1	-	0.0023
								Combined Standard Uncertainty:		0.004
								Expanded Uncertainty:		0.008

EMI, PRT 883912, Uncertainty at -35 ºC

	Platinum Resistance Thermometer						Calibration Temperature:			-35 °C
	Quantity Xi	Estimation of the quantity xi	Uncert. of xi	Probability Distribution	Divisor	Standard Uncertainty u(xi)	Unit	Sensitivity coefficient ci	Unit	Contribution to the combined uncertainty $u_i(y)$ [ºC]
Measurement system	Reference temperature, t_N	-34.9391	0.0002	Normal	1	0.0002	°C	1	-	0.0002
	Calibration of reference SPRT, δt_{cal}	0	0.0026	Normal	2	0.0013	°C	1	-	0.0013
	Drift of the reference SPRT, δt_{drift}	0	0.0020	Rectangular	1.73	0.0012	°C	1	-	0.0012
	Calibration of the resistance bridge, $\delta t_{Br\ cal}$	0	0.0010	Normal	2	0.0005	°C	1	-	0.0005
	Drift of the resistance bridge, $\delta t_{Br\ drift}$	0	0.0010	Rectangular	1.73	0.0006	°C	1	-	0.0006
	Resolution of the resistance bridge, $\delta t_{Br\ res}$	0	0.0001	Rectangular	3.46	0.00003	°C	1	-	0.00003
UUT	Reading of the test thermometer, R_N	86.03233	0.00002	Normal	1	0.00002	Ω	2.5	°C/ Ω	0.00005
	Calibration of the resistance bridge, $\delta R_{Br\ cal}$	0	0.00040	Normal	2	0.00020	Ω	2.5	°C/ Ω	0.0005
	Drift of the resistance bridge, $\delta R_{Br\ drift}$	0	0.00050	Rectangular	1.73	0.00029	Ω	2.5	°C/ Ω	0.0007
	Resolution of the resistance bridge, $\delta R_{Br\ res}$	0	0.00004	Rectangular	3.46	0.00001	Ω	2.5	°C/ Ω	0.00003
	Repeatability of the UUT, $\delta R_{UUT\ rep}$	0	0.00018	Rectangular	1.73	0.00010	Ω	2.5	°C/ Ω	0.0003
	Hysteresis of the UUT, $\delta R_{UUT\ hyst}$	0	0.00100	Rectangular	1.73	0.00058	Ω	2.5	°C/ Ω	0.0014
	Immersion error of UUT, $\delta R_{UUT\ Ims}$	0	0.00040	Rectangular	1.73	0.00023	Ω	2.5	°C/ Ω	0.0006
Comparison medium	Temp. stability of bath, δt_{sta}	0	0.0020	Normal	1	0.0020	°C	1	-	0.0020
	Temp. uniformity of the bath, δt_{uni}	0	0.0080	Rectangular	3.46	0.0023	°C	1	-	0.0023
						Combined Standard Uncertainty:				0.004
						Expanded Uncertainty:				0.008

EMI, PRT 883912, Uncertainty at 50 ºC

	Platinum Resistance Thermometer						Calibration Temperature:			50 °C
	Quantity Xi	Estimation of the quantity xi	Uncert. of xi	Probability Distribution	Divisor	Standard Uncertainty u(xi)	Unit	Sensitivity coefficient ci	Unit	Contribution to the combined uncertainty $u_i(y)$ [ºC]
Measurement system	Reference temperature, t_N	49.850	0.00001	Normal	1	0.00001	°C	1	-	0.00001
	Calibration of reference SPRT, δt_{cal}	0	0.0026	Normal	2	0.0013	°C	1	-	0.0013
	Drift of the reference SPRT, δt_{drift}	0	0.0020	Rectangular	1.73	0.0012	°C	1	-	0.0012
	Calibration of the resistance bridge, $\delta t_{Br\ cal}$	0	0.0010	Normal	2	0.0005	°C	1	-	0.0005
	Drift of the resistance bridge, $\delta t_{Br\ drift}$	0	0.0010	Rectangular	1.73	0.0006	°C	1	-	0.0006
	Resolution of the resistance bridge, $\delta t_{Br\ res}$	0	0.0001	Rectangular	3.46	0.00003	°C	1	-	0.00003
UUT	Reading of the test thermometer, R_N	119.76943	0.000001	Normal	1	0.000001	Ω	2.5	°C/ Ω	0.000003
	Calibration of the resistance bridge, $\delta R_{Br\ cal}$	0	0.00040	Normal	2	0.00020	Ω	2.5	°C/ Ω	0.0005
	Drift of the resistance bridge, $\delta R_{Br\ drift}$	0	0.00050	Rectangular	1.73	0.00029	Ω	2.5	°C/ Ω	0.0007
	Resolution of the resistance bridge, $\delta R_{Br\ res}$	0	0.00004	Rectangular	3.46	0.00001	Ω	2.5	°C/ Ω	0.00003
	Repeatability of the UUT, $\delta R_{UUT\ rep}$	0	0.00025	Rectangular	1.73	0.00015	Ω	2.5	°C/ Ω	0.0004
	Hysteresis of the UUT, $\delta R_{UUT\ hyst}$	0	0.00100	Rectangular	1.73	0.00058	Ω	2.5	°C/ Ω	0.0014
	Immersion error of UUT, $\delta R_{UUT\ Ims}$	0	0.00040	Rectangular	1.73	0.00023	Ω	2.5	°C/ Ω	0.0006
Comparison medium	Temp. stability of bath, δt_{sta}	0	0.0020	Normal	1	0.0020	°C	1	-	0.0020
	Temp. uniformity of the bath, δt_{uni}	0	0.0080	Rectangular	3.46	0.0023	°C	1	-	0.0023
						Combined Standard Uncertainty:				0.004
						Expanded Uncertainty:				0.008

EMI, PRT 883912, Uncertainty at 100 ºC

	Platinum Resistance Thermometer						Calibration Temperature:			100 °C
	Quantity Xi	Estimation of the quantity xi	Uncert. of xi	Probability Distribution	Divisor	Standard Uncertainty u(xi)	Unit	Sensitivity coefficient ci	Unit	Contribution to the combined uncertainty $u_i(y)$ [°C]
Measurement system	Reference temperature, t_N	99.937	0.0001	Normal	1	0.0001	°C	1	-	0.0001
	Calibration of reference SPRT, δt_{cal}	0	0.0026	Normal	2	0.0013	°C	1	-	0.0013
	Drift of the reference SPRT, δt_{drift}	0	0.0020	Rectangular	1.73	0.0012	°C	1	-	0.0012
	Calibration of the resistance bridge, $\delta t_{Br\ cal}$	0	0.0010	Normal	2	0.0005	°C	1	-	0.0005
	Drift of the resistance bridge, $\delta t_{Br\ drift}$	0	0.0010	Rectangular	1.73	0.0006	°C	1	-	0.0006
	Resolution of the resistance bridge, $\delta t_{Br\ res}$	0	0.0001	Rectangular	3.46	0.00003	°C	1	-	0.00003
UUT	Reading of the test thermometer, R_N	139.28211	0.00001	Normal	1	0.00001	Ω	2.5	°C/ Ω	0.00003
	Calibration of the resistance bridge, $\delta R_{Br\ cal}$	0	0.00040	Normal	2	0.00020	Ω	2.5	°C/ Ω	0.0005
	Drift of the resistance bridge, $\delta R_{Br\ drift}$	0	0.00050	Rectangular	1.73	0.00029	Ω	2.5	°C/ Ω	0.0007
	Resolution of the resistance bridge, $\delta R_{Br\ res}$	0	0.00004	Rectangular	3.46	0.00001	Ω	2.5	°C/ Ω	0.00003
	Repeatability of the UUT, $\delta R_{UUT\ rep}$	0	0.00029	Rectangular	1.73	0.00017	Ω	2.5	°C/ Ω	0.0004
	Hysteresis of the UUT, $\delta R_{UUT\ hyst}$	0	0.00100	Rectangular	1.73	0.00058	Ω	2.5	°C/ Ω	0.0014
	Immersion error of UUT, $\delta R_{UUT\ Ims}$	0	0.00040	Rectangular	1.73	0.00023	Ω	2.5	°C/ Ω	0.0006
Comparison medium	Temp. stability of bath, δt_{sta}	0	0.0050	Normal	1	0.0050	°C	1	-	0.0050
	Temp. uniformity of the bath, δt_{uni}	0	0.0080	Rectangular	3.46	0.0023	°C	1	-	0.0023
							Combined Standard Uncertainty:			0.006
							Expanded Uncertainty:			0.012

EMI, PRT 883912, Uncertainty at 200 ºC

	Platinum Resistance Thermometer						Calibration Temperature:			200 °C
	Quantity Xi	Estimation of the quantity xi	Uncert. of xi	Probability Distribution	Divisor	Standard Uncertainty u(xi)	Unit	Sensitivity coefficient ci	Unit	Contribution to the combined uncertainty $u_i(y)$ [°C]
Measurement system	Reference temperature, t_N	199.9953	0.0001	Normal	1	0.0001	°C	1	-	0.0001
	Calibration of reference SPRT, δt_{cal}	0	0.0026	Normal	2	0.0013	°C	1	-	0.0013
	Drift of the reference SPRT, δt_{drift}	0	0.0020	Rectangular	1.73	0.0012	°C	1	-	0.0012
	Calibration of the resistance bridge, $\delta t_{Br\ cal}$	0	0.0010	Normal	2	0.0005	°C	1	-	0.0005
	Drift of the resistance bridge, $\delta t_{Br\ drift}$	0	0.0010	Rectangular	1.73	0.0006	°C	1	-	0.0006
	Resolution of the resistance bridge, $\delta t_{Br\ res}$	0	0.0001	Rectangular	3.46	0.00003	°C	1	-	0.00003
UUT	Reading of the test thermometer, R_N	177.37643	0.00004	Normal	1	0.00004	Ω	2.5	°C/ Ω	0.0001
	Calibration of the resistance bridge, $\delta R_{Br\ cal}$	0	0.00140	Normal	2	0.00070	Ω	2.5	°C/ Ω	0.0018
	Drift of the resistance bridge, $\delta R_{Br\ drift}$	0	0.00050	Rectangular	1.73	0.00029	Ω	2.5	°C/ Ω	0.0007
	Resolution of the resistance bridge, $\delta R_{Br\ res}$	0	0.00004	Rectangular	3.46	0.00001	Ω	2.5	°C/ Ω	0.00003
	Repeatability of the UUT, $\delta R_{UUT\ rep}$	0	0.00037	Rectangular	1.73	0.00021	Ω	2.5	°C/ Ω	0.0005
	Hysteresis of the UUT, $\delta R_{UUT\ hyst}$	0	0.00100	Rectangular	1.73	0.00058	Ω	2.5	°C/ Ω	0.0014
	Immersion error of UUT, $\delta R_{UUT\ Ims}$	0	0.00040	Rectangular	1.73	0.00023	Ω	2.5	°C/ Ω	0.0006
Comparison medium	Temp. stability of bath, δt_{sta}	0	0.0070	Normal	1	0.0070	°C	1	-	0.0070
	Temp. uniformity of the bath, δt_{uni}	0	0.0080	Rectangular	3.46	0.0023	°C	1	-	0.0023
							Combined Standard Uncertainty:			0.008
							Expanded Uncertainty:			0.016

EMI, PRT 883912, Uncertainty at 250 ºC

	Platinum Resistance Thermometer						Calibration Temperature:			250 °C
	Quantity Xi	Estimation of the quantity xi	Uncert. of xi	Probability Distribution	Divisor	Standard Uncertainty u(xi)	Unit	Sensitivity coefficient ci	Unit	Contribution to the combined uncertainty $u_i(y)$ [^oC]
Measurement system	Reference temperature, t_N	249.8811	0.0001	Normal	1	0.0001	°C	1	-	0.0001
	Calibration of reference SPRT, δt_{cal}	0	0.0026	Normal	2	0.0013	°C	1	-	0.0013
	Drift of the reference SPRT, δt_{drift}	0	0.0020	Rectangular	1.73	0.0012	°C	1	-	0.0012
	Calibration of the resistance bridge, $\delta t_{Br\ cal}$	0	0.0010	Normal	2	0.0005	°C	1	-	0.0005
	Drift of the resistance bridge, $\delta t_{Br\ drift}$	0	0.0010	Rectangular	1.73	0.0006	°C	1	-	0.0006
	Resolution of the resistance bridge, $\delta t_{Br\ res}$	0	0.0001	Rectangular	3.46	0.00003	°C	1	-	0.00003
UUT	Reading of the test thermometer, R_N	195.92949	0.00003	Normal	1	0.00003	Ω	2.5	°C/ Ω	0.0001
	Calibration of the resistance bridge, $\delta R_{Br\ cal}$	0	0.00240	Normal	2	0.00120	Ω	2.5	°C/ Ω	0.0030
	Drift of the resistance bridge, $\delta R_{Br\ drift}$	0	0.00050	Rectangular	1.73	0.00029	Ω	2.5	°C/ Ω	0.0007
	Resolution of the resistance bridge, $\delta R_{Br\ res}$	0	0.00004	Rectangular	3.46	0.00001	Ω	2.5	°C/ Ω	0.0000
	Repeatability of the UUT, $\delta R_{UUT\ rep}$	0	0.00041	Rectangular	1.73	0.00024	Ω	2.5	°C/ Ω	0.0006
	Hysteresis of the UUT, $\delta R_{UUT\ hyst}$	0	0.00100	Rectangular	1.73	0.00058	Ω	2.5	°C/ Ω	0.0014
	Immersion error of UUT, $\delta R_{UUT\ Ims}$	0	0.00040	Rectangular	1.73	0.00023	Ω	2.5	°C/ Ω	0.0006
Comparison medium	Temp. stability of bath, δt_{sta}	0	0.0070	Normal	1	0.0070	°C	1	-	0.0070
	Temp. uniformity of the bath, δt_{uni}	0	0.0080	Rectangular	3.46	0.0023	°C	1	-	0.0023
						Combined Standard Uncertainty:				0.008
						Expanded Uncertainty:				0.017

UME, PRT 883912, Uncertainty at TPW

C. UNCERTAINTY CALCULATION								
Name of Laboratory:	TUBITAK UME							
Thermometer:	883912							
Points of Calibration:	**0.01**	**°C**						
Quantity	**Estimation of the Quantity**	**Unit**	**Probability Distribution**	**Standard Uncertainty**	**Sensitivity Coefficient**	**Unit**	**Contribution to the Combined Uncertainty (°C)**	
Reference TPW Uncertainty	0.0001	° C	Normal	0.0001	1	-	0.0001	
Reference Display Certificate	0.00025	° C	Normal	0.0001	1	-	0.0001	
Reference Display Drift	0.001	° C	Rectangular	0.0006	1	-	0.0006	
Device Under Calibration Repeatability	0.00001	Ω	Normal	0.00001	2.5	° C / Ω	0.0000	
Device Under Calibration Resolution	0.0001	Ω	Rectangular	0.00003	2.5	° C / Ω	0.0001	
Device Under Calibration Hysteresis	0.001004	Ω	Rectangular	0.00058	2.5	° C / Ω	0.0015	
Device Under Calibration interpolation	0.00275	° C	Rectangular	0.0016	1	-	0.0016	
				Combined Uncertainty:		**u=**	0.002	° C
				Expanded Uncertainty for k=2:		**U=**	0.004	° C

UME, PRT 883912, Uncertainty at -70 °C

Points of Calibration:	**-70**	**°C**						
Quantity	**Estimation of the Quantity**	**Unit**	**Probability Distribution**	**Standard Uncertainty**	**Sensitivity Coefficient**	**Unit**	**Contribution to the Combined Uncertainty (°C)**	
Reference Thermometer Certificate	0.002	° C	Normal	0.0010	1	-	0.0010	
Reference Thermometer Drift	0.001	° C	Rectangular	0.0006	1	-	0.0006	
Reference Display Certificate	0.00025	° C	Normal	0.0001	1	-	0.0001	
Reference Display Drift	0.001	° C	Rectangular	0.0006	1	-	0.0006	
Characterization of Temperature Source	0.004	° C	Rectangular	0.0020	1	-	0.0020	
Device Under Calibration Repeatability	0.00003	Ω	Normal	0.00001	2.5	° C / Ω	0.0000	
Device Under Calibration Resolution	0.0001	Ω	Rectangular	0.00003	2.5	° C / Ω	0.0001	
Device Under Calibration Hysteresis	0.001004	Ω	Rectangular	0.00058	2.5	° C / Ω	0.0015	
Device Under Calibration interpolation	0.00275	° C	Rectangular	0.0016	1	-	0.0016	
				Combined Uncertainty:		**u=**	0.003	° C
				Expanded Uncertainty for k=2:		**U=**	0.006	° C

UME, PRT 883912, Uncertainty at -35 °C

Points of Calibration:	**-35**	**°C**						
Quantity	**Estimation of the Quantity**	**Unit**	**Probability Distribution**	**Standard Uncertainty**	**Sensitivity Coefficient**	**Unit**	**Contribution to the Combined Uncertainty (°C)**	
Reference Thermometer Certificate	0.002	° C	Normal	0.0010	1	-	0.0010	
Reference Thermometer Drift	0.001	° C	Rectangular	0.0006	1	-	0.0006	
Reference Display Certificate	0.00025	° C	Normal	0.0001	1	-	0.0001	
Reference Display Drift	0.001	° C	Rectangular	0.0006	1	-	0.0006	
Characterization of Temperature Source	0.004	° C	Rectangular	0.0020	1	-	0.0020	
Device Under Calibration Repeatability	0.00003	Ω	Normal	0.00001	2.5	° C / Ω	0.0000	
Device Under Calibration Resolution	0.0001	Ω	Rectangular	0.00003	2.5	° C / Ω	0.0001	
Device Under Calibration Hysteresis	0.001004	Ω	Rectangular	0.00058	2.5	° C / Ω	0.0015	
Device Under Calibration interpolation	0.00275	° C	Rectangular	0.0016	1	-	0.0016	
				Combined Uncertainty:		**u=**	0.003	° C
				Expanded Uncertainty for k=2:		**U=**	0.006	° C

UME, PRT 883912, Uncertainty at 50 ºC

Points of Calibration:	50 °C							
Quantity	**Estimation of the Quantity**	**Unit**	**Probability Distribution**	**Standard Uncertainty**	**Sensitivity Coefficient**	**Unit**	**Contribution to the Combined Uncertainty (°C)**	
Reference Thermometer Certificate	0.002	° C	Normal	0.0010	1	-	0.0010	
Reference Thermometer Drift	0.001	° C	Rectangular	0.0006	1	-	0.0006	
Reference Display Certificate	0.00025	° C	Normal	0.0001	1	-	0.0001	
Reference Display Drift	0.001	° C	Rectangular	0.0006	1	-	0.0006	
Characterization of Temperature Source	0.005	° C	Rectangular	0.0025	1	-	0.0025	
Device Under Calibration Repeatability	0.00006	Ω	Normal	0.00002	2.5	° C / Ω	0.0000	
Device Under Calibration Resolution	0.0001	Ω	Rectangular	0.00003	2.5	° C / Ω	0.0001	
Device Under Calibration Hysteresis	0.001004	Ω	Rectangular	0.00058	2.5	° C / Ω	0.0015	
Device Under Calibration interpolation	0.00275	° C	Rectangular	0.0016	1	-	0.0016	
				Combined Uncertainty:		**u=**	0.004	° C
				Expanded Uncertainty for k=2:		**U=**	0.007	° C

UME, PRT 883912, Uncertainty at 100 ºC

Points of Calibration:	100 °C							
Quantity	**Estimation of the Quantity**	**Unit**	**Probability Distribution**	**Standard Uncertainty**	**Sensitivity Coefficient**	**Unit**	**Contribution to the Combined Uncertainty (°C)**	
Reference Thermometer Certificate	0.002	° C	Normal	0.0010	1	-	0.0010	
Reference Thermometer Drift	0.001	° C	Rectangular	0.0006	1	-	0.0006	
Reference Display Certificate	0.00025	° C	Normal	0.0001	1	-	0.0001	
Reference Display Drift	0.001	° C	Rectangular	0.0006	1	-	0.0006	
Characterization of Temperature Source	0.007	° C	Rectangular	0.0035	1	-	0.0035	
Device Under Calibration Repeatability	0.00003	Ω	Normal	0.00001	2.5	° C / Ω	0.0000	
Device Under Calibration Resolution	0.0001	Ω	Rectangular	0.00003	2.5	° C / Ω	0.0001	
Device Under Calibration Hysteresis	0.001004	Ω	Rectangular	0.00058	2.5	° C / Ω	0.0015	
Device Under Calibration interpolation	0.00275	° C	Rectangular	0.0016	1	-	0.0016	
				Combined Uncertainty:		**u=**	0.004	° C
				Expanded Uncertainty for k=2:		**U=**	0.009	° C

UME, PRT 883912, Uncertainty at 200 ºC

Points of Calibration:	200 °C							
Quantity	**Estimation of the Quantity**	**Unit**	**Probability Distribution**	**Standard Uncertainty**	**Sensitivity Coefficient**	**Unit**	**Contribution to the Combined Uncertainty (°C)**	
Reference Thermometer Certificate	0.002	° C	Normal	0.0010	1	-	0.0010	
Reference Thermometer Drift	0.001	° C	Rectangular	0.0006	1	-	0.0006	
Reference Display Certificate	0.00025	° C	Normal	0.0001	1	-	0.0001	
Reference Display Drift	0.001	° C	Rectangular	0.0006	1	-	0.0006	
Characterization of Temperature Source	0.009	° C	Rectangular	0.0045	1	-	0.0045	
Device Under Calibration Repeatability	0.00018	Ω	Normal	0.00006	2.5	° C / Ω	0.0001	
Device Under Calibration Resolution	0.0001	Ω	Rectangular	0.00003	2.5	° C / Ω	0.0001	
Device Under Calibration Hysteresis	0.001004	Ω	Rectangular	0.00058	2.5	° C / Ω	0.0015	
Device Under Calibration interpolation	0.00275	° C	Rectangular	0.0016	1	-	0.0016	
				Combined Uncertainty:		**u=**	0.005	° C
				Expanded Uncertainty for k=2:		**U=**	0.010	° C

UME, PRT 883912, Uncertainty at 250 ºC

Points of Calibration:	250 °C							
Quantity	Estimation of the Quantity	Unit	Probability Distribution	Standard Uncertainty	Sensitivity Coefficient	Unit	Contribution to the Combined Uncertainty (°C)	
Reference Thermometer Certificate	0.002	°C	Normal	0.0010	1	-	0.0010	
Reference Thermometer Drift	0.001	°C	Rectangular	0.0006	1	-	0.0006	
Reference Display Certificate	0.00025	°C	Normal	0.0001	1	-	0.0001	
Reference Display Drift	0.001	°C	Rectangular	0.0006	1	-	0.0006	
Characterization of Temperature Source	0.009	°C	Rectangular	0.0045	1	-	0.0045	
Device Under Calibration Repeatability	0.00012	Ω	Normal	0.00004	2.5	°C / Ω	0.0001	
Device Under Calibration Resolution	0.0001	Ω	Rectangular	0.00003	2.5	°C / Ω	0.0001	
Device Under Calibration Hysteresis	0.001004	Ω	Rectangular	0.00058	2.5	°C / Ω	0.0015	
Device Under Calibration interpolation	0.00275	°C	Rectangular	0.0016	1	-	0.0016	
				Combined Uncertainty:		u=	0.005	°C
				Expanded Uncertainty for k=2:		U=	0.010	°C

SASO-NMCC, PRT 883912, Uncertainty at TPW

Measurement Uncertainty for PRT. 883912						
Quantity X_i	Estimation of the quantity x_i	Unit	Probability distribution	Standard uncertainty	Sensitivity coefficient c_i	Contribution to the combined uncertainty $u(x_i)$ (°C)
TPW Uncertainty						
Chemical impurity	0.0001	°C	Rectangular	0.00003	1	0.00003
Residual Gas pressure	0.0000	°C	Rectangular	0.00001	1	0.00001
Hydrostatic head pressure	0.0000	°C	Rectangular	0.00001	1	0.00001
Isotopic correction/composition	0.0000	°C	Rectangular	0.00001	1	0.00001
Strain, crystal defect and crystal size	0.0003	°C	Rectangular	0.00009	1	0.00009
Phase transition realization repeatability	0.0000	°C	Rectangular	0.00001	1	0.00001
Measurement System						
Bridge errors	0.0005	°C	Rectangular	0.00014	1	0.00014
Standard resistor stability	0.0001	°C	Rectangular	0.00003	1	0.00003
Calibration of standard resistor	0.0002	°C	Normal	0.00009	1	0.00009
PRT						
Repeatability in PRT resistance measurement	0.0003	°C	Rectangular	0.00007	1	0.00007
Short-term stability of PRT at TPW	0.0049	°C	Rectangular	0.00141	1	0.00141
Hysterisis in the PRT measurements, measured and estimated at 100 °C	0.0017	°C	Rectangular	0.00049	1	0.00049
Error in the PRT immersion	0.0000	°C	Rectangular	0.00000	1	0.00000
Self-heating effect	0.0027	°C	Rectangular	0.00077	1	0.00077
Insulation and leakage effect	0.0001	°C	Rectangular	0.00003	1	0.00003
			Combined uncertainty in °C, u			0.0017
			Expanded uncertainty for k=2 in °C, U			0.0034

SASO-NMCC, PRT 883912, Uncertainty at -70 ºC

Measurement Uncertainty for PRT. 883912

Quantity X_i	Estimation of the quantity x_i	Unit	Probability distribution	Standard uncertainty	Sensitivity coefficient c_i	Contribution to the combined uncertainty $u(x_i)$ (°C)
Calibration of standard thermometer	0.0060	°C	Normal	0.0030	1	0.0030
Repeatability of reference temperature measurement	0.0061	°C	t-student	0.0014	1	0.0014
Drift of the standard thermometer measured TPW	0.0004	°C	Rectangular	0.0001	1	0.0001
Self-heating of the standard thermometer measured at TPW	0.0016	°C	Rectangular	0.0005	1	0.0005
Repeatability of the PRT under test resistance reading	0.0082	°C	t-student	0.0018	1	0.0018
Short-term stability of the PRT measured at TPW	0.0049	°C	Rectangular	0.0014	1	0.0014
Self-heating of the PRT measured at TPW	0.0027	°C	Rectangular	0.0008	1	0.0008
Hysterisis in the PRT measurements, measured and estimated at 100 °C	0.0017	°C	Rectangular	0.0005	1	0.0005
Error in the PRT immersion	0.0000	°C	Rectangular	0.0000	1	0.0000
Repeatability in the PRT calibration	0.0035	°C	Rectangular	0.0010	1	0.0010
Calibration of the reading instrument	0.00008	Ω	Normal	0.00004	2.5	0.0001
Readability (Resolution) of the reading instrument	0.00000	Ω	Rectangular	0.00000	2.5	0.0000
Instability of the liquid bath (alcohol bath)	0.0340	°C	Rectangular	0.0098	1	0.0098
Inhomogeneity of the liquid bath (alcohol bath)	0.0200	°C	Rectangular	0.0058	1	0.0058
			Combined uncertainty in °C, u			0.012
			Expanded uncertainty for k=2 in °C, U			0.024

SASO-NMCC, PRT 883912, Uncertainty at -35 ºC

Measurement Uncertainty for PRT. 883912

Quantity X_i	Estimation of the quantity x_i	Unit	Probability distribution	Standard uncertainty	Sensitivity coefficient c_i	Contribution to the combined uncertainty $u(x_i)$ (°C)
Calibration of standard thermometer	0.0060	°C	Normal	0.0030	1	0.0030
Repeatability of reference temperature measurement	0.0035	°C	t-student	0.0008	1	0.0008
Drift of the standard thermometer measured TPW	0.0004	°C	Rectangular	0.0001	1	0.0001
Self-heating of the standard thermometer measured at TPW	0.0016	°C	Rectangular	0.0005	1	0.0005
Repeatability of the PRT under test resistance reading	0.0036	°C	t-student	0.0008	1	0.0008
Short-term stability of the PRT measured at TPW	0.0049	°C	Rectangular	0.0014	1	0.0014
Self-heating of the PRT measured at TPW	0.0027	°C	Rectangular	0.0008	1	0.0008
Hysterisis in the PRT measurements, measured and estimated at 100 °C	0.0017	°C	Rectangular	0.0005	1	0.0005
Error in the PRT immersion	0.0000	°C	Rectangular	0.0000	1	0.0000
Repeatability in the PRT calibration	0.0012	°C	Rectangular	0.0003	1	0.0003
Calibration of the reading instrument	0.00010	Ω	Normal	0.00005	2.5	0.0001
Readability (Resolution) of the reading instrument	0.00000	Ω	Rectangular	0.00000	2.5	0.0000
Instability of the liquid bath (alcohol bath)	0.0143	°C	Rectangular	0.0041	1	0.0041
Inhomogeneity of the liquid bath (alcohol bath)	0.0061	°C	Rectangular	0.0018	1	0.0018
			Combined uncertainty in °C, u			0.006
			Expanded uncertainty for k=2 in °C, U			0.012

SASO-NMCC, PRT 883912, Uncertainty at 50 ºC

Measurement Uncertainty for PRT. 883912						
Quantity X_i	Estimation of the quantity x_i	Unit	Probability distribution	Standard uncertainty	Sensitivity coefficient c_i	Contribution to the combined uncertainty $u(x_i)$ (°C)
Calibration of standard thermometer	0.0060	°C	Normal	0.0030	1	0.0030
Repeatability of reference temperature measurement	0.0003	°C	t-student	0.0001	1	0.0001
Drift of the standard thermometer measured TPW	0.0004	°C	Rectangular	0.0001	1	0.0001
Self-heating of the standard thermometer measured at TPW	0.0016	°C	Rectangular	0.0005	1	0.0005
Repeatability of the PRT under test resistance reading	0.0004	°C	t-student	0.0001	1	0.0001
Short-term stability of the PRT measured at TPW	0.0049	°C	Rectangular	0.0014	1	0.0014
Self-heating of the PRT measured at TPW	0.0027	°C	Rectangular	0.0008	1	0.0008
Hysterisis in the PRT measurements, measured and estimated at 100 °C	0.0017	°C	Rectangular	0.0005	1	0.0005
Error in the PRT immersion	0.0000	°C	Rectangular	0.0000	1	0.0000
Repeatability in the PRT calibration	0.0270	°C	Rectangular	0.0078	1	0.0078
Calibration of the reading instrument	0.00014	Ω	Normal	0.00007	2.5	0.0002
Readability (Resolution) of the reading instrument	0.00000	Ω	Rectangular	0.00000	2.5	0.0000
Instability of the liquid bath (water bath)	0.0013	°C	Rectangular	0.0004	1	0.0004
Inhomogeneity of the liquid bath (water bath)	0.0016	°C	Rectangular	0.0005	1	0.0005
			Combined uncertainty in °C, u			0.009
			Expanded uncertainty for k=2 in °C, U			0.017

SASO-NMCC, PRT 883912, Uncertainty at 100 ºC

Measurement Uncertainty for PRT. 883912						
Quantity X_i	Estimation of the quantity x_i	Unit	Probability distribution	Standard uncertainty	Sensitivity coefficient c_i	Contribution to the combined uncertainty $u(x_i)$ (°C)
Calibration of standard thermometer	0.0060	°C	Normal	0.0030	1	0.0030
Repeatability of reference temperature measurement	0.0003	°C	t-student	0.0001	1	0.0001
Drift of the standard thermometer measured TPW	0.0004	°C	Rectangular	0.0001	1	0.0001
Self-heating of the standard thermometer measured at TPW	0.0016	°C	Rectangular	0.0005	1	0.0005
Repeatability of the PRT under test resistance reading	0.0007	°C	t-student	0.0002	1	0.0002
Short-term stability of the PRT measured at TPW	0.0049	°C	Rectangular	0.0014	1	0.0014
Self-heating of the PRT measured at TPW	0.0027	°C	Rectangular	0.0008	1	0.0008
Hysterisis in the PRT measurements, measured and estimated at 100 °C	0.0017	°C	Rectangular	0.0005	1	0.0005
Error in the PRT immersion	0.0000	°C	Rectangular	0.0000	1	0.0000
Repeatability in the PRT calibration	0.0279	°C	Rectangular	0.0081	1	0.0081
Calibration of the reading instrument	0.00016	Ω	Normal	0.00008	2.5	0.0002
Readability (Resolution) of the reading instrument	0.00000	Ω	Rectangular	0.00000	2.5	0.0000
Instability of the liquid bath (oil bath)	0.0015	°C	Rectangular	0.0004	1	0.0004
Inhomogeneity of the liquid bath (oil bath)	0.0027	°C	Rectangular	0.0008	1	0.0008
			Combined uncertainty in °C, u			0.009
			Expanded uncertainty for k=2 in °C, U			0.018

SASO-NMCC, PRT 883912, Uncertainty at 200 ºC

Measurement Uncertainty for PRT. 883912

Quantity X_i	Estimation of the quantity x_i	Unit	Probability distribution	Standard uncertainty	Sensitivity coefficient c_i	Contribution to the combined uncertainty $u(x_i)$ (°C)
Calibration of standard thermometer	0.0060	°C	Normal	0.0030	1	0.0030
Repeatability of reference temperature measurement	0.0014	°C	t-student	0.0003	1	0.0003
Drift of the standard thermometer measured TPW	0.0004	°C	Rectangular	0.0001	1	0.0001
Self-heating of the standard thermometer measured at TPW	0.0016	°C	Rectangular	0.0005	1	0.0005
Repeatability of the PRT under test resistance reading	0.0015	°C	t-student	0.0003	1	0.0003
Short-term stability of the PRT measured at TPW	0.0049	°C	Rectangular	0.0014	1	0.0014
Self-heating of the PRT measured at TPW	0.0027	°C	Rectangular	0.0008	1	0.0008
Hysterisis in the PRT measurements, measured and estimated at 100 °C	0.0017	°C	Rectangular	0.0005	1	0.0005
Error in the PRT immersion	0.0000	°C	Rectangular	0.0000	1	0.0000
Repeatability in the PRT calibration	0.0250	°C	Rectangular	0.0072	1	0.0072
Calibration of the reading instrument	0.00021	Ω	Normal	0.00010	2.5	0.0003
Readability (Resolution) of the reading instrument	0.00000	Ω	Rectangular	0.00000	2.5	0.0000
Instability of the liquid bath (salt bath)	0.0066	°C	Rectangular	0.0019	1	0.0019
Inhomogeneity of the liquid bath (salt bath)	0.0093	°C	Rectangular	0.0027	1	0.0027
			Combined uncertainty in °C, u			0.009
			Expanded uncertainty for k=2 in °C, U			0.017

SASO-NMCC, PRT 883912, Uncertainty at 250 ºC

Measurement Uncertainty for PRT. 883912

Quantity X_i	Estimation of the quantity x_i	Unit	Probability distribution	Standard uncertainty	Sensitivity coefficient c_i	Contribution to the combined uncertainty $u(x_i)$ (°C)
Calibration of standard thermometer	0.0060	°C	Normal	0.0030	1	0.0030
Repeatability of reference temperature measurement	0.0013	°C	t-student	0.0003	1	0.0003
Drift of the standard thermometer measured TPW	0.0004	°C	Rectangular	0.0001	1	0.0001
Self-heating of the standard thermometer measured at TPW	0.0016	°C	Rectangular	0.0005	1	0.0005
Repeatability of the PRT under test resistance reading	0.0009	°C	t-student	0.0002	1	0.0002
Short-term stability of the PRT measured at TPW	0.0049	°C	Rectangular	0.0014	1	0.0014
Self-heating of the PRT measured at TPW	0.0027	°C	Rectangular	0.0008	1	0.0008
Hysterisis in the PRT measurements, measured and estimated at 100 °C	0.0017	°C	Rectangular	0.0005	1	0.0005
Error in the PRT immersion	0.0000	°C	Rectangular	0.0000	1	0.0000
Repeatability in the PRT calibration	0.0380	°C	Rectangular	0.0110	1	0.0110
Calibration of the reading instrument	0.00023	Ω	Normal	0.00012	2.5	0.0003
Readability (Resolution) of the reading instrument	0.00000	Ω	Rectangular	0.00000	2.5	0.0000
Instability of the liquid bath (salt bath)	0.0049	°C	Rectangular	0.0014	1	0.0014
Inhomogeneity of the liquid bath (salt bath)	0.0068	°C	Rectangular	0.0020	1	0.0020
			Combined uncertainty in °C, u			0.012
			Expanded uncertainty for k=2 in °C, U			0.024

QATAR STANDARDS, PRT 883912, Uncertainty at Ice Point

Therm. No. 883912 @ 0.00 C		Quantity X_i	Unit	Probability Distribution	Standard Uncertainty	Sensitivity coefficient ci	Unit	Contribution to the combined uncertainty $u(x_i)$ [°C]
SPRT	Type A standard uncertainty	0.00001	oC	Normal	0.00001	1	oC	0.00001
	Calibration- SPRT	0.00400	oC	Normal	0.00200	1	oC	0.00200
	Drift- -SPRT	0.00400	oC	Rectangular	0.00231	1	oC	0.00231
	Calibration- reading instrument	0.00003	Ω	Normal	0.00001	0.403	Ω/oC	0.00003
	Drift- reading instrument	0.00003	Ω	Rectangular	0.00001	0.403	Ω/oC	0.00004
Ice Point	Ice Bath uncertainty	0.00330	oC	Rectangular	0.00191	1	oC	0.00191
UUT	Type A standard uncertainty	0.00000	Ω	Normal	0.00000	0.403	Ω/oC	0.00000
	Short-term stability-UUT	0.00004	oC	Rectangular	0.00003	1	oC	0.00003
	Calibration- reading instrument	0.00003	Ω	Normal	0.00001	0.403	Ω/oC	0.00003
	Drift- reading instrument	0.00003	Ω	Rectangular	0.00001	0.403	Ω/oC	0.00004
	Heat conduction-UUT	0.00500	oC	Rectangular	0.00289	1	oC	0.00289
	Hysteresis- UUT	0.00300	oC	Rectangular	0.00173	1	oC	0.00173
			Combined Uncertainty =			0.005	°C	
			Expanded Uncertainty =			0.010	°C	

QATAR STANDARDS, PRT 883912, Uncertainty at -35 °C

Therm. No. 883912 @ -35 C		Quantity X_i	Unit	Probability Distribution	Standard Uncertainty	Sensitivity coefficient c_i	Unit	Contribution to the combined uncertainty $u(x_i)$ [°C]
SPRT	Type A standard uncertainty	0.00001	oC	Normal	0.00001	1	oC	0.00001
	Calibration- SPRT	0.00600	oC	Normal	0.00300	1	oC	0.00300
	Drift- -SPRT	0.00600	oC	Rectangular	0.00346	1	oC	0.00346
	Calibration- reading instrument	0.00003	Ω	Normal	0.00001	0.403	Ω/oC	0.00003
	Drift- reading instrument	0.00003	Ω	Rectangular	0.00001	0.403	Ω/oC	0.00004
Dry Block	Axial Uniformity	0.00100	oC	Rectangular	0.00058	1	oC	0.00058
	Radial Uniformity	0.00050	oC	Rectangular	0.00029	1	oC	0.00029
	Stability	0.00180	oC	Rectangular	0.00104	1	oC	0.00104
UUT	Type A standard uncertainty	0.00002	Ω	Normal	0.00002	0.403	Ω/oC	0.00005
	Short-term stability-UUT	0.00004	oC	Rectangular	0.00003	1	oC	0.00003
	Calibration- reading instrument	0.00003	Ω	Normal	0.00001	0.403	Ω/oC	0.00003
	Drift- reading instrument	0.00003	Ω	Rectangular	0.00001	0.403	Ω/oC	0.00004
	Heat conduction-UUT	0.00900	oC	Rectangular	0.00520	1	oC	0.00520
	Hysteresis- UUT	0.00300	oC	Rectangular	0.00173	1	oC	0.00173
			Combined Uncertainty =			0.007	°C	
			Expanded Uncertainty =			0.014	°C	

QATAR STANDARDS, PRT 883912, Uncertainty at 50 °C

Therm. No. 883912 @ 50 C		Quantity X_i	Unit	Probability Distribution	Standard Uncertainty	Sensitivity coefficient c_i	Unit	Contribution to the combined uncertainty $u(x_i)$ [°C]
SPRT	Type A standard uncertainty	0.00001	oC	Normal	0.00001	1	oC	0.00001
	Calibration- SPRT	0.00500	oC	Normal	0.00250	1	oC	0.00250
	Drift- -SPRT	0.00500	oC	Rectangular	0.00289	1	oC	0.00289
	Calibration- reading instrument	0.00003	Ω	Normal	0.00001	0.392	Ω/oC	0.00003
	Drift- reading instrument	0.00003	Ω	Rectangular	0.00001	0.392	Ω/oC	0.00004
Dry Block	Axial Uniformity	0.00250	oC	Rectangular	0.00144	1	oC	0.00144
	Radial Uniformity	0.00130	oC	Rectangular	0.00075	1	oC	0.00075
	Stability	0.00210	oC	Rectangular	0.00121	1	oC	0.00121
UUT	Type A standard uncertainty	0.00005	Ω	Normal	0.00005	0.392	Ω/oC	0.00012
	Short-term stability-UUT	0.00004	oC	Rectangular	0.00003	1	oC	0.00003
	Calibration- reading instrument	0.00003	Ω	Normal	0.00001	0.392	Ω/oC	0.00003
	Drift- reading instrument	0.00003	Ω	Rectangular	0.00001	0.392	Ω/oC	0.00004
	Heat conduction-UUT	0.01000	oC	Rectangular	0.00577	1	oC	0.00577
	Hysteresis- UUT	0.00300	oC	Rectangular	0.00173	1	oC	0.00173
				Combined Uncertainty =		0.007	°C	
				Expanded Uncertainty =		0.015	°C	

QATAR STANDARDS, PRT 883912, Uncertainty at 100 °C

Therm. No. 883912 @ 100 C		Quantity X_i	Unit	Probability Distribution	Standard Uncertainty	Sensitivity coefficient c_i	Unit	Contribution to the combined uncertainty $u(x_i)$ [°C]
SPRT	Type A standard uncertainty	0.00048	oC	Normal	0.00048	1	oC	0.00048
	Calibration- SPRT	0.00600	oC	Normal	0.00300	1	oC	0.00300
	Drift- -SPRT	0.00600	oC	Rectangular	0.00346	1	oC	0.00346
	Calibration- reading instrument	0.00003	Ω	Normal	0.00002	0.386	Ω/oC	0.00004
	Drift- reading instrument	0.00003	Ω	Rectangular	0.00002	0.386	Ω/oC	0.00004
Oil Bath	Uniformity	0.00400	oC	Rectangular	0.00231	1	oC	0.00231
	Stability	0.00300	oC	Rectangular	0.00173	1	oC	0.00173
UUT	Type A standard uncertainty	0.00023	Ω	Normal	0.00023	0.386	Ω/oC	0.00059
	Short-term stability-UUT	0.00004	oC	Rectangular	0.00003	1	oC	0.00003
	Calibration- reading instrument	0.00003	Ω	Normal	0.00002	0.386	Ω/oC	0.00004
	Drift- reading instrument	0.00003	Ω	Rectangular	0.00002	0.386	Ω/oC	0.00004
	Heat conduction-UUT	0.01500	oC	Rectangular	0.00866	1	oC	0.00866
	Hysteresis- UUT	0.00300	oC	Rectangular	0.00173	1	oC	0.00173
				Combined Uncertainty =		0.010	°C	
				Expanded Uncertainty =		0.021	°C	

QATAR STANDARDS, PRT 883912, Uncertainty at 200 °C

Therm. No. 883912 @ 200 C		Quantity X_i	Unit	Probability Distribution	Standard Uncertainty	Sensitivity coefficient c_i	Unit	Contribution to the combined uncertainty $u(x_i)$ [°C]
SPRT	Type A standard uncertainty	0.00038	oC	Normal	0.00038	1	oC	0.00038
	Calibration- SPRT	0.00700	oC	Normal	0.00350	1	oC	0.00350
	Drift- -SPRT	0.00700	oC	Rectangular	0.00404	1	oC	0.00404
	Calibration- reading instrument	0.00003	Ω	Normal	0.00002	0.375	Ω/oC	0.00004
	Drift- reading instrument	0.00003	Ω	Rectangular	0.00002	0.375	Ω/oC	0.00005
Oil Bath	Uniformity	0.01200	oC	Rectangular	0.00693	1	oC	0.00693
	Stability	0.00500	oC	Rectangular	0.00289	1	oC	0.00289
UUT	Type A standard uncertainty	0.00054	Ω	Normal	0.00054	0.375	Ω/oC	0.00145
	Short-term stability-UUT	0.00004	oC	Rectangular	0.00003	1	oC	0.00003
	Calibration- reading instrument	0.00003	Ω	Normal	0.00002	0.375	Ω/oC	0.00004
	Drift- reading instrument	0.00003	Ω	Rectangular	0.00002	0.375	Ω/oC	0.00005
	Heat conduction-UUT	0.02200	oC	Rectangular	0.01270	1	oC	0.01270
	Hysteresis- UUT	0.00300	oC	Rectangular	0.00173	1	oC	0.00173
			Combined Uncertainty =			0.016	°C	
			Expanded Uncertainty =			0.032	°C	

QATAR STANDARDS, PRT 883912, Uncertainty at 250 °C

883912 250 C		Quantity X_i	Unit	Probability Distribution	Standard Uncertainty	Sensitivity coefficient c_i	Unit	Contribution to the combined uncertainty $u(x_i)$ [°C]
SPRT	Type A standard uncertainty	0.01804	oC	Normal	0.01804	1	oC	0.01804
	Calibration- SPRT	0.00700	oC	Normal	0.00350	1	oC	0.00350
	Drift- -SPRT	0.00700	oC	Rectangular	0.00404	1	oC	0.00404
	Calibration- reading instrument	0.00004	Ω	Normal	0.00002	0.368	Ω/oC	0.00005
	Drift- reading instrument	0.00004	Ω	Rectangular	0.00002	0.368	Ω/oC	0.00005
Oil Bath	Uniformity	0.01200	oC	Rectangular	0.00693	1	oC	0.00693
	Stability	0.00500	oC	Rectangular	0.00289	1	oC	0.00289
UUT	Type A standard uncertainty	0.00361	Ω	Normal	0.00361	0.368	Ω/oC	0.00980
	Short-term stability-UUT	0.00004	oC	Rectangular	0.00003	1	oC	0.00003
	Calibration- reading instrument	0.00004	Ω	Normal	0.00002	0.368	Ω/oC	0.00005
	Drift- reading instrument	0.00004	Ω	Rectangular	0.00002	0.368	Ω/oC	0.00005
	Heat conduction-UUT	0.02500	oC	Rectangular	0.01443	1	oC	0.01443
	Hysteresis- UUT	0.00300	oC	Rectangular	0.00173	1	oC	0.00173
			Combined Uncertainty =			0.027	°C	
			Expanded Uncertainty =			0.054	°C	