Final Report

SIM.T-S2

Report on the comparison of the calibration of 100 Ω Platinum Resistance Thermometers

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April 2013

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0. INTRODUCTION.

The purpose of this report is to present the final results from the comparison of 100 Ω platinum resistance thermometers (PRTs) between the Centro Español de Metrología (Spanish Metrology Center, CEM) and the five national laboratories of the countries of the Andean Community of Nations (CAN) with the participation of the Centro Nacional de Metrología (National Metrology Center, CENAM) of Mexico as co-pilot and representative of the Inter-American System of Metrology (SIM).

This interlaboratories comparison was carried out under the “Technical Assistance and Cooperation Program in Quality Matters European Union- Andean Community¨.

The purpose of the comparison is checking the equivalence between the participating laboratories in the calibration of platinum resistance thermometers by comparison. CEM has acted as the pilot laboratory also providing the two thermometers used, whose characteristics are shown in table 2, Thermometers initially planned in the protocol (see annex), could not be used because the initial characterization performed in CEM showed a significant lack of stability.

The final circulation scheme was as follows:

Laboratory	Date of control measurements at 0º C
CEM	July 01, 2004
CENAM	November 03, 2004
SENCAMER	November 15, 2004
IEN-CMFT	February 04, 2005
SIC	February 28, 2005
INDECOPI	April 08, 2005
IBMETRO	May 03, 2005
CEM	June 03, 2005

Table 1. Schedule of events

Temperature values will be referred to the International Temperature Scale of 1990 (ITS-90).

1. PARTICIPANTS

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2. MEASUREMENT METHODOLOGY

The protocol of the comparison (see the annex) was prepared by CEM and discussed with the participant laboratories in May 2004. It was agreed to make the comparison using the reduced resistance values of each laboratory at 1 mA current.

In order to maintain as much control as possible over the traveller PRTs and checking the influence of transport and, if it were appropriate, to correct possible accidents if it was requested, in the receiving instructions was specified to report to CEM the PRTs measured resistance values at the triple point of water or at the ice point prior to the calibration.

3. DESCRIPTION OF THERMOMETERS

The PRTs used as traveller thermometers, were intended to represent the normal industrial resistance thermometers having, at the same time, enough stability to allow the comparison of the results. It was decided to use two different instruments in order to increase the reliability of the comparison.

Table 2 provides a summary of the main features of the PRTs used.

Trademark	Isotech	Isotech
Model	935/14/16	935/14/61
Temperature range	-100 to 450º C	-50 to 250º C
Resistance at 0º C	100 Ω	100 Ω
Alpha coefficient	0,00385	0,00385
Stability	0,010 Ω per year	0,010 Ω per year
Sensitive element's length	25 mm	25 mm
Dipstick length	450 mm	300 mm
Dipstick diameter	6 mm	4,1 mm

Table 2, PRTs characteristics

4. CHARACTERIZATION OF THERMOMETERS

PRTs characterization was conducted by CEM and consisted mainly of two studies:

- Heat conduction study
- Hysteresis study

4.1. Heat conduction study

A heat conduction study was done for both models in order to determine the proper immersion depth for each PRT. The study was conducted in the extreme temperatures of calibration: -50 ºC and 250º C, and consisted in full immersion of the PRT and then decreasing the immersion depth centimeter by centimeter taking readings of the PRT resistance value in each position. Below are two graphs (figures 1 and 2) with the results obtained.

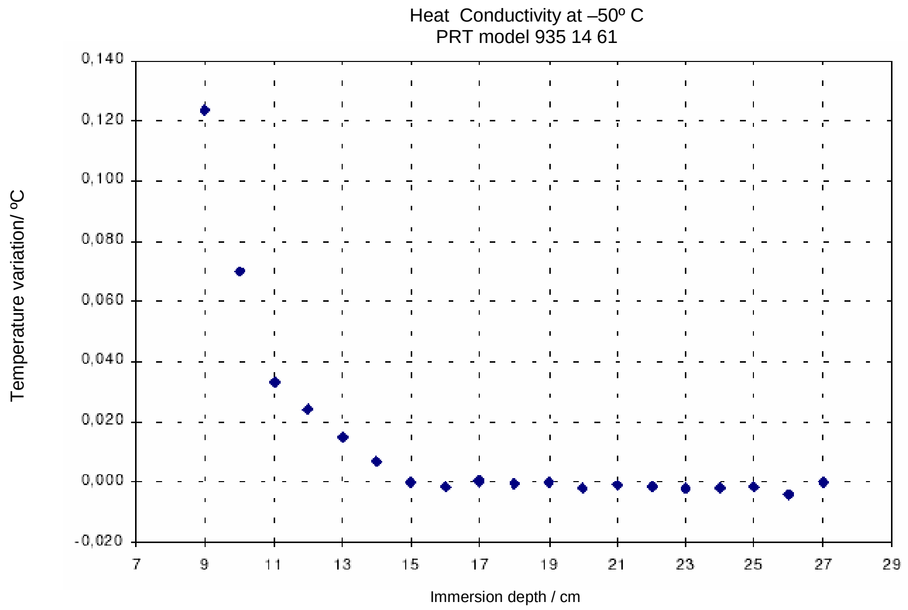

Figure 1. Heat Conduction at –50º C. ¨Short¨ PRT

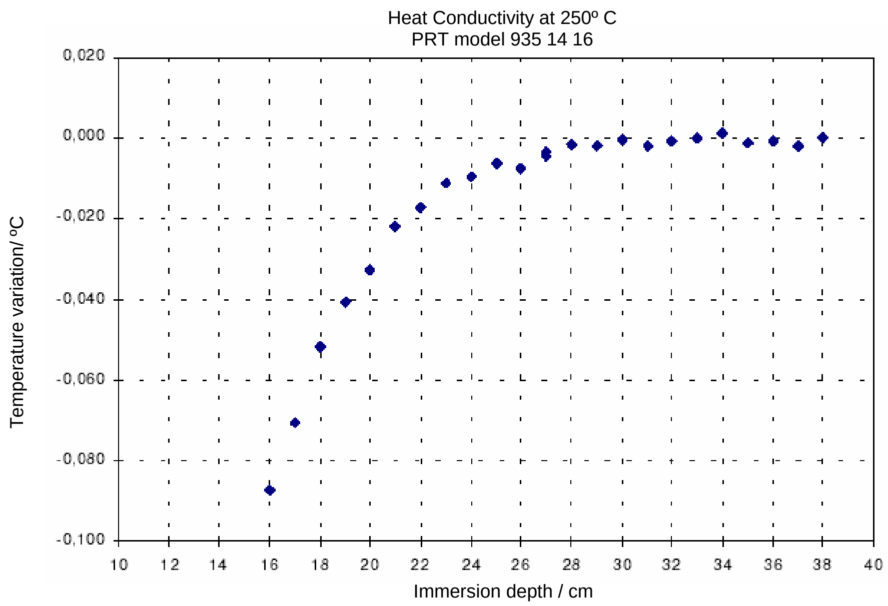

Figure 2. Heat Conduction at 250º C, ¨Large¨ PRT

4.2. Hysteresis study

Both PRTs were subjected to five temperature cycles, each of them consisting of:

1. Heating at 250º C for at least 10 minutes.
2. Air cooling to room temperature.
3. Determination of *R* (0ºC).
4. Cooling to –50ºC for at least 10 minutes.
5. Air heating to room temperature.
6. Determination of *R* (0ºC).

This hysteresis study was conducted twice, one before the first calibration at CEM and the other one before the last calibration at CEM. Figures 3 and 4 show the results obtained before the last calibration. It can be seen that the model 935 14 16 (¨large¨) has lower hysteresis and higher stability in thermal cycling than the model 935 14 61 (¨short¨).

In the case of PRT s/n 16004/6 each temperature cycle started with a heating at 250 ºC so measurement #1 in figure 3 corresponds to a determination of *R* (0ºC) just after the heating. On the contrary, in the case of PRT s/n16004/1 the temperature cycles started with a cooling at -50 ºC instead of a heating, in consequence, measurement #1 in figure 4 corresponds to a determination of *R* (0ºC) just after the cooling.

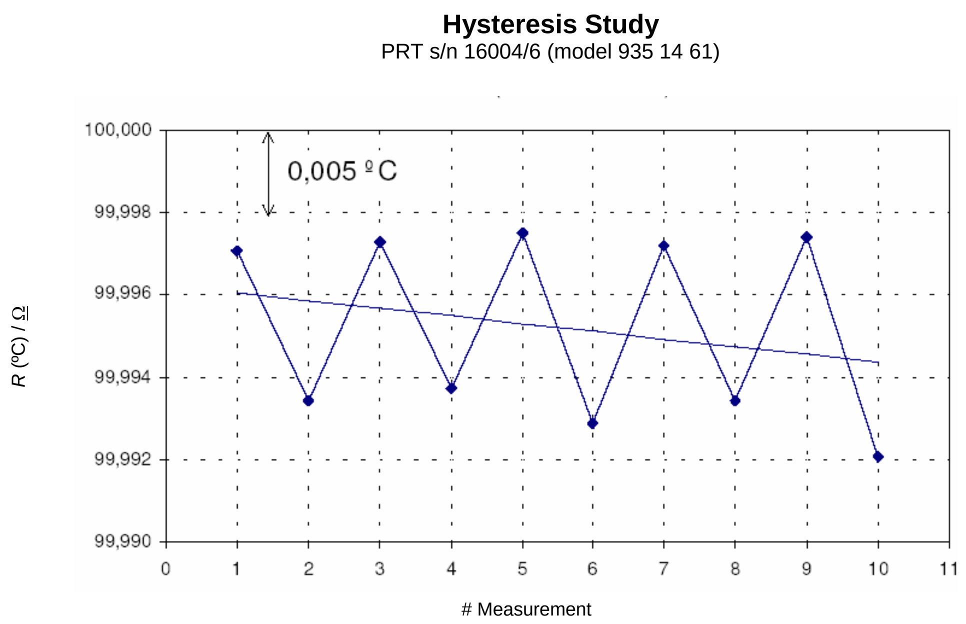

Figure 3. Behaviour of ¨short¨ PRT in thermal cycling

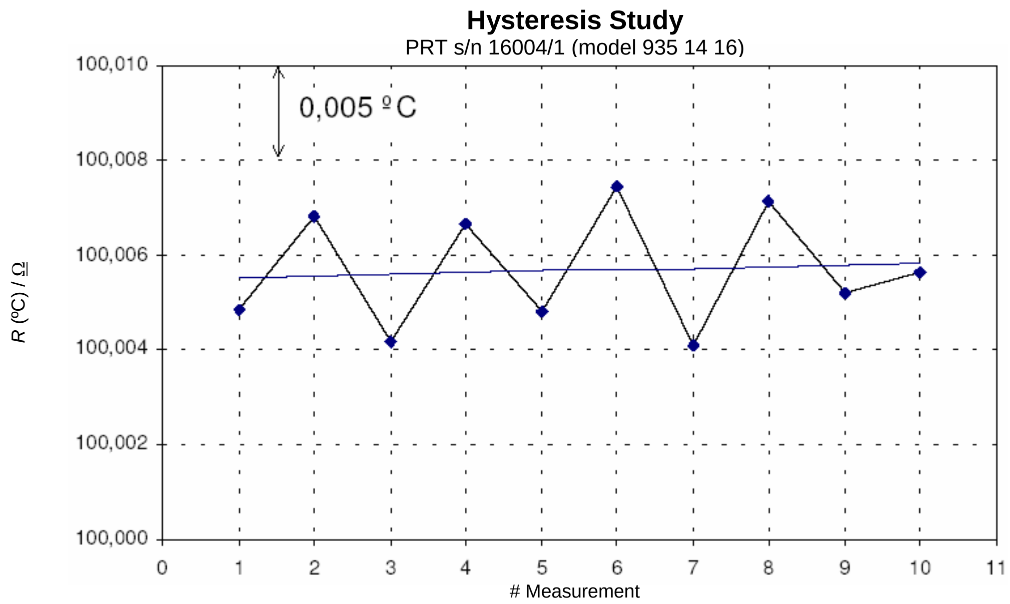

Figure 4. Behaviour of ¨large¨ PRT in thermal cycling

5. THERMOMETER'S STABILITY THROUGHOUT THE COMPARISON

The thermometer's receiving instructions specified measure *R*(0ºC) and send the results immediately to CEM. This data let to check the thermometer status after the successive displacements and, if significant changes were detected, let to take appropriate actions.

R(0ºC) measurements were performed by the laboratories at the water triple point or at the ice bath with temperature assignation. In order to standardize the results and comparing them, the resistance values were extrapolated to the water triple point temperature 0,01 ºC. The results obtained for both thermometers are given in Tables 3 and 4 and graphically in figures 5 and 6. The uncertainties showed are those supplied by the laboratories in the reception formats.

All values are within the assigned uncertainties and the last measurement done by CEM did not show any significant drift.

Laboratory	T °C	R_t Ω	R(0,01°C) Ω	U °C
CEM	0,001	99,996 1	99,999 5	0,020
SENCAMER	0,010	99,993 0	99,993 0	0,020
IEN-CMFT	0,085	100,029 7	100,000 0	0,011
SIC	0,000	99,994 1	99,998 1	0,010
INDECOPI	0,000	100,000 0	100,004 0	0,040
IBMETRO	0,010	99,998 0	99,998 0	0,015
CEM	0,010	99,998 0	99,998 0	0,020

Table 3. Control measures at the water triple point for ¨short¨ PRT n/s 16004/6 (model 935 14 61)

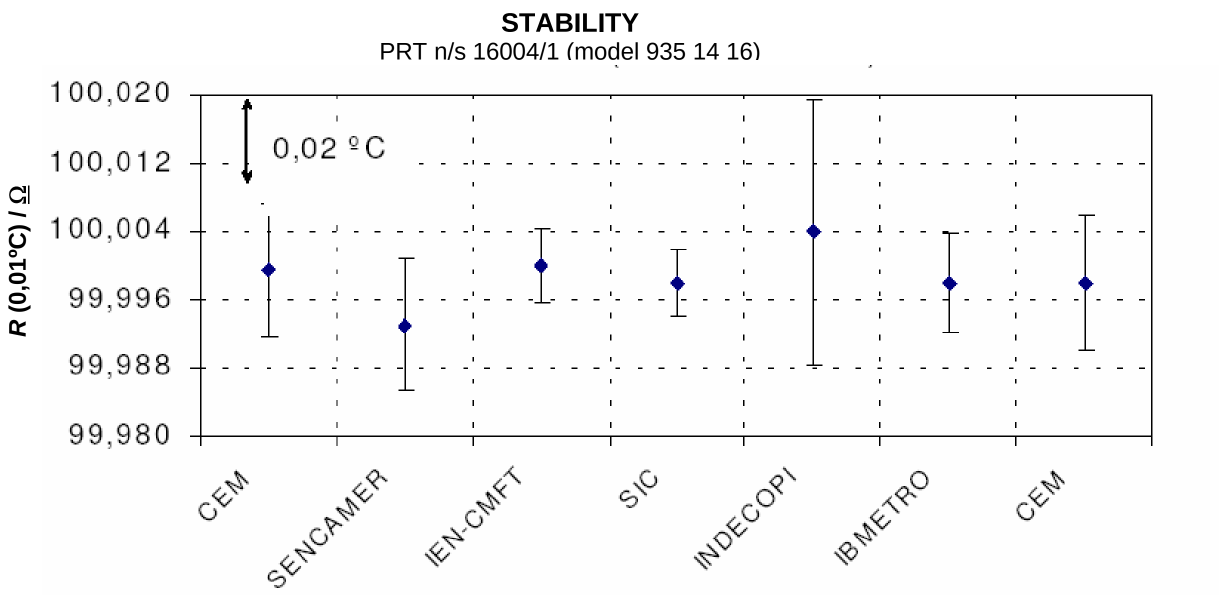

Figure 5. Control measures at the water triple point for ¨short¨ PRT n/s 16004/6 (model 935 14 61)

Laboratory	T ºC	R_t Ω	R(0,01ºC) Ω	U ºC
CEM	0,001	100,006 1	100,009 7	0,020
SENCAMER	0,010	100,003 0	100,003 0	0,020
IEN-CMFT	0,100	100,035 9	100,000 0	0,011
SIC	0,000	100,011 0	100,015 0	0,010
INDECOPI	0,000	100,010 0	100,014 0	0,040
IBMETRO	0,010	100,008 0	100,008 0	0,015
CEM	0,010	100,009 0	100,009 0	0,020

Table 4. Control measures at the water triple point for ¨large¨ PRT n/s 16004/6 (model 935 14 16)

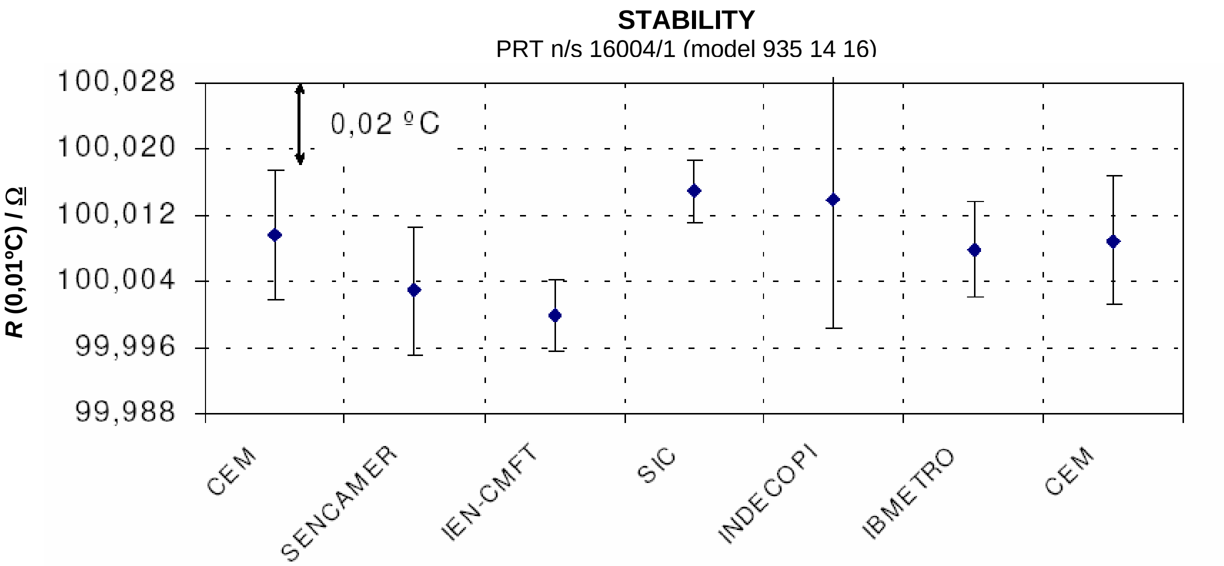

Figure 6. Control measures at the water triple point for ¨large¨ PRT n/s 16004/6 (model 935 14 16)

6. CALIBRATION METHOD AND INSTRUMENTATION USED

The calibration method to be used was by comparison, in isothermal media, against previously calibrated reference standards.

The annex 2 of this report shows the comparison protocol, which describes the process and measurement points. The procedure used by each laboratory should be the usual for each laboratory.

Table 5 shows a summary of the instruments used by all of the laboratories.

7. ANALYSIS OF RESULTS

In order to compare the results, the data sent by each laboratory were extrapolated to the reference temperatures given in the protocol. For this purpose, sensitivity coefficients (defined as the resistance change of each PRT with temperature) were used. They were given by the fitting curves got in the last calibration at CEM. For the fitting, the reference functions of the ITS-90 were used. Equations of the following type, fitted by least squares method, were applied to the differences between the measured values and the reference ones:

$$W_\mathrm{d} = a \cdot (W - 1) + b \cdot (W - 1)^2 \qquad (1)$$

Evaluation of the results was made in terms of the reduced resistance W_t in each calibration point in order to eliminate possible PRTs instabilities. For each laboratory was taken the last measured value of resistance at the water triple point (tables 10 and 11) for W_t calculation.

	Standard Thermometers	Measurement Equipment	Isothermal Medias	Traceability
CEM	Pt-100 Hart Mod. 5681	ASL bridge Mod. F700 Tinsley Electrical Resistance Mod. 5685 A	Heto Alcohol Bath Mod. KB 25 Heto Water Bath Mod. KB 216 Heto Oil Bath Mod. KB 12	CEM
CENAM	Pt-100 Hart Mod.5682 Pt-25 Rosemount Mod. 162ce	ASL bridge Mod. F17	Isotech Mod. Nixon Hart Mod 7007	CENAM
SENCAMER	Pt-25 Rosemount Mod. 162ce	ASL bridge Mod. F16 ASL thermometer Mod. F150	Haake alcohol bath Mod. K75 Julabo oil Bath Mod. TD12 P.T. cell Jarret water Mod. A13	PTB (DKD) ASL SENCAMER
IEN-CMFT	Pt-100 Hart Mod. 5612	HP multimeter Mod. 3458A Hart thermometer Mod. Chub E4 1529	Hart Bath 6330 Hart Bath 7320	HART SCIENTIFIC FLUKE
SIC	Pt-25 Rosemount Mod. 162 ce	ASL bridge Mod. F700	Tamson water bath Mod. TXVB70 ASL oil bath Mod. LU550 Heto Salts Bath mod. KB41	CENAM SIC ASL TINSLEY
INDECOPI	SPRT-25 Tinsley Mod. 5187 SPRT-25 Scientific Mod. 5699	PRT Adapter Guideline 99301 Agilent Multimeter 34420A Guildline Electrical Res. Mod. 9330 Tettex Electrical Res. Mod. 3205/6/7 Fuke Electrical Res. Mod.742A	Polystat Alcohol Bath Mod. 12101-45 Lauda water bath Mod. D60 Lauda oil bath Mod. NBS/S15-22 Hart water P.T. Cell Mod. 5901 n/s 1421 PTB water P.T. Cell Mod. 55/92(9,12) n/s 153/81	CENAM PTB INTI
IBMETRO	Pt-25 Hart Mod. 5699	HP multimeter Mod. 3458A Prema Scanner Mod. 2080 Winka Switcher Mod. Box 20	Lauda glycol bath Mod. UB 65 J Lauda oil Bath Mod. UB 65 J Hart water P.T. Cell Mod. 5901	LACOMET Kalibrierservice R. Mikulla (DKD)

Table 5. Summary of the instrumentation used by the participants.

7.1 Uncertainty calculation of the reference values

For each calibration point it was considered as the reference values the mean between the first and the last calibration at CEM because the thermometers shown enough stability throughout the comparison. CEM has Calibration Measurement Capabilities (CMCs) approved for calibration of industrial platinum resistance thermometers by comparison with uncertainties from 0,01 ºC to 0,02 ºC in the temperature range (-80, 250) ºC, supported by its participation in the CCT-K3 regional comparison EURAMET.T-K3,

For calculating the uncertainty of the reference value, the following mathematical model was considered:

$$W_{\text{ref.},\,t} = (W_{\text{CEM1,},\,t} + W_{\text{CEM2,},\,t}) / 2 + \delta W_{\text{est.},\,t} + \Delta W_{\text{ext.},t} \qquad (2)$$

where:

- $W_{\text{ref.},t}$: W reference value of the comparison at the calibration point t.
- $W_{\text{CEM1,},t}$ and $W_{\text{CEM2,},t}$: W values at the calibration point t measured at he first and the last calibration at CEM respectively.
- $\delta W_{\text{est.},t}$: correction due to lack of stability at the calibration point t of the PRT.
- $\Delta W_{\text{ext.},t}$: extrapolation value in the calibration point for getting the reference temperature t.

Taken into account that the uncertainties corresponding to the first and final CEM calibrations are highly correlated, applying the law of propagation of uncertainties to (2):

$$u^2(W_{\text{ref.},\,t}) = u^2(W_{\text{CEM}}) + u^2(\delta W_{\text{est.},\,t}) + u^2(\Delta W_{\text{ext},\,t}) \qquad (3)$$

with:

- $u(W_{\text{ref.},t})$: standard uncertainty of the W reference value at the calibration point t.
- $u(W_{\text{CEM}})$: CEM standard uncertainty of the W CEM value at the point t.
- $u(\delta W_{\text{est.},t})$: standard uncertainty due to the lack of stability of the PRT throughout the comparison. It was calculated considering the difference between the first and the last calibration of the PRT at the point t as the maximum value for this cause and using a rectangular probability distribution.
- $u(\Delta W_{\text{ext.},t})$: standard uncertainty due to the extrapolation of the values of W. It was considered a value of 0,004ºC corresponding to the standard deviation of the fitting residues.

The values of $u(\delta W_{\text{est.},t})$ and $u(\Delta W_{\text{ext.},t})$ are small and have little influence on the uncertainty of the reference value $u(W_{\text{ref.},t})$. The uncertainty value $u(\Delta W_{\text{ext.},t})$ was quadratically composed with the one of the calibration of each laboratory in order to account for the extrapolation of the measured values as an additional source of uncertainty.

Data from SENCAMER in the calibration points at –40ºC and –30ºC, and for IEN-CMFT at 250ºC were removed from the tables and graphs, on proper request and before realising this report, due to problems during the measurements in these laboratories. The results of the other participants or of the pilot had not been released to these laboratories prior to their withdrawal of data. The problems were related to the equipment used to perform the comparison: instabilities of the isothermal media and calibration of the reference standards. All participating laboratories agreed the withdrawal of these data form the final report.

7.2 Standardized Deviation Coefficients calculation

In order to asses the results of the participant laboratories, the standardized deviation coefficients were calculated at each calibration point and for each laboratory. They are defined as:

$$E_{\mathrm{L}t} = \frac{|W_{\mathrm{L}t} - W_{\mathrm{R}t}|}{\sqrt{U_{\mathrm{L}t}^2 + U_{\mathrm{R}t}^2}} \qquad (4)$$

where:

- $U_{\mathrm{L},t,}$: Calibration expanded uncertainty of the laboratory L at the temperature *t*.
- $U_{\mathrm{R},t,}$: Calibration expanded uncertainty of the pilot laboratory at the temperature *t*.

Below the results are presented in tabular and graphical form for both PRTs at each calibration point.

In the tables presented, each column is:

- Column 1: identification of the participants.
- Column 2: ***t***, measured temperatures by the participants.
- Column 3: $\boldsymbol{R_\mathrm{t}}$, measured resistance values by the participants in each calibration point.
- Column 4: $\boldsymbol{R_\mathrm{t}}$ **in *t* ref**, PRT resistance values extrapolated to the nominal value of the calibration point *t*.
- Column 5: $\boldsymbol{W_{,t}}$ **in *t* ref** $W_{,\mathrm{t}}$ values for PRT calculated as the quotient of R_t (column 4) and the *R*(0,01ºC) value of the final calibration (tables 10 and 11). For CENAM, *R*(0,01ºC) values that appears in the bottom of each table were used.
- Column 6: **Dif in *R*/*W*** difference, expressed in ºC, between the ($\boldsymbol{R_\mathrm{t}}$ **in *t* ref** or) $\boldsymbol{W_{,\mathrm{t}}}$ values obtained in column (4 or) 5 for each participant and the reference value of the comparison.
- Column 7: $\boldsymbol{E_{\mathrm{l,t}}}$ standardized deviation coefficient.
- Column 8: ***U*** expanded uncertainty for $\boldsymbol{W_{,t}}$ (column 5), or for *R*(0,01ºC) expressed in ºC, obtained by quadratic combination of the uncertainty calculated by the participants and the one of the extrapolation (see section 7.1 of this report).

In the corresponding values for CEM, it is included too the values of the differences and the standardized deviation coefficients in order to show the PRTs stability throughout the comparison and the repeatability of the calibrations performed.

In the following tables and graphs the results of the measurements made by CENAM have been included, which did not appear in the draft prior to this final report because they had not been received. The pilot laboratory confirmed that the data supplied by CENAM after the first draft report were consistent with the raw data accumulated at the time of the comparison. All participating laboratories agreed the inclusion of CENAM results in the final report. The procedure followed by CENAM differed from that used by other laboratories because the PRTs were measured at the triple point of water after each calibration point, so the calculation of uncertainties performed by CENAM excluded the component due to the thermometer hysteresis. Therefore, the data processing was performed accordingly, i.e. for the calculation of $W_{,t}$ in the nominal values of the calibration points the R(0,01ºC) measurements carried out after each of them have been used. At the bottom of each table it is shown the CENAM R(0,01ºC) value used.

“Short” PRT 16004/6 (935 14 61)

Ref. t 0,010º C **Start of Calibration**
PRT Sensitivity 0,391 2 Ω/ºC

Laboratory	***t*** **ºC**	***R_t*** **Ω**	***R_t* in *t* ref Ω**	**Dif in *R* ºC**	***$E_{l,t}$***	***U*** **ºC**
CEM	0,001	99,996 1	99,999 5	0,002	0,08	0,022
CENAM	0,010	99,995 3	99,995 3	- 0,008		
SENCAMER						
IEN-CMFT	0,000	100,037 5	100,041 4	0,110	3,15	0,027
SIC						
INDECOPI	0,010	100,001 1	100,001 1	0,007	0,26	0,014
IBMETRO	0,010	99,999 0	99,999 0	0,001	0,04	0,017
CEM	0,000	99,993 9	99,997 6	-0,002	0,08	0,022

Table 6

“Large” PRT 16004/1 (935 14 16)

Ref. t 0,010º C **Start of Calibration**
PRT Sensitivity 0,391 9 Ω/ºC

Laboratory	***t*** **ºC**	***R_t*** **Ω**	***R_t* in *t* ref Ω**	**Dif in *R* ºC**	***$E_{l,t}$***	***U*** **ºC**
CEM	0,001	100,006 1	100,009 6	0,001	0,03	0,022
CENAM	0,010	100,003 6	100,003 6	-0,015		
SENCAMER						
IEN-CMFT	0,000	100,045 4	100,049 3	0,102	2,93	0,027
SIC						
INDECOPI	0,010	100,009 5	100,009 5	0,001	0,02	0,027
IBMETRO	0,010	100,008 4	100,008 4	-0,002	0,09	0,014
CEM	0,000	100,005 2	100,009 0	-0,001	0,03	0,022

Table 7

¨Short¨ PRT 16004/6 (935 14 61)

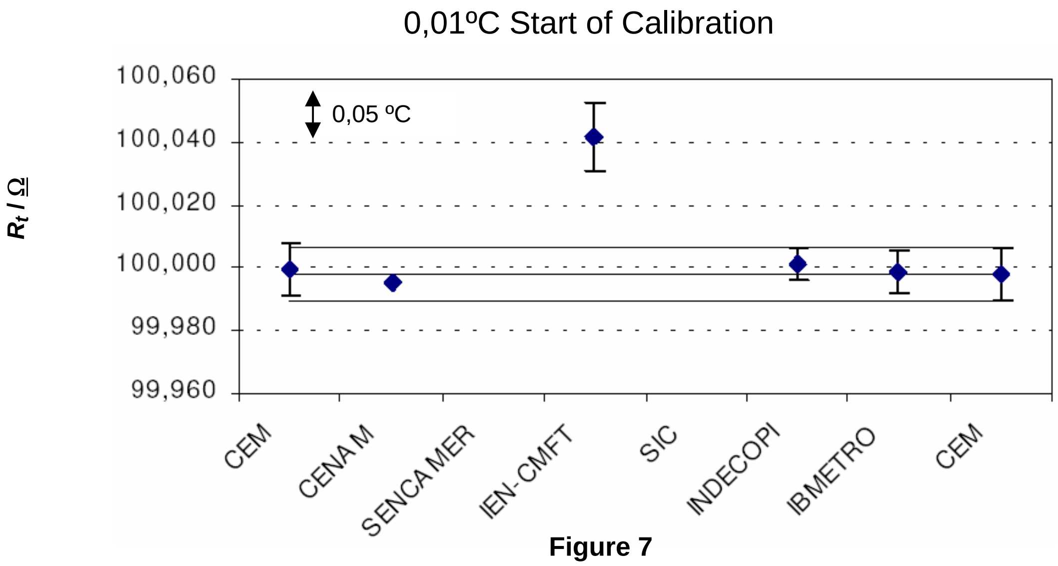

Figure 7

"Large" PRT 16004/1 (935 14 16)

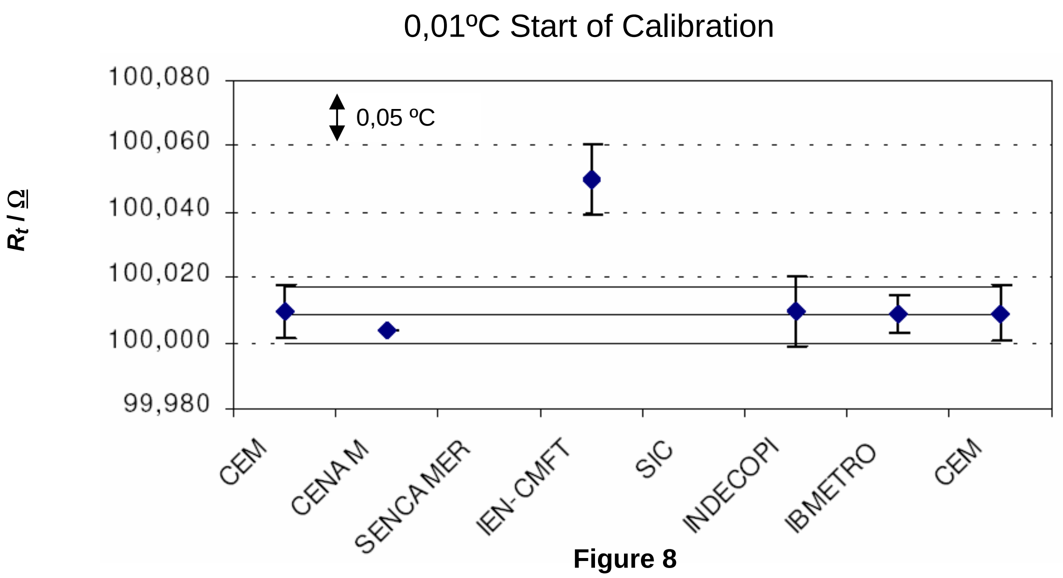

Figure 8

“Short” PRT 16004/6 (935 14 61)

Ref. t	0,010º C	**Half of the calibration**
PRT Sensitivity	0,391 2 Ω/ºC	

Laboratory	***t*** **ºC**	**R_t Ω**	**R_t in *t* ref Ω**	**Dif in *R* ºC**	**$E_{l,t}$**	***U*** **ºC**
CEM	0,001	99,993 4	99,996 9	-0,001	0,03	0,022
CENAM	0,010	99,995 6	99,995 6	-0,004		
SENCAMER						
IEN-CMFT	0,000	100,037 7	100,041 6	0,113	3,26	0,027
SIC						
INDECOPI	0,010	100,001 3	100,001 3	0,010	0,41	0,014
IBMETRO	0,010	100,001 0	100,001 0	0,010	0,35	0,017
CEM	0,000	99,993 9	99,997 6	0,001	0,03	0,022

Table 8

“Large” PRT 16004/1 (935 14 16)

Ref. t	0,010º C	**Half of the calibration**
PRT Sensitivity	0,391 9 Ω/ºC	

Laboratory	***t*** **ºC**	**R_t Ω**	**R_t in *t* ref Ω**	**Dif in *R* ºC**	**$E_{l,t}$**	***U*** **ºC**
CEM	0,001	100,004 5	100,008 0	0,000	0,01	0,022
CENAM	0,010	100,004 1	100,004 1	-0,010		
SENCAMER						
IEN-CMFT	0,000	100,044 0	100,047 9	0,101	2,91	0,027
SIC						
INDECOPI	0,010	100,008 2	100,008 2	0,000	0,00	0,027
IBMETRO	0,010	100,008 9	100,008 9	0,002	0,07	0,014
CEM	0,001	100,004 6	100,008 3	0,000	0,01	0,022

Table 9

¨Short¨PRT 16004/6 (935 14 61)

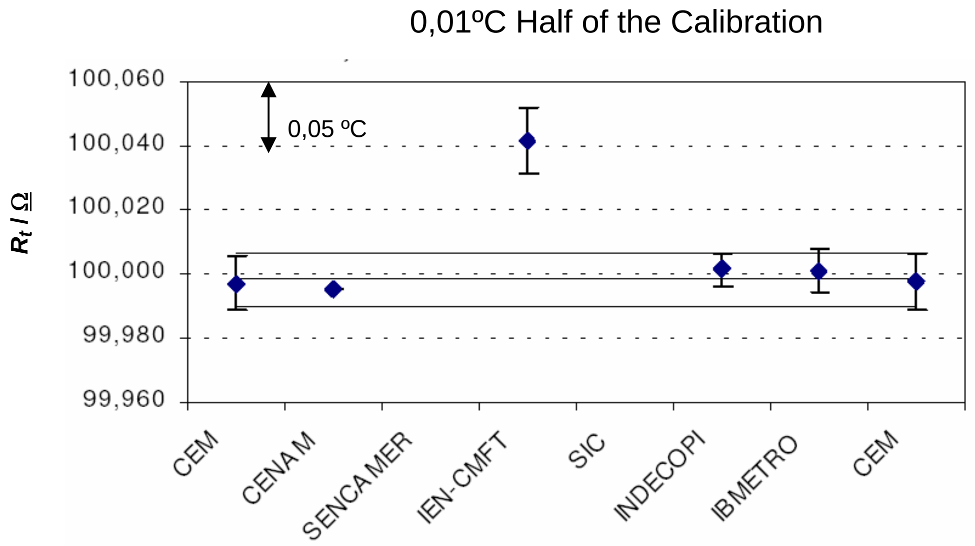

Figure 9

"Large" PRT 16004/1 (935 14 16)

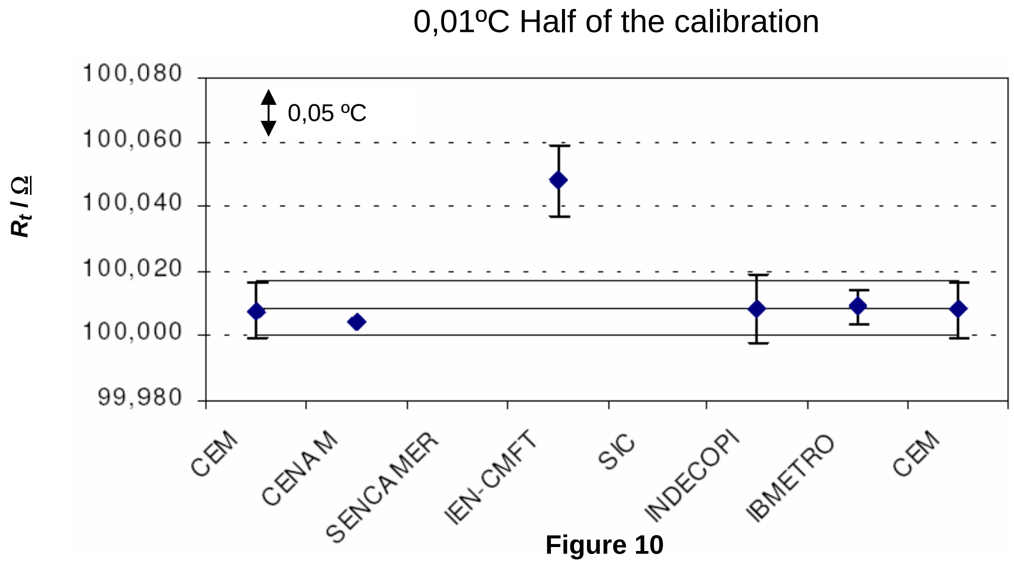

Figure 10

“Short” PRT 16004/6 (935 14 61)

Ref. t	0,010º C	**End of Calibration**
PRT Sensitivity	0,391 2 Ω/ºC	

Laboratory	***t*** **ºC**	R_t **Ω**	R_t **in** ***t*** **ref Ω**	**Dif in** ***R*** **ºC**	$E_{l,t}$	***U*** **ºC**
CEM	0,001	99,995 0	99,998 5	0,001	0,04	0,022
CENAM	0,010	99,992 2	99,992 2	-0,015		
SENCAMER	0,010	99,995 0	99,995 0	-0,008	0,28	0,017
IEN-CMFT	0,001	100,037 7	100,041 2	0,110	3,17	0,027
SIC	0,000	99,995 9	99,999 8	0,005	0,19	0,011
INDECOPI	0,010	100,001 2	100,001 2	0,008	0,32	0,014
IBMETRO	0,010	99,999 0	99,999 0	0,002	0,09	0,017
CEM	0,000	99,993 9	99,997 6	-0,001	0,04	0,022

Table 10

“large” PRT 16004/1 (935 14 16)

Ref. t	0,010º C	**End of Calibration**
PRT Sensitivity	0,391 9 Ω/ºC	

Laboratory	***t*** **ºC**	R_t **Ω**	R_t **in** ***t*** **ref Ω**	**Dif in** ***R*** **ºC**	$E_{l,t}$	***U*** **ºC**
CEM	0,001	100,004 5	100,008 0	-0,001	0,04	0,022
CENAM	0,010	100,001 5	100,001 5	-0,018		
SENCAMER	0,010	100,004 0	100,004 0	-0,012	0,42	0,017
IEN-CMFT	0,001	100,046 1	100,049 6	0,105	3,01	0,027
SIC	0,000	100,006 0	100,009 9	0,004	0,15	0,011
INDECOPI	0,010	100,008 4	100,008 4	0,000	0,01	0,027
IBMETRO	0,010	100,008 4	100,008 4	0,000	0,01	0,014
CEM	0,000	100,005 2	100,009 0	0,001	0,04	0,022

Table 11

¨Short¨PRT 16004/6 (935 14 61)

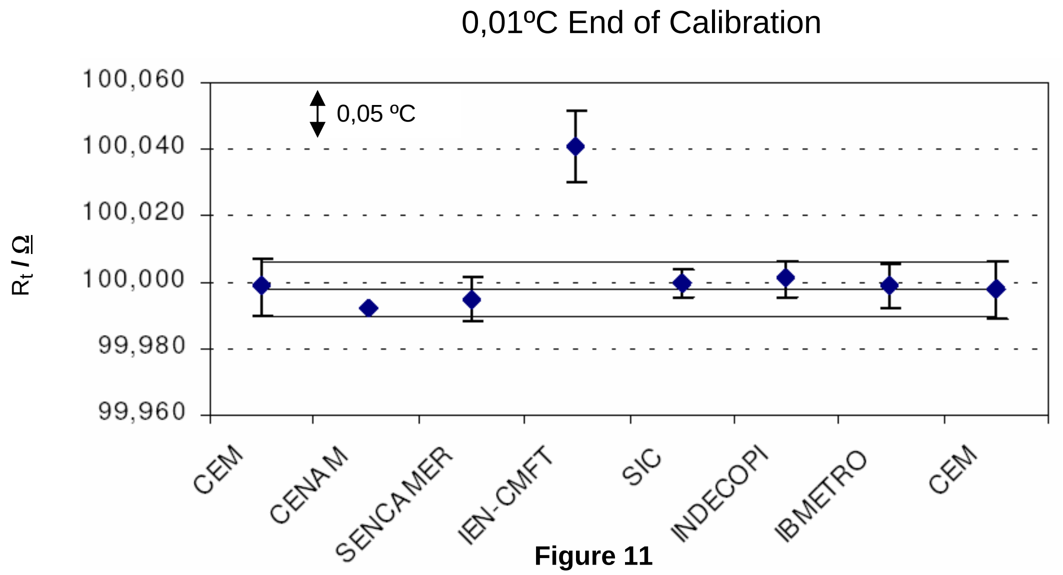

Figure 11

¨Large¨ PRT 16004/1 (935 14 16)

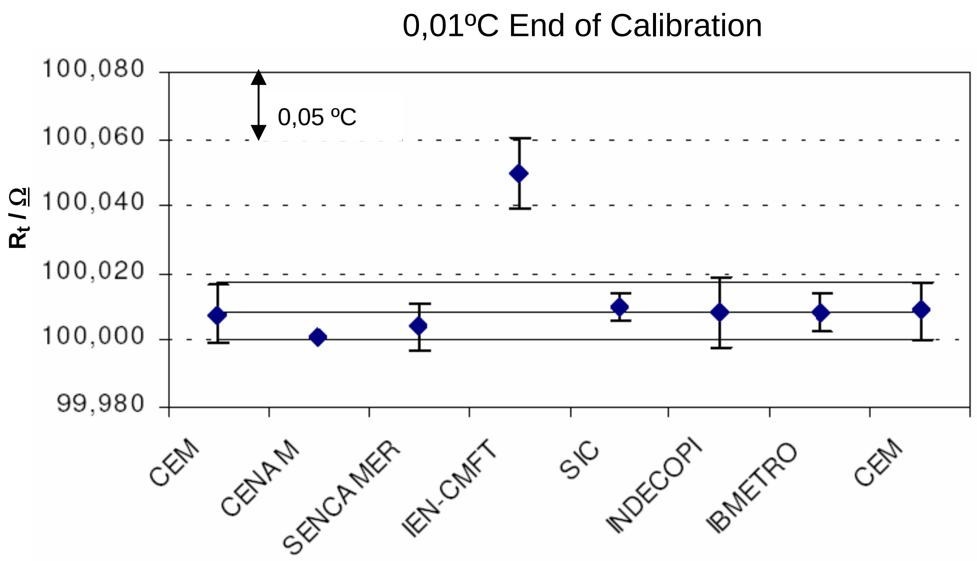

Figure 12

“Short” PRT 16004/6 (935 14 61)

Ref. *t* - 40º C

PRT Sensitivity 0,395 6 Ω/ºC

Laboratory	*t* ºC	R_t Ω	R_t in *t* ref Ω	*W* in *t* ref Ω/Ω	Dif in *W* ºC	$E_{l,t}$	*U* ºC
CEM	-39,830	84,324 7	84,257 3	0,842 586	-0,001	0,02	0,022
CENAM	-40,733	83,958 7	84,248 7	0,842 552	-0,009	0,35	0,010
SENCAMER							
IEN-CMFT(*)							
SIC(*)							
INDECOPI	-39,987	84,264 2	84,259 1	0,842 580	-0,002	0,05	0,033
IBMETRO(*)							
CEM	-39,672	84,386 7	84,256 9	0,842 590	0,001	0,02	0,022
R (0,01ºC)	CENAM =	99,992 2					

Table 12

“Llarge” PRT 16004/1 (935 14 16)

Ref. *t* - 40º C

PRT Sensitivity 0,396 8 Ω/ºC

Laboratory	*t* ºC	R_t Ω	R_t in *t* ref Ω	*W* in *t* ref Ω/Ω	Dif in *W* ºC	$E_{l,t}$	*U* ºC
CEM	-39,821	84,316 0	84,244 8	0,842 381	0,001	0,03	0,022
CENAM	-40,762	83,943 8	84,246 2	0,842 449	0,018	0,72	0,010
SENCAMER							
IEN-CMFT(*)							
SIC(*)							
INDECOPI	-39,987	84,251 9	84,246 7	0,842 397	0,005	0,12	0,035
IBMETRO(*)							
CEM	-39,697	84,365 2	84,244 9	0,842 374	-0,001	0,03	0,022
R (0,01ºC)	CENAM =	100,001 5					

Table 13

(*) The laboratory did not measure in this calibration point

“Short” PRT 16004/6 (935 14 61)

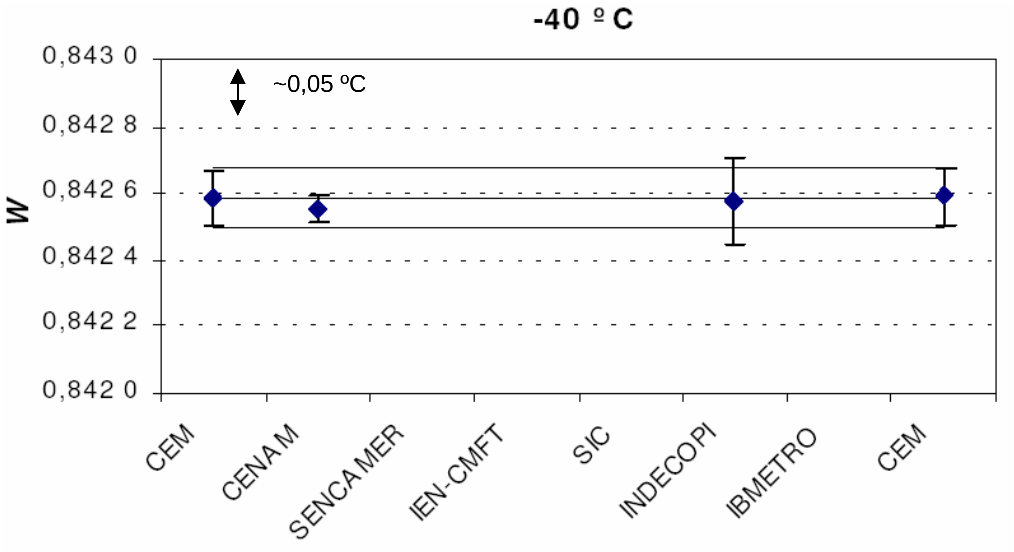

Figure 13

“Large” PRT 16004/1 (935 14 16)

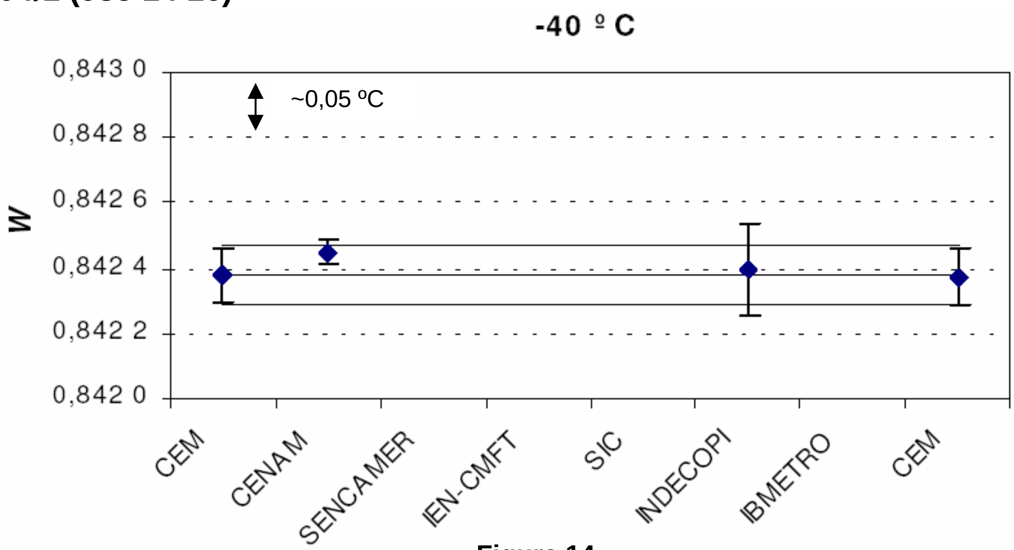

Figure 14

"Short" PRT 16004/6 (935 14 61)

Ref. *t* - 30º C

PRT Sensitivity 0,395 0 Ω/ºC

Laboratory	***t*** **ºC**	R_t **Ω**	R_t **in *t* ref Ω**	***W* in *t* ref Ω/Ω**	**Dif in *W* ºC**	$E_{l,t}$	***U*** **ºC**
CEM	-29,752	88,307 6	88,209 6	0,882 110	-0,001	0,05	0,022
CENAM	-30,495	88,011 7	88,207 2	0,882 141	0,006	0,26	0,009
SENCAMER							
IEN-CMFT(*)							
SIC(*)							
INDECOPI	-29,977	88,223 1	88,213 8	0,882 127	0,003	0,08	0,030
IBMETRO	-27,150	89,344 0	88,218 4	0,882 193	0,020	0,42	0,041
CEM	-29,768	88,301 6	88,210 0	0,882 121	0,001	0,05	0,022
R (0,01ºC)	CENAM =	99,992 2					

Table 14

"Large" PRT 16004/1 (935 14 16)

Ref. *t* - 30º C

PRT Sensitivity 0,396 6 Ω/ºC

Laboratory	***t*** **ºC**	R_t **Ω**	R_t **in *t* ref Ω**	***W* in *t* ref Ω/Ω**	**Dif in *W* ºC**	$E_{l,t}$	***U*** **ºC**
CEM	-29,772	88,292 5	88,202 2	0,881 952	0,000	0,00	0,022
CENAM	-30,488	88,006 3	88,199 3	0,881 980	0,007	0,29	0,009
SENCAMER							
IEN-CMFT(*)							
SIC(*)							
INDECOPI	-29,977	88,214 8	88,205 5	0,881 981	0,007	0,19	0,031
IBMETRO	-27,150	89,340 0	88,212 7	0,882 053	0,025	0,60	0,036
CEM	-29,786	88,287 8	88,203 2	0,881 952	0,000	0,00	0,022
R (0,01ºC)	CENAM =	100,001 5					

Table 15

(*) The laboratory did not measure in this calibration point

“Short” PRT 16004/6 (935 14 61)

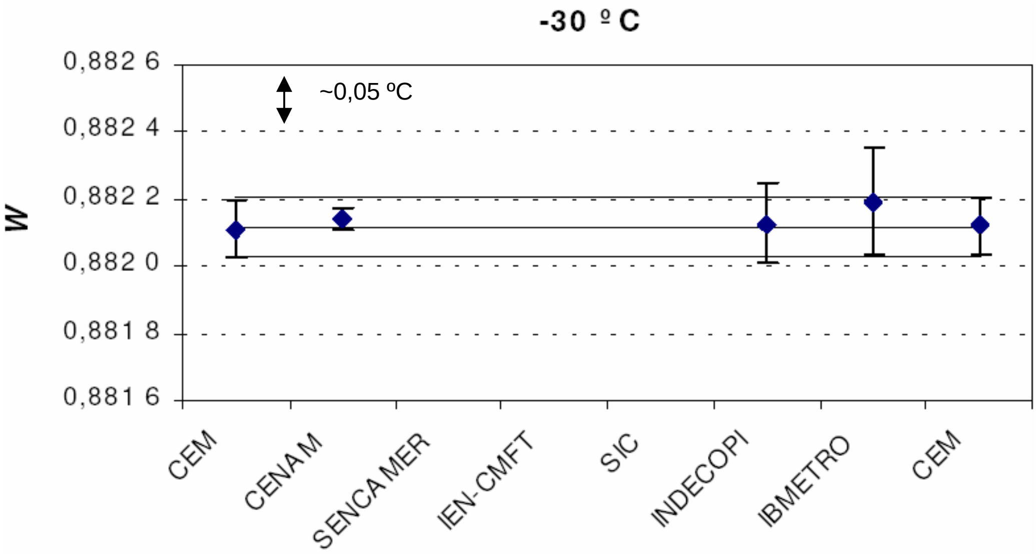

Figure 15

“Large” PRT 16004/1 (935 14 16)

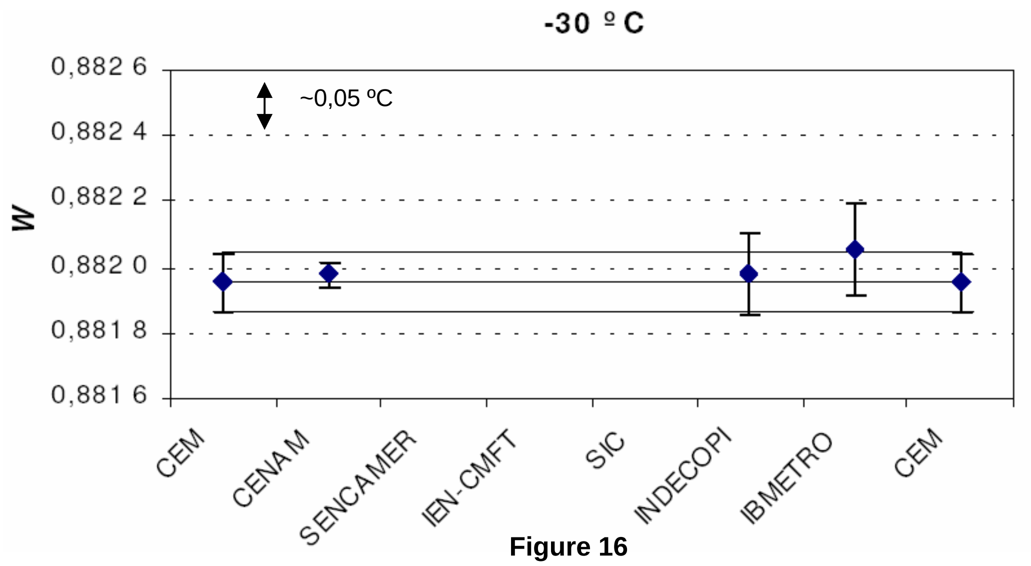

Figure 16

"Short" PRT 16004/6 (935 14 61)

Ref. *t* - 20º C

PRT Sensitivity 0,393 7 Ω/ºC

Laboratory	***t*** **ºC**	**R_t** **Ω**	**R_t in *t* ref** **Ω**	***W* in *t* ref** **Ω/Ω**	**Dif in *W*** **ºC**	**$E_{l,t}$**	***U*** **ºC**
CEM	-19,744	92,251 2	92,150 3	0,921 517	-0,002	0,05	0,022
CENAM	-20,021	92,138 5	92,146 8	0,921 521	-0,001	0,02	0,009
SENCAMER	-20,174	92,065 0	92,133 7	0,921 383	-0,036	0,38	0,090
IEN-CMFT	-19,891	92,231 6	92,188 7	0,921 507	-0,004	0,12	0,027
SIC(*)							
INDECOPI	-19,970	92,165 6	92,153 8	0,921 526	0,001	0,02	0,028
IBMETRO	-20,005	92,160 0	92,162 0	0,921 629	0,027	0,57	0,041
CEM	-19,563	92,322 6	92,150 8	0,921 530	0,002	0,05	0,022
R (0,01ºC)	CENAM =	99,994 2					

Table 16

"Large" PRT 16004/1 (935 14 16)

Ref. *t* - 20º C

PRT Sensitivity 0,396 6 Ω/ºC

Laboratory	***t*** **ºC**	**R_t** **Ω**	**R_t in *t* ref** **Ω**	***W* in *t* ref** **Ω/Ω**	**Dif in *W*** **ºC**	**$E_{l,t}$**	***U*** **ºC**
CEM	-19,742	92,249 4	92,147 7	0,921 403	0,001	0,02	0,022
CENAM	-20,014	92,139 4	92,144 9	0,921 423	0,006	0,24	0,009
SENCAMER	-20,174	92,151 0	92,219 8	0,922 161	0,193	2,07	0,090
IEN-CMFT	-19,891	92,230 4	92,187 3	0,921 416	0,004	0,11	0,027
SIC(*)							
INDECOPI	-19,970	92,164 2	92,152 4	0,921 446	0,012	0,32	0,028
IBMETRO	-20,005	92,158 0	92,160 0	0,921 522	0,031	0,72	0,036
CEM	-19,559	92,321 9	92,148 1	0,921 398	-0,001	0,02	0,022
R (0,01ºC)	CENAM =	100,002 8					

Table 17

(*) The laboratory did not measure in this calibration point

“Short” PRT 16004/6 (935 14 61)

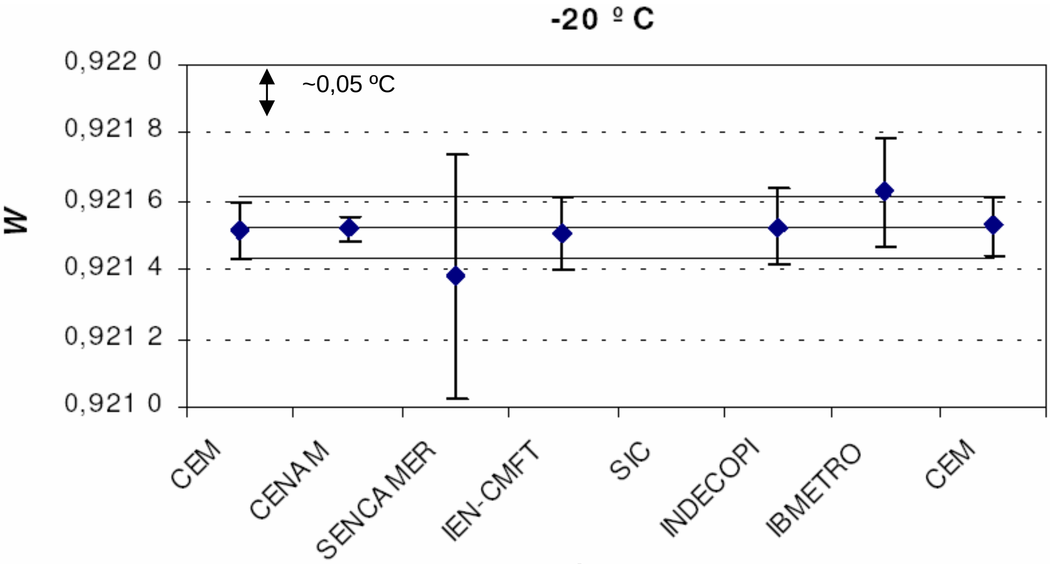

Figure 17

“Large” PRT 16004/1 (935 14 16)

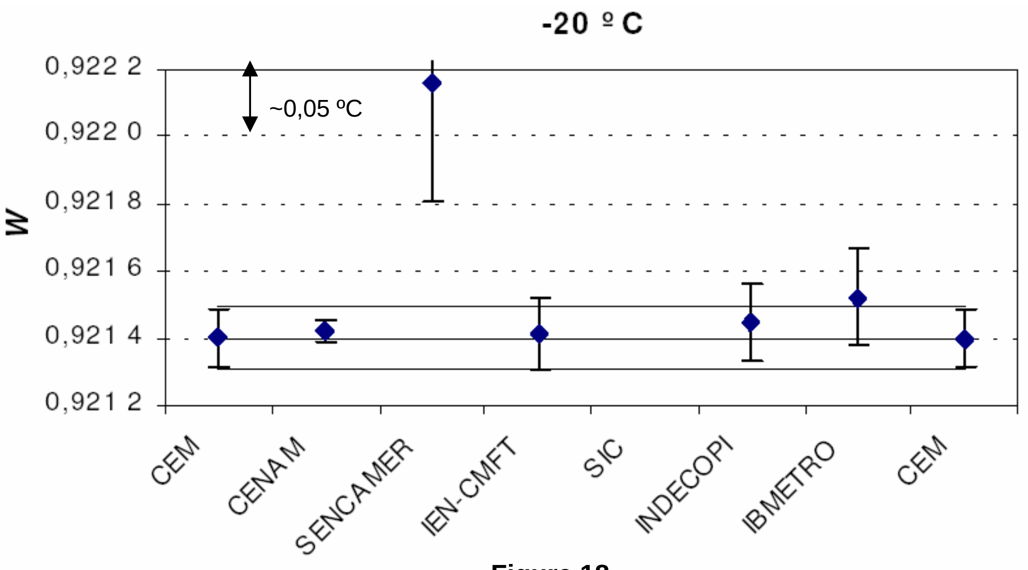

Figure 18

"Short" PRT 16004/6 (935 14 61)

Ref. *t* - 10º C

PRT Sensitivity 0,392 5 Ω/ºC

Laboratory	*t* ºC	R_t Ω	R_t in *t* ref Ω	*W* in *t* ref Ω/Ω	Dif in *W* ºC	$E_{l,t}$	*U* ºC
CEM	-9,661	96,211 4	96,078 2	0,960 830	0,003	0,10	0,022
CENAM	-9,704	96,191 5	96,075 3	0,960 768	-0,013	0,49	0,009
SENCAMER	-10,038	96,057 0	96,072 1	0,960 769	-0,012	0,13	0,090
IEN-CMFT	-9,996	96,121 0	96,119 4	0,960 798	-0,005	0,13	0,027
SIC(*)							
INDECOPI	-9,960	96,099 2	96,083 7	0,960 825	0,002	0,05	0,031
IBMETRO	-10,190	96,016 0	96,090 6	0,960 915	0,025	0,53	0,041
CEM	-9,629	96,223 5	96,078 1	0,960 804	-0,003	0,10	0,022
R (0,01ºC)	CENAM =	99,995 0					

Table 18

"Large" PRT 16004/1 (935 14 16)

Ref. *t* - 10º C

PRT Sensitivity 0,393 1 Ω/ºC

Laboratory	*t* ºC	R_t Ω	R_t in *t* ref Ω	*W* in *t* ref Ω/Ω	Dif in *W* ºC	$E_{l,t}$	*U* ºC
CEM	-9,667	96,212 7	96,081 6	0,960 790	0,006	0,18	0,022
CENAM	-9,701	96,195 8	96,078 3	0,960 705	-0,015	0,54	0,009
SENCAMER	-10,038	96,114 0	96,129 1	0,961 253	0,124	1,31	0,090
IEN-CMFT	-10,002	96,126 1	96,126 9	0,960 792	0,007	0,17	0,027
SIC(*)							
INDECOPI	-9,960	96,101 2	96,085 6	0,960 776	0,002	0,06	0,031
IBMETRO	-10,190	96,018 0	96,092 7	0,960 846	0,020	0,45	0,036
CEM	-9,620	96,232 2	96,082 8	0,960 741	-0,006	0,18	0,022
R (0,01ºC)	CENAM =	100,002 7					

Table 19

(*) The laboratory did not measure in this calibration point

“Short” PRT 16004/6 (935 14 61)

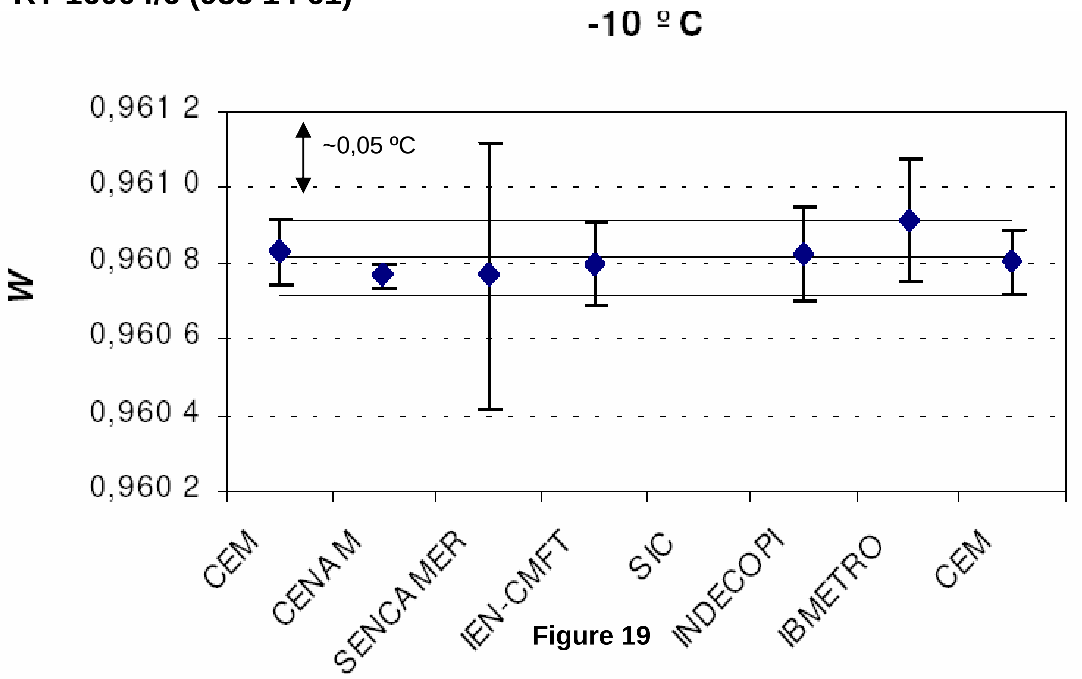

Figure 19

“Large” PRT 16004/1 (935 14 16)

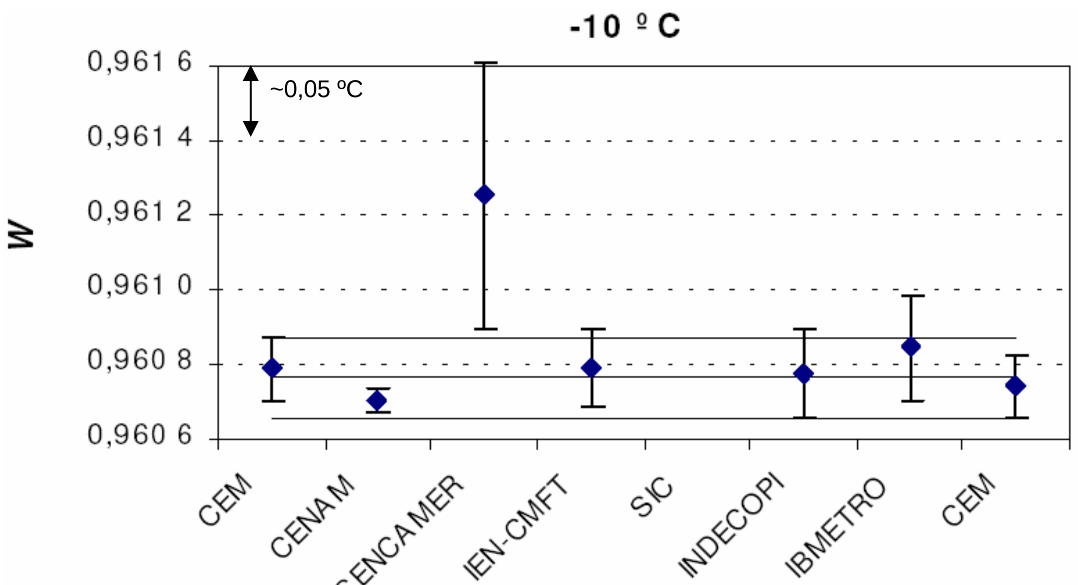

Figure 20

“Short” PRT 16004/6 (935 14 61)
Ref. *t* 50º C
PRT Sensitivity 0,385 1 Ω/ºC

Laboratory	*t* ºC	R_t Ω	R_t in *t* ref Ω	*W* in *t* ref Ω/Ω	Dif in *W* ºC	$E_{l,t}$	*U* ºC
CEM	50,432	119,558 3	119,392 0	1,193 939	0,002	0,05	0,022
CENAM	50,006	119,388 5	119,386 2	1,193 914	-0,005	0,19	0,008
SENCAMER	49,963	119,378 0	119,392 3	1,193 983	0,013	0,39	0,024
IEN-CMFT	49,998	119,445 3	119,446 1	1,193 969	0,009	0,26	0,028
SIC	50,038	119,410 2	119,395 7	1,193 959	0,007	0,27	0,011
INDECOPI	50,004	119,403 7	119,402 0	1,194 005	0,019	0,50	0,030
IBMETRO	50,025	119,402 0	119,392 4	1,193 936	0,001	0,02	0,046
CEM	50,182	119,459 9	119,389 8	1,193 926	- 0,002	0,05	0,022
R (0,01ºC)	CENAM =	99,995 6					

Table 20

“Large” PRT 16004/1 (935 14 16)
Ref. *t* 50º C
PRT Sensitivity 0,385 7 Ω/ºC

Laboratory	*t* ºC	R_t Ω	R_t in *t* ref Ω	*W* in *t* ref Ω/Ω	Dif in *W* ºC	$E_{l,t}$	*U* ºC
CEM	50,441	119,603 3	119,433 2	1,194 236	0,003	0,09	0,022
CENAM	50,004	119,426 7	119,425 2	1,194 203	-0,006	0,23	0,008
SENCAMER	49,963	119,400 0	119,414 3	1,194 095	-0,034	0,99	0,024
IEN-CMFT	49,999	119,482 8	119,483 2	1,194 239	0,004	0,10	0,028
SIC	50,039	119,448 0	119,433 0	1,194 211	-0,004	0,14	0,011
INDECOPI	50,004	119,439 8	119,438 1	1,194 281	0,014	0,37	0,030
IBMETRO	50,025	119,438 0	119,428 4	1,194 183	-0,011	0,23	0,041
CEM	50,179	119,501 1	119,432 2	1,194 215	-0,003	0,09	0,022
R (0,01ºC)	CENAM =	100,004 1					

Table 21

“Short” PRT 16004/6 (935 14 61)

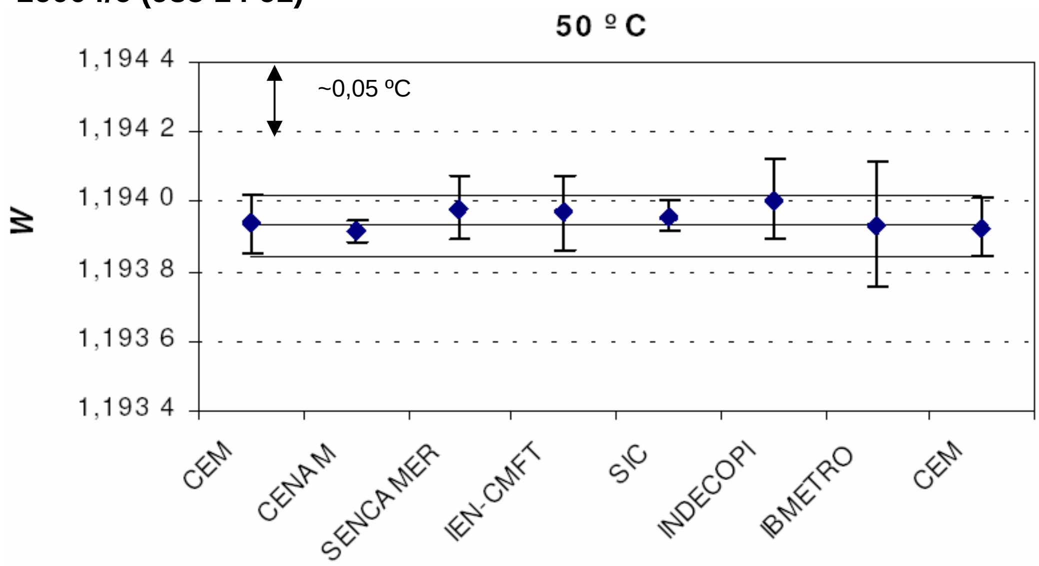

Figure 21

“Large” PRT 16004/1 (935 14 16)

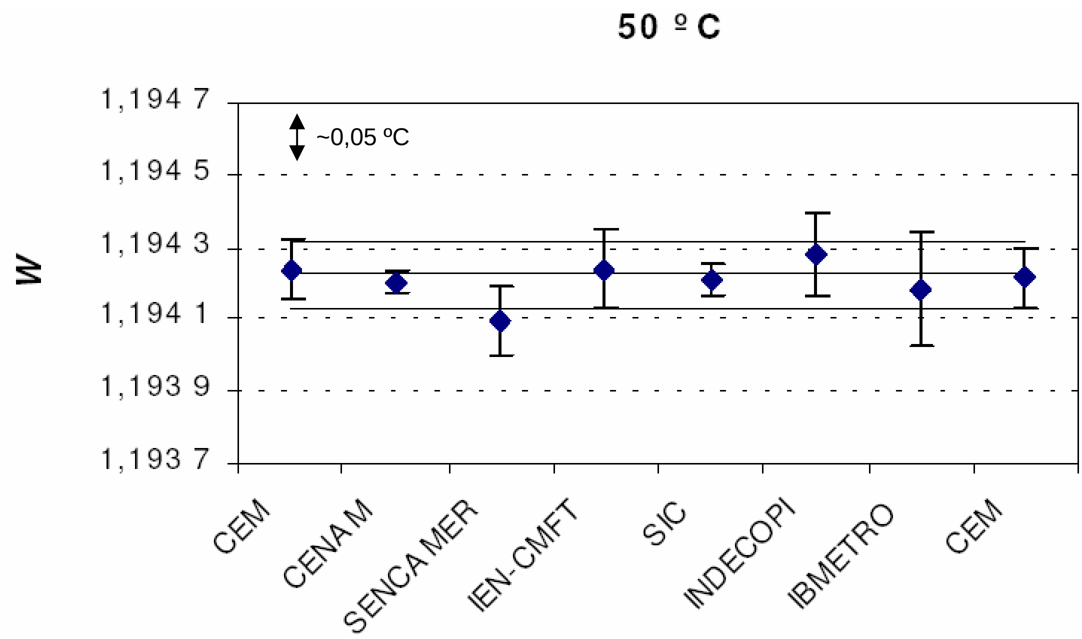

Figure 22

“Short” PRT 16004/6 (935 14 61)

Ref. *t* 100º C

PRT Sensitivity 0,379 5 Ω/ºC

Laboratory	*t* ºC	R_t Ω	R_t in *t* ref Ω	*W* in *t* ref Ω/Ω	Dif in *W* ºC	$E_{l,t}$	*U* ºC
CEM	99,314	138,228 7	138,489 0	1,384 911	-0,002	0,06	0,022
CENAM	99,976	138,475 1	138,484 2	1,384 903	-0,004	0,17	0,009
SENCAMER	99,928	138,456 0	138,483 3	1,384 902	-0,004	0,13	0,024
IEN-CMFT	99,988	138,542 7	138,547 3	1,384 902	-0,005	0,12	0,028
SIC	100,003	138,488 4	138,487 1	1,384 874	-0,012	0,39	0,020
INDECOPI	100,004	138,502 5	138,501 2	1,384 995	0,020	0,48	0,034
IBMETRO	99,740	138,392 0	138,490 7	1,384 921	0,000	0,01	0,046
CEM	99,691	138,372 0	138,489 3	1,384 926	0,002	0,06	0,022

R (0,01ºC) CENAM = 99,995 6

Table 22

“Large” PRT 16004/1 (935 14 16)

Ref. *t* 100º C

PRT Sensitivity 0,380 2 Ω/ºC

Laboratory	*t* ºC	R_t Ω	R_t in *t* ref Ω	*W* in *t* ref Ω/Ω	Dif in *W* ºC	$E_{l,t}$	*U* ºC
CEM	99,283	138,293 6	138,566 0	1,385 549	0,000	0,00	0,022
CENAM	99,971	138,545 9	138,556 9	1,385 514	-0,009	0,37	0,009
SENCAMER	99,928	138,503 0	138,530 4	1,385 248	-0,079	2,36	0,024
IEN-CMFT	99,985	138,618 2	138,623 9	1,385 551	0,001	0,02	0,028
SIC	100,003	138,567 5	138,566 2	1,385 525	-0,006	0,21	0,018
INDECOPI	100,004	138,573 2	138,571 9	1,385 602	0,014	0,34	0,034
IBMETRO	99,740	138,466 0	138,564 9	1,385 532	-0,004	0,14	0,022
CEM	99,683	138,446 6	138,567 3	1,385 548	0,000	0,00	0,022

R (0,01ºC) CENAM = 100,004 0

Table 23

“Short” PRT 16004/6 (935 14 61)

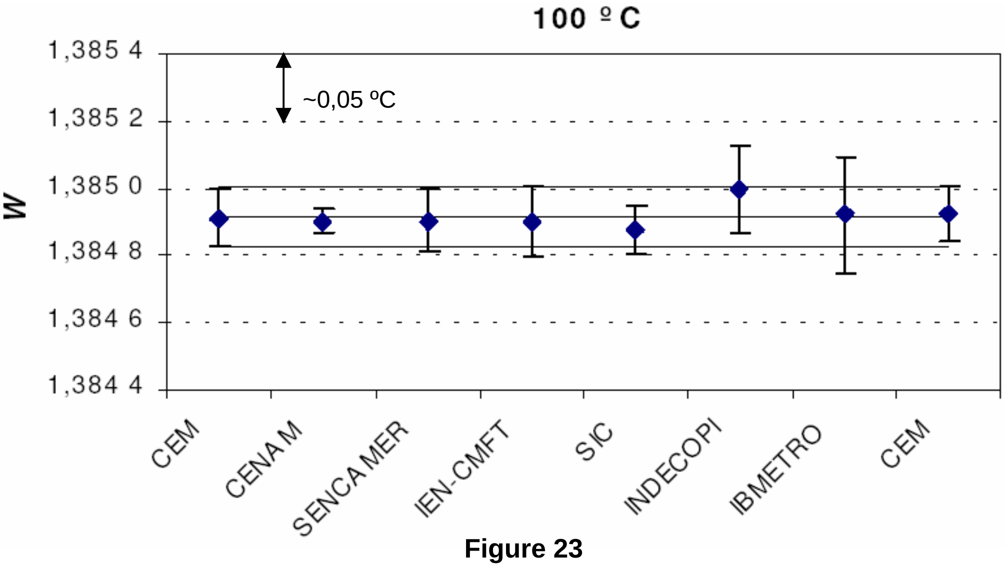

Figure 23

“Large” PRT 16004/1 (935 14 16)

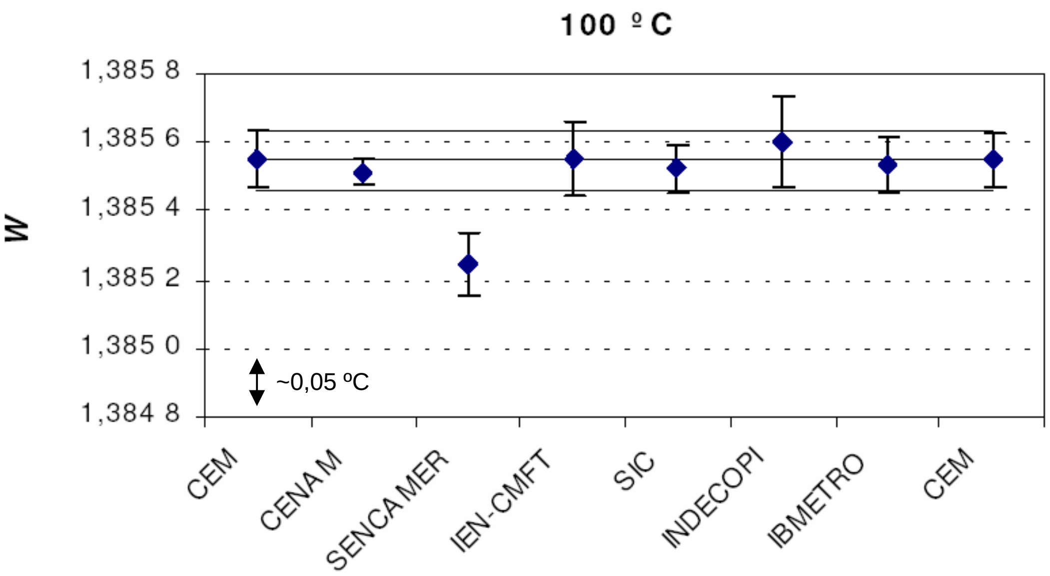

Figure 24

“Short” PRT 16004/6 (935 14 61)

Ref. *t* 150º C

PRT Sensitivity 0,373 3 Ω/ºC

Laboratory	***t*** **ºC**	**R_t** **Ω**	**R_t in *t* ref** **Ω**	***W* in *t* ref** **Ω/Ω**	**Dif in *W*** **ºC**	**$E_{l,t}$**	***U*** **ºC**
CEM	149,021	156,928 3	157,293 9	1,572 963	-0,002	0,08	0,022
CENAM	149,850	157,231 5	157,287 5	1,572 944	-0,007	0,29	0,009
SENCAMER	150,356	157,428 0	157,295 1	1,573 030	0,016	0,33	0,041
IEN-CMFT	149,986	157,327 4	157,332 6	1,572 678	-0,079	1,87	0,035
SIC	150,220	157,379 0	157,296 7	1,572 970	-0,001	0,01	0,027
INDECOPI	150,003	157,302 4	157,301 4	1,572 995	0,006	0,15	0,034
IBMETRO	149,820	157,228 0	157,295 2	1,572 968	-0,001	0,02	0,051
CEM	150,476	157,472 0	157,294 3	1,572 981	0,002	0,08	0,022
R (0,01ºC)	CENAM =	99,995 6					

Table 24

“Llarge” PRT 16004/1 (935 14 16)

Ref. *t* 150º C

PRT Sensitivity 0,374 0 Ω/ºC

Laboratory	***t*** **ºC**	**R_t** **Ω**	**R_t in *t* ref** **Ω**	***W* in *t* ref** **Ω/Ω**	**Dif in *W*** **ºC**	**$E_{l,t}$**	***U*** **ºC**
CEM	149,144	157,086 6	157,406 9	1,573 942	0,001	0,03	0,022
CENAM	149,865	157,345 3	157,395 8	1,573 898	-0,011	0,43	0,009
SENCAMER	150,356	157,508 0	157,374 8	1,573 685	-0,068	1,44	0,041
IEN-CMFT	149,959	157,460 5	157,475 8	1,573 977	0,010	0,25	0,035
SIC	150,215	157,488 3	157,408 0	1,573 924	-0,004	0,14	0,015
INDECOPI	150,003	157,409 0	157,408 0	1,573 948	0,002	0,05	0,040
IBMETRO	149,820	157,338 0	157,405 3	1,573 921	-0,005	0,09	0,046
CEM	150,475	157,585 5	157,407 7	1,573 935	-0,001	0,03	0,022
R (0,01ºC)	CENAM =	100,003 8					

Table 25

“Short” PRT 16004/6 (935 14 61)

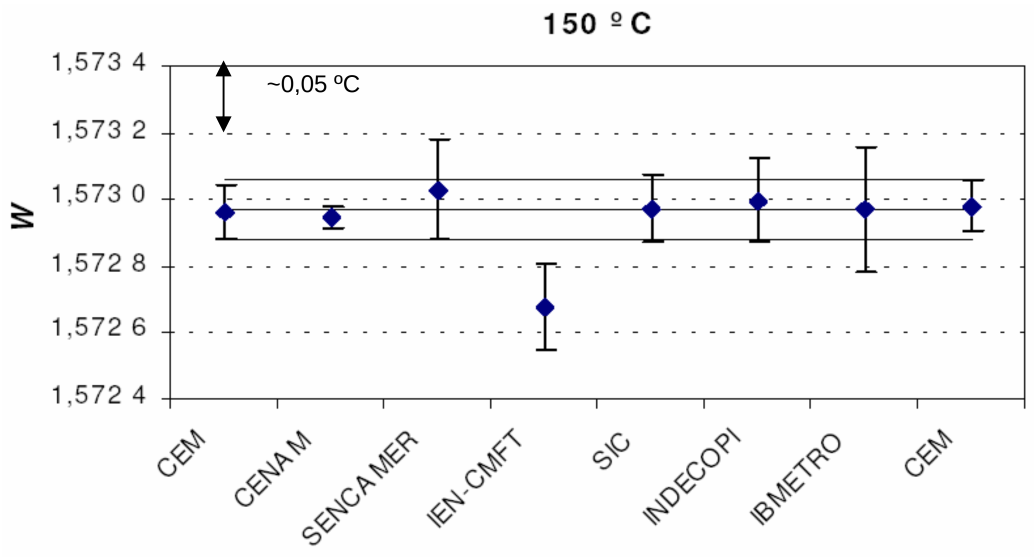

Figure 25

“Large” PRT 16004/1 (935 14 16)

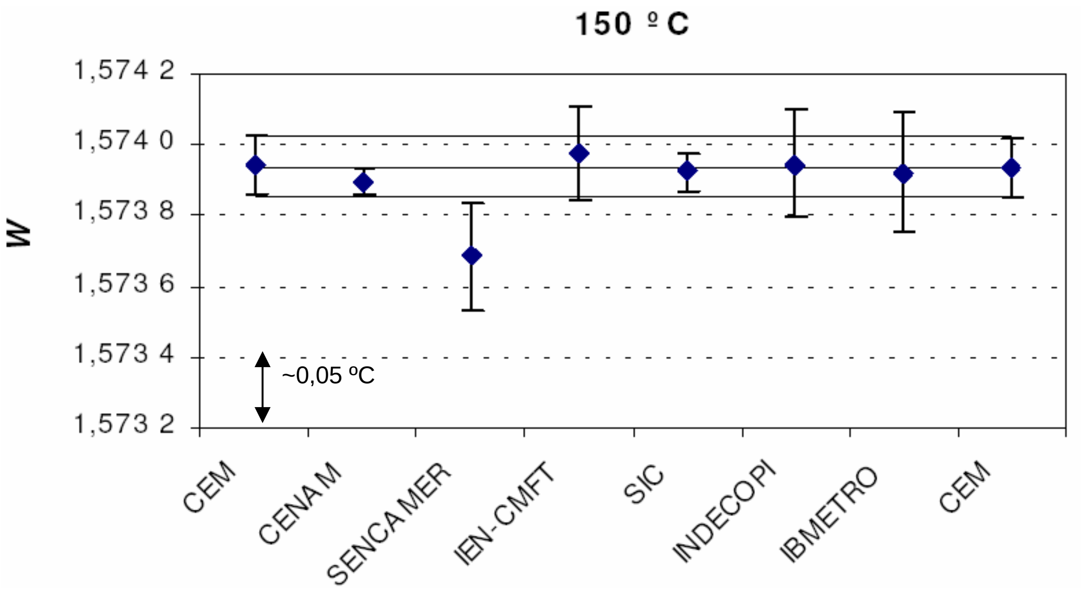

Figure 26

“Short” PRT 16004/6 (935 14 61)

Ref. *t* 200º C

PRT Sensitivity 0,367 6 Ω/ºC

Laboratory	*t* ºC	R_t Ω	R_t in *t* ref Ω	*W* in *t* ref Ω/Ω	Dif in *W* ºC	$E_{l,t}$	*U* ºC
CEM	199,597	175,663 2	175,811 4	1,758 141	0,002	0,05	0,022
CENAM	199,978	175,791 1	175,799 2	1,758 067	-0,018	0,74	0,009
SENCAMER	199,813	175,760 0	175,828 7	1,758 375	0,065	1,39	0,041
IEN-CMFT	199,969	175,858 5	175,869 9	1,757 974	-0,044	0,81	0,049
SIC	199,867	175,755 1	175,803 9	1,758 042	-0,025	0,58	0,037
INDECOPI	199,966	175,800 2	175,812 7	1,758 105	-0,008	0,21	0,032
IBMETRO	199,985	175,800 0	175,805 5	1,758 073	-0,017	0,31	0,051
CEM	199,688	175,694 1	175,808 8	1,758 130	-0,002	0,05	0,022
R (0,01ºC)	CENAM =	99,995 7					

Table 26

“Llarge” PRT 16004/1 (935 14 16)

Ref. *t* 200º C

PRT Sensitivity 0,368 4 Ω/ºC

Laboratory	*t* ºC	R_t Ω	R_t in *t* ref Ω	*W* in *t* ref Ω/Ω	Dif in *W* ºC	$E_{l,t}$	*U* ºC
CEM	199,474	175,765 4	175,959 1	1,759 525	0,011	0,28	0,022
CENAM	199,962	175,933 5	175,947 5	1,759 410	-0,020	0,55	0,009
SENCAMER	199,813	175,861 0	175,929 9	1,759 229	-0,069	1,29	0,041
IEN-CMFT	199,975	176,043 0	176,052 2	1,759 649	-0,045	0,75	0,049
SIC	199,928	175,929 2	175,955 7	1,759 382	-0,028	0,57	0,033
INDECOPI	199,966	175,947 0	175,959 5	1,759 447	-0,010	0,21	0,032
IBMETRO	199,985	175,946 0	175,951 5	1,759 367	-0,031	0,55	0,046
CEM	199,690	175,845 6	175,960 0	1,759 442	-0,011	0,28	0,022
R (0,01ºC)	CENAM =	100,003 7					

Table 27

“Short” PRT 16004/6 (935 14 61)

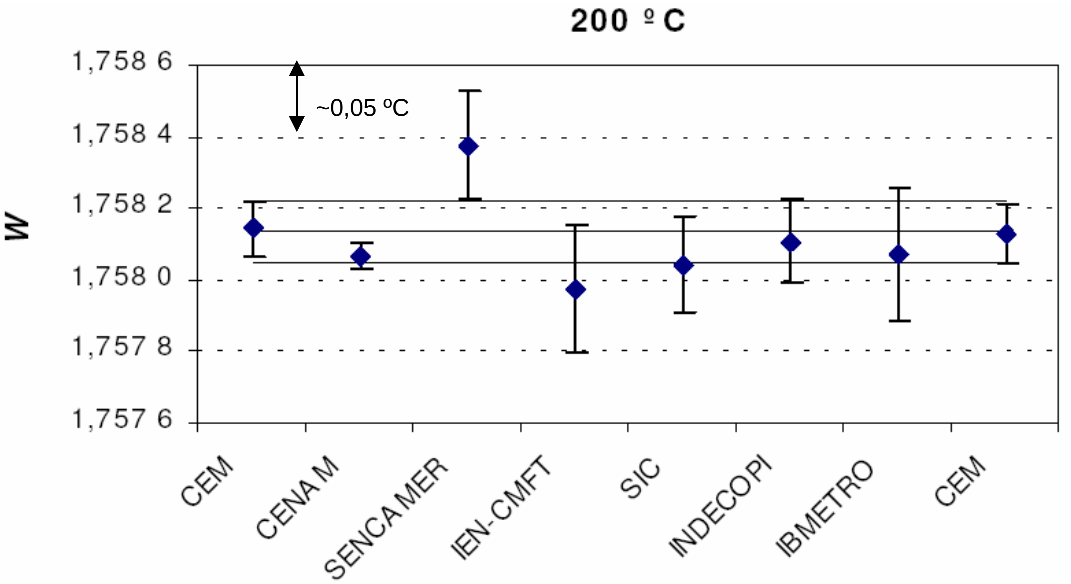

Figure 27

“Large” PRT 16004/1 (935 14 16)

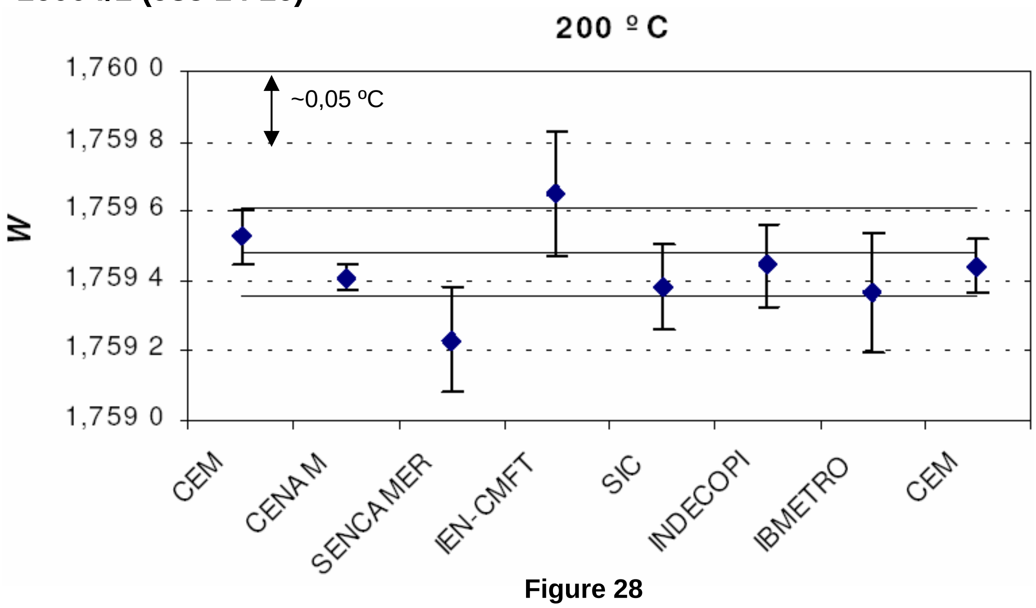

Figure 28

“Short” PRT 16004/6 (935 14 61)

Ref. *t* 250º C

PRT Sensitivity 0,362 0 Ω/ºC

Laboratory	***t*** **ºC**	**R_t** **Ω**	**R_t in *t* ref** **Ω**	***W* in *t* ref** **Ω/Ω**	**Dif in *W*** **ºC**	**$E_{l,t}$**	***U*** **ºC**
CEM	250,460	194,201 3	194,034 8	1,940 378	-0,005	0,16	0,022
CENAM	250,039	194,037 0	194,022 9	1,940 320	-0,021	0,77	0,009
SENCAMER	249,625	193,910 0	194,045 7	1,940 554	0,043	0,90	0,041
IEN-CMFT							
SIC	249,399	193,813 6	194,031 1	1,940 315	-0,023	0,61	0,026
INDECOPI	250,010	194,041 0	194,037 6	1,940 352	-0,013	0,21	0,054
IBMETRO(*)							
CEM	249,804	193,966 1	194,037 0	1,940 417	0,005	0,16	0,022
R (0,01ºC)	CENAM =	99,995 3					

Table 28

“Large” PRT 16004/1 (935 14 16)

Ref. *t* 250º C

PRT Sensitivity 0,362 8 Ω/ºC

Laboratory	***t*** **ºC**	**R_t** **Ω**	**R_t in *t* ref** **Ω**	***W* in *t* ref** **Ω/Ω**	**Dif in *W*** **ºC**	**$E_{l,t}$**	***U*** **ºC**
CEM	250,452	194,386 0	194,222 2	1,942 066	0,002	0,05	0,022
CENAM	250,056	194,230 2	194,209 9	1,942 029	-0,008	0,34	0,009
SENCAMER	249,625	194,077 0	194,213 0	1,942 053	-0,002	0,04	0,041
IEN-CMFT							
SIC	249,409	194,006 2	194,220 5	1,942 012	-0,013	0,39	0,024
INDECOPI	250,010	194,226 5	194,223 1	1,942 067	0,002	0,04	0,053
		1					
IBMETRO(*)							
CEM	249,791	194,147 0	194,222 9	1,942 054	-0,002	0,05	0,022
R (0,01ºC)	CENAM =	100,003 6					

Table 29

(*) The laboratory did not measure in this calibration point

“Short” PRT 16004/6 (935 14 61)

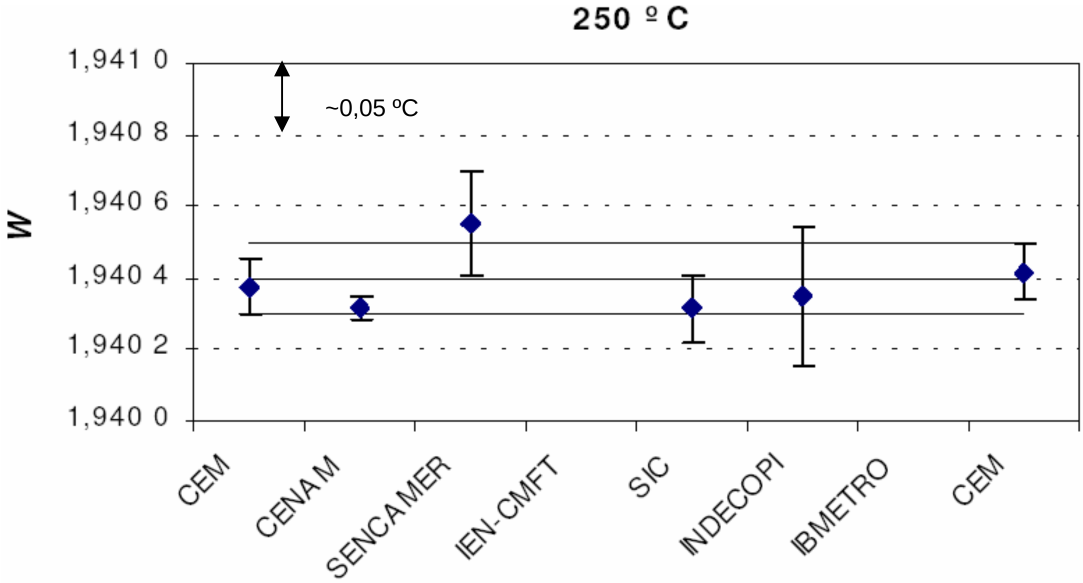

Figure 29

“Large” PRT 16004/1 (935 14 16)

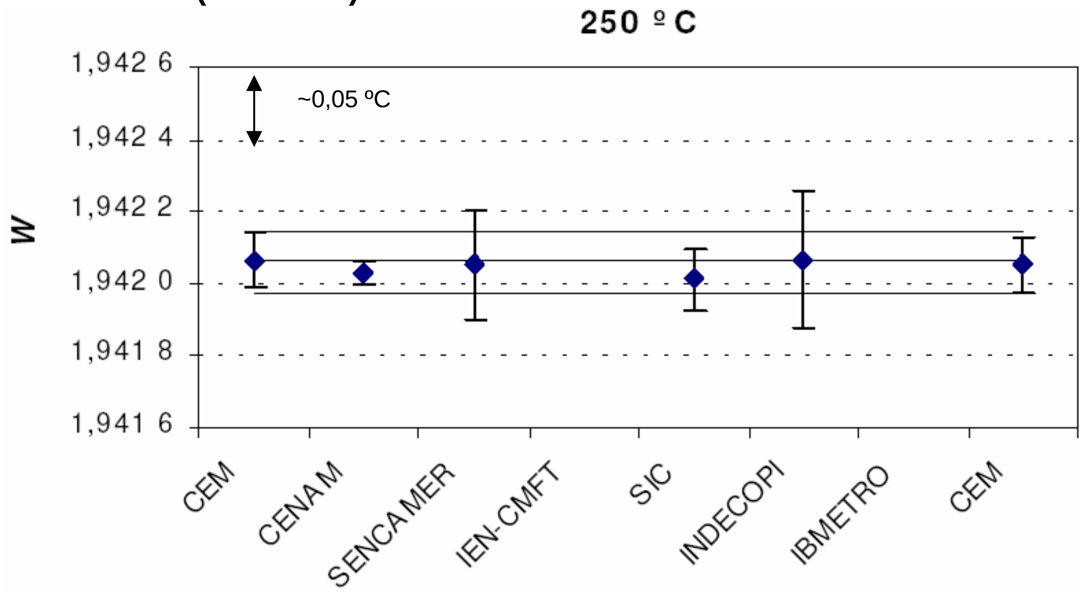

Figure 30

7.3 Review of data by SENCAMER

After the release of the draft report with the results of the comparison, SENCAMER revised their data and found an error in calibration of the two standard electrical resistances used at the following calibration points: –20 ºC, 150 ºC, 200 ºC, and 250 ºC; causing an error in the temperature values determined by the laboratory. Both standards resistors were adequately calibrated after the release of the draft report and new data where sent to the coordinator who checked that only the resistors values have been changed. All participants agreed with the inclusion of the new data in this additional section.

Below are two tables with the data correction and the graphics for these points.

"Short" PRT 16004/6 (935 14 61)

t ºC	R_t Ω	R_t in t ref Ω	W in t ref Ω/Ω	Dif in W ºC	$E_{\mathrm{l},t}$	U ºC
-20,189	92,064 9	92,139 3	0,921 439	-0,021	0,23	0,090
150,391	157,428 0	157,282 0	1,572 898	-0,020	0,42	0,041
199,853	175,760 0	175,814 0	1,758 228	0,025	0,53	0,041
249,669	193,910 0	194,029 8	1,940 395	-0,001	0,01	0,041

Table 30

"large" PRT 16004/1 (935 14 16)

t ºC	R_t Ω	R_t in t ref Ω	W in t ref Ω/Ω	Dif in W ºC	$E_{\mathrm{l},t}$	U ºC
-10,038	96,114 0	96,129 1	0,961 253	0,124	1,31	0,090
150,391	157,508 0	157,361 7	1,573 554	-0,103	2,19	0,041
199,853	175,861 0	175,915 1	1,759 081	-0,109	2,04	0,041
249,669	194,077 0	194,197 1	1,941 893	-0,046	0,98	0,041

Table 31

“Short” PRT 16004/6 (935 14 61)

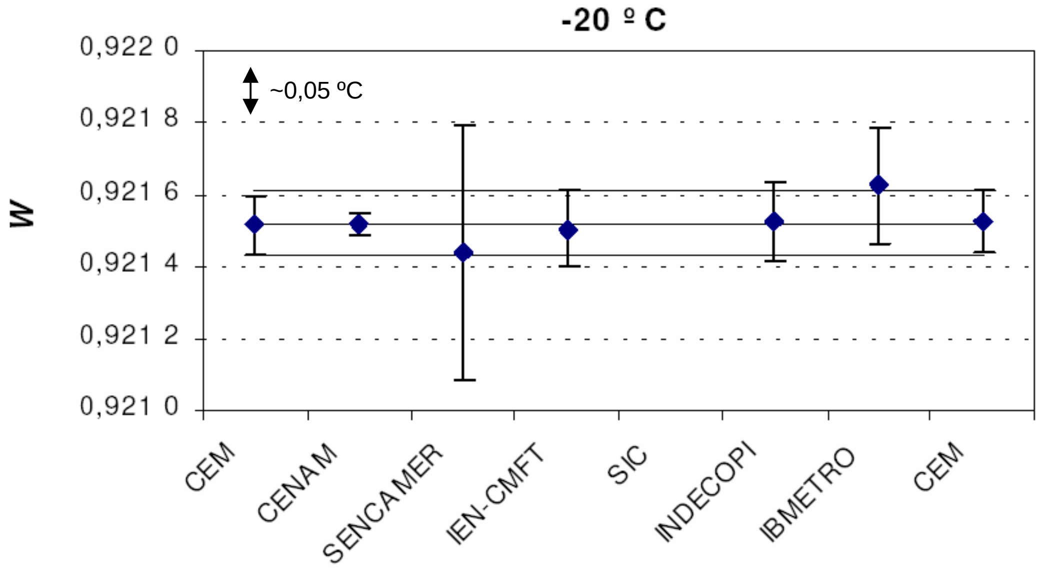

Figure 31

“Large” PRT 16004/1 (935 14 16)

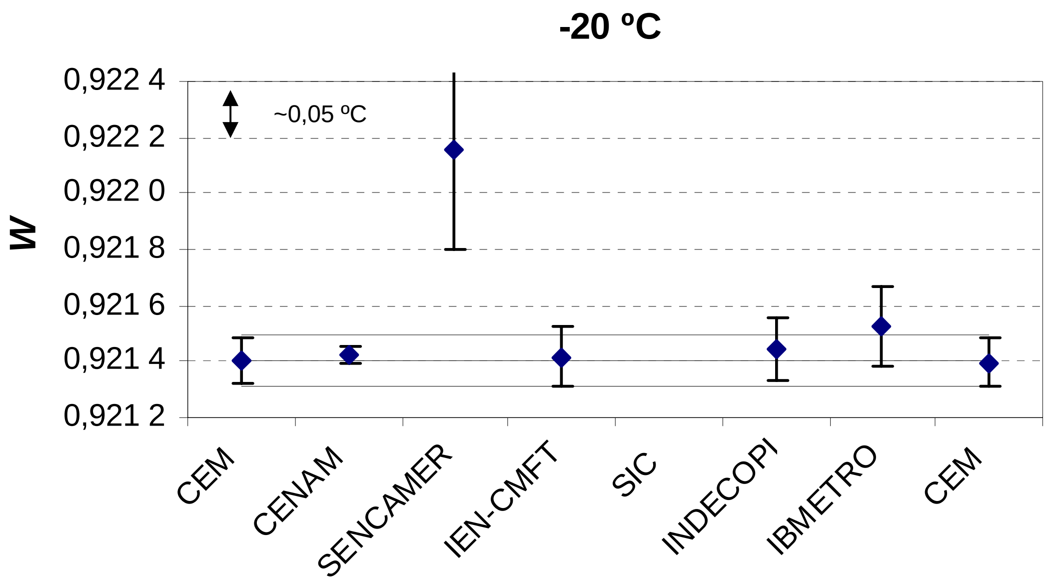

Figure 32

“Short” PRT 16004/6 (935 14 61)

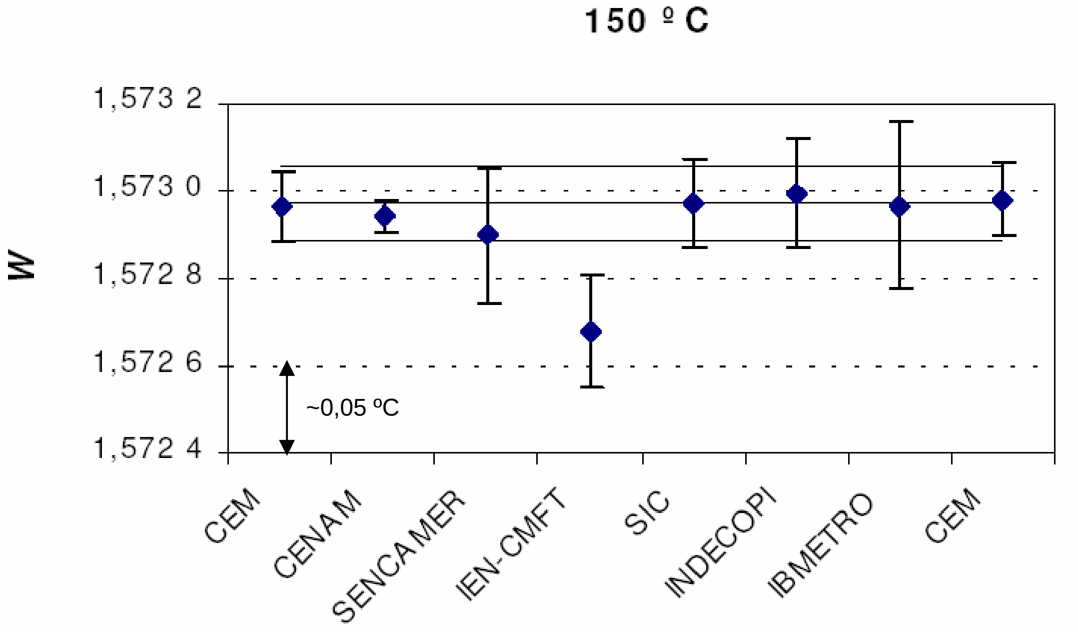

Figure 33

“Large” PRT 16004/1 (935 14 16)

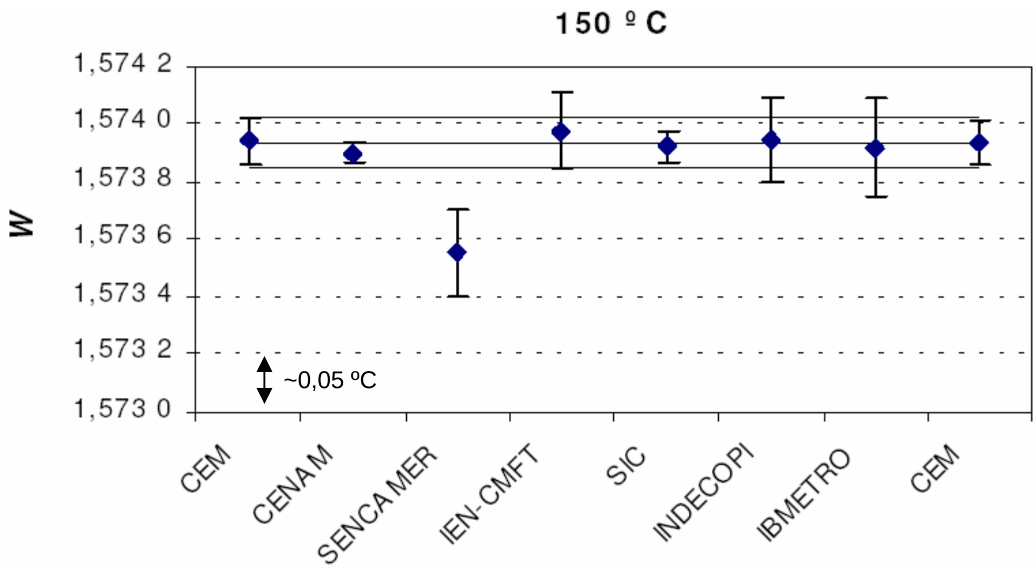

Figure 34

“Short” PRT 16004/6 (935 14 61)

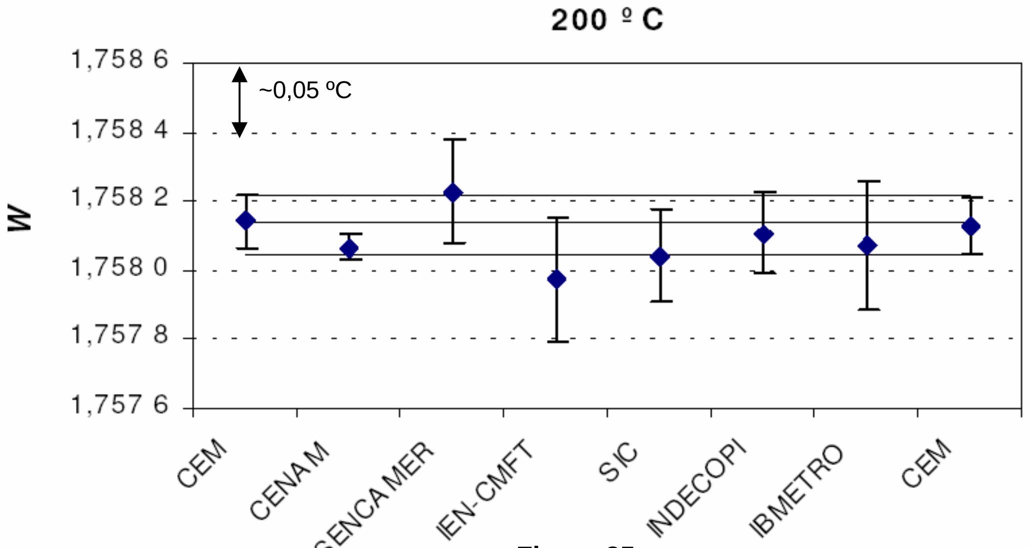

Figure 35

“Large” PRT 16004/1 (935 14 16)

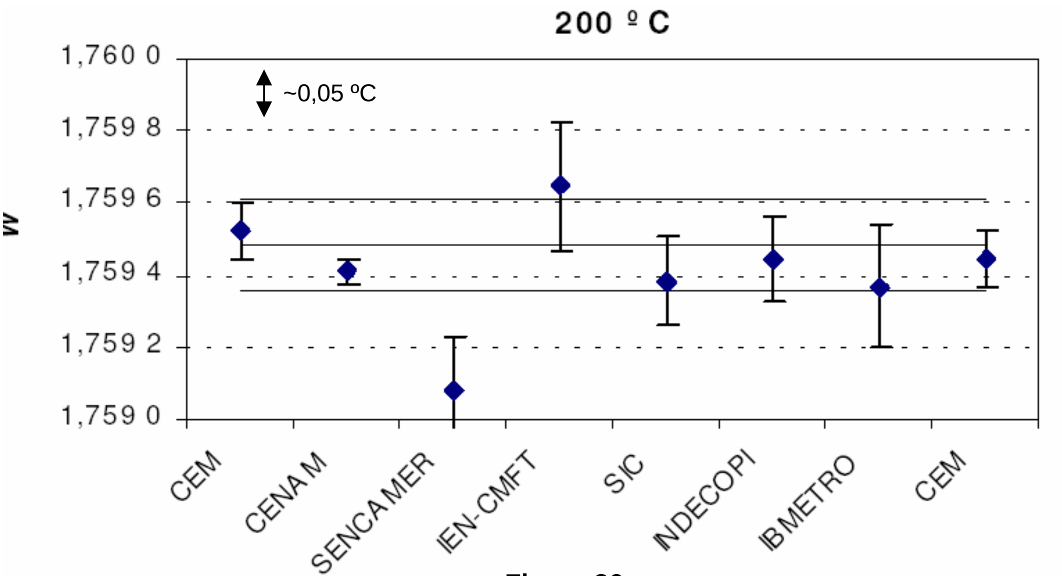

Figure 36

“Short” PRT 16004/6 (935 14 61)

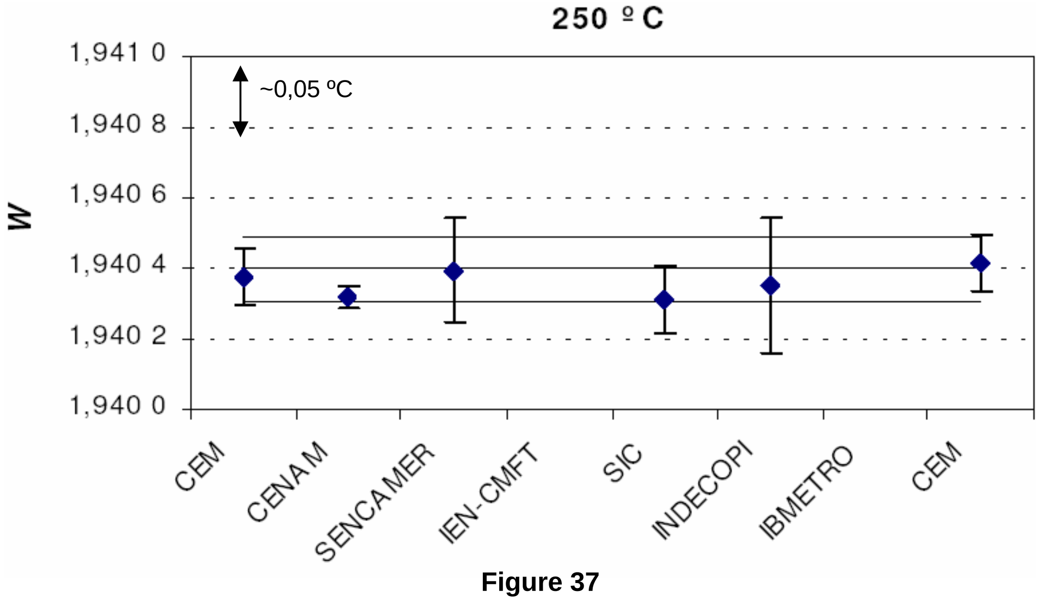

Figure 37

“large” PRT 16004/1 (935 14 16)

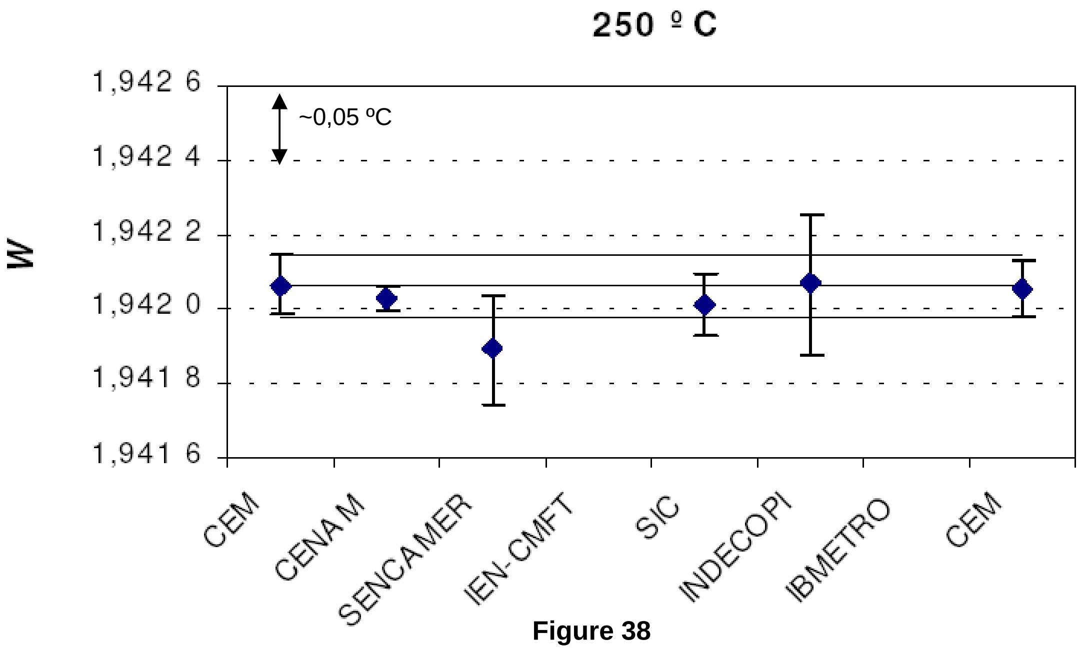

Figure 38

8. CONCLUSIONS

Tthermometers have shown an acceptable behavior throughout the comparison as figures 5 and 6 show, and then the results can be considered valid for comparing the measurement capabilities of participant laboratories.

The comparison results are considered interesting and useful for all participant laboratories, having obtained a general coherency in the measurements except for some specific problems which are discussed below.

It has revealed the existence of hysteresis in the thermometers, a common phenomenon in industrial PRTs with encapsulated sensor, indicating the need for doing thermal cycles to asses this uncertainty source.

The heat conduction through the PRT stem is known as one of the most common sources of uncertainty the calibration and could be the reason of some deviations in the comparison as can be seen for SENCAMER data for the "large" PRT (model 935 14 16) in the calibration points – 20 ºC, -10 ºC, 100 ºC, and 150 ºC (see figures 18, 20, 24, and 26). Note that the immersion depths reported in the results presentation formats were at the most extreme case of 14 cm (SENCAMER). After data correction by SENCAMER (section 7.3, of this report) it seems to confirm the suspicion of a systematic error by thermal conduction of the ¨large¨ thermometer.

With respect the IEN-CMFT measurements at the triple point of water:

- The first measurement of *R* (0,01ºC) for determining the PRTs stability is coherent with those made by CEM and the rest of participants (figures 5 and 6).
- The *R* (0,01ºC) measurements during the calibration differ significantly from the above and those of other (figures 7 to 11).
- When using the latter values for W_t calculations at different reference temperatures, the values are again coherent (but not of the resistance ones).

This leads us to wonder if the reference electrical resistance or the measurement system were changed between the initial measurements and the calibration measurements. This doubt was cleared by the laboratory by stating that for the initial 0 ºC control measurements it used the multimeter HP 3458 A, while in the calibration itself it used the Hart Chub E4 1529 thermometer (see table 5 which summarizes the instrumentation used).

Previous works and the current one for this comparison show that the expanded uncertainty of 0,02ºC appears to be the limit that can support the best industrial PRTs in the range from –40ºC to 250ºC and not all can be calibrated with this uncertainty. It should be noted that for stability reasons, the PRTs used as traveler instruments, despite they are of 100 Ω and α = 0,0038 5 ºC^{-1}, were chosen among the most stable and are marketed a semi-standards.

Analyzed the results and causes of errors found it would be interesting that the CAN laboratories would repeat between them this comparison in order to verify that these ones have been resolved satisfactorily.

ANNEX 1

PARTICIPANT LABORATORIES UNCERTAINTY BUDGETS

Quantity, *Xi*	Estimation of the quantity, *Xi*	Units	Probability distributions	Standard uncertainty, u(*Xi*)	Sensitivity coefficient, *ci*	Contribution to the combined standard uncertainty, *ci·u* (xi)					
From laboratory measurement system						**-80 °C a 0 °C**		**0 °C a 90 °C**		**90 °C a 250 °C**	
SPRTs reading	-	Ω/Ω	rectangular	1,00E-06 /√3	*Rs/ √2st*	0,000 1	ºC	0,000 1	ºC	0,000 1	ºC
Bridge calibration	0	Ω/Ω	normal	2,31E-06	*Rs/ √2st*	0,000 4	ºC	0,000 4	ºC	0,000 4	ºC
Standard resistor calibration	100	Ω	normal	2,80E-04 /2	*Lp/ √2st*	0,000 5	ºC	0,000 5	ºC	0,000 5	ºC
Standard resistor drift	0	Ω	rectangular	1,00E-04 /√3	*Lp/ √2st*	0,000 2	ºC	0,000 2	ºC	0,000 2	ºC
SPRTs calibration	0	ºC	normal	0,002 /2	1	0,001 0	ºC	0,001 0	ºC	0,001 0	ºC
SPRTs drift	0	ºC	rectangular	0,002 0 /√3	1	0,001 2	ºC	0,001 2	ºC	0,001 2	ºC
Bath estability (-80, 0) ºC	0	ºC	rectangular	0,0024	1	0,002 4	ºC		ºC		ºC
Bath estability (0,100) ºC		ºC	rectangular	0,0017	1			0,001 7			
Bath estability (100,250) ºC		ºC	rectangular	0,0031	1					0,003 1	
Bath uniformity(-80, 0) ºC	0	ºC	rectangular	0,0043	1	0,004 3	ºC		ºC		ºC
Bath uniformity (0,100) ºC		ºC	rectangular	0,0025	1			0,002 5			
Bath uniformity (100,250) ºC		ºC	rectangular	0,0059	1					0,005 9	
t_{ref}		°C			*sx*	0,002 0	Ω	0,001 3	Ω	0,002 7	Ω
From reading of the thermometer under calibration											
SPRTs reading		Ω/Ω	rectangular	1,00E-06 /√3	*Rs*	0,000 1	Ω	0,000 1	Ω	0,000 1	Ω
Bridge calibration	0	Ω/Ω	normal	2,31E-06	*Rs*	0,000 2	Ω	0,000 2	Ω	0,000 2	Ω
Standard resistor calibration	100	Ω	normal	2,80E-04 /2	*Lx*	0,000 3	Ω	0,000 3	Ω	0,000 3	Ω
Standard resistor drift	0	Ω	rectangular	1,00E-04 /√3	*Lx*	0,000 1	Ω	0,000 1	Ω	0,000 1	Ω
From characteristics of the thermometer under calibration											
Stability and hysteresis	0	Ω	rectangular	0,002 /1	1	0,002 0	Ω	0,002 0	Ω	0,002 0	Ω
					u(Rx)=	0,002 9	Ω	0,002 4	Ω	0,003 4	Ω
					U(Rx)(k = 2)=	0,006	Ω	0,005	Ω	0,007	Ω
					U(tx)(k = 2)=	0,015	ºC	0,012	ºC	0,017	ºC
					Uasiggned=	0,02	ºC	0,02	ºC	0,02	ºC

CENAM

t = 250 °C **Uncertainty = 4,3 mK (k=2)**

X_i	Value	Unit	Probability Distribution	Uncertainty	Sensitivity coefficient	Unit	Contribution
Measurement system							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Calibration	2,0	mK	normal	2,0	1	mK	2,0
Drift	0	mK	normal	0	1	mK	0
Bath stability	0,5	mK	rectangular	0,3	1	mK	0,3
Bath uniformity	0,5	mK	rectangular	0,3	1	mK	0,3
Combined			2,1	mK	Expanded	4,2	mK
Thermometer under calibration							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Stability	0,2	mK	rectangular	0,1	1	mK	0,1
Combined			0,5	mK	Expanded	1,0	mK

t = 200 °C **Uncertainty = 4,9 mK (k=2)**

X_i	Value	Unit	Probability Distribution	Uncertainty	Sensitivity coefficient	Unit	Contribution
Measurement system							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Calibration	2,0	mK	normal	2,0	1	mK	2,0
Drift	0	mK	normal	0	1	mK	0
Bath stability	0,5	mK	rectangular	0,3	1	mK	0,3
Bath uniformity	2,0	mK	rectangular	1,2	1	mK	1,2
Combined			2,4	mK	Expanded	4,8	mK
Thermometer under calibration							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Stability	0,2	mK	rectangular	0,1	1	mK	0,1
Combined			0,5	mK	Expanded	1,0	mK

***t* = 150 °C Uncertainty = 4,5 mK (*k*=2)**

X_i	Value	Unit	Probability Distribution	Uncertainty	Sensitivity coefficient	Unit	Contribution
Measurement system							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Calibration	2,0	mK	normal	2,0	1	mK	2,0
Drift	0	mK	normal	0	1	mK	0
Bath stability	0,5	mK	rectangular	0,3	1	mK	0,3
Bath uniformity	1,0	mK	rectangular	0,6	1	mK	0,6
Combined			2,2	mK	Expanded	4,3	mK
Thermometer under calibration							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Stability	0,2	mK	rectangular	0,1	1	mK	0,1
Combined			0,5	mK	Expanded	1,0	mK

***t* = 100 °C Uncertainty = 4,4 mK (*k*=2)**

X_i	Value	Unit	Probability Distribution	Uncertainty	Sensitivity coefficient	Unit	Contribution
Measurement system							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Calibration	2,0	mK	normal	2,0	1	mK	2,0
Drift	0	mK	normal	0	1	mK	0
Bath stability	0,5	mK	rectangular	0,3	1	mK	0,3
Bath uniformity	1,0	mK	rectangular	0,6	1	mK	0,6
Combined			2,2	mK	Expanded	4,3	mK
Thermometer under calibration							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Stability	0,2	mK	rectangular	0,1	1	mK	0,1
Combined			0,5	mK	Expanded	1,0	mK

***t* = 50 °C** **Uncertainty = 2,8 mK (*k*=2)**

X_i	Value	Unit	Probability Distribution	Uncertainty	Sensitivity coefficient	Unit	Contribution
Measurement system							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Calibration	1,0	mK	normal	1,0	1	mK	1,0
Drift	0	mK	normal	0	1	mK	0
Bath stability	0,5	mK	rectangular	0,3	1	mK	0,3
Bath uniformity	1,0	mK	rectangular	0,6	1	mK	0,6
Combined			1,3	mK	Expanded	2,6	mK
Thermometer under calibration							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Stability	0,2	mK	rectangular	0,1	1	mK	0,1
Combined			0,5	mK	Expandida	1,0	mK

***t* = -10 °C** **Uncertainty = 3,2 mK (*k*=2)**

X_i	Value	Unit	Probability Distribution	Uncertainty	Sensitivity coefficient	Unit	Contribution
Thermometer under calibration							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Calibration	0,5	mK	normal	0,5	1	mK	0,5
Drift	0	mK	normal	0	1	mK	0
Bath stability	0,5	mK	rectangular	0,3	1	mK	0,3
Bath uniformity	1,0	mK	rectangular	0,6	1	mK	0,6
Combined			1,0	mK	Expanded	1,9	mK
Termómetro bajo calibración							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Stability	2,0	mK	rectangular	1,2	1	mK	1,2
Combined			1,3	mK	Expanded	2,5	mK

***t* = -20 °C   Uncertainty = 3,2 mK (*k*=2)**

X_i	Value	Unit	Probability Distribution	Uncertainty	Sensitivity coefficient	Unit	Contribution
Measurement system							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Calibration	0,5	mK	normal	0,5	1	mK	0,5
Drift	0	mK	normal	0	1	mK	0
Bath stability	0,5	mK	rectangular	0,3	1	mK	0,3
Bath uniformity	1,0	mK	rectangular	0,6	1	mK	0,6
Combined			1,0	mK	Expanded	1,9	mK
Thermometer under calibration							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Stability	2,0	mK	rectangular	1,2	1	mK	1,2
Combined Combined			1,3	mK	Expanded	2,5	mK

***t* = -30 °C   Uncertainty = 3,4 mK (*k*=2)**

X_i	Value	Unit	Probability Distribution	Uncertainty	Sensitivity coefficient	Unit	Contribution
Measurement system							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Calibration	0,8	mK	normal	0,8	1	mK	0,8
Drift	0	mK	normal	0	1	mK	0
Bath stability	0,5	mK	rectangular	0,3	1	mK	0,3
Bath uniformity	1,0	mK	rectangular	0,6	1	mK	0,6
Combinada patrón			1,1	mK	Expanded	2,2	mK
Thermometer under calibration							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Stability	2,0	mK	rectangular	1,2	1	mK	1,2
Combined			1,3	mK	Expanded	2,5	mK

***t* = -40 °C   Uncertainty = 6,0 mK (*k* =2)**

X_i	Value	Unit	Probability Distribution	Uncertainty	Sensitivity coefficient	Unit	Contribution
Measurement system							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Calibration	2,0	mK	normal	2,0	1	mK	2,0
Drift	0	mK	normal	0	1	mK	0
Bath stability	0,5	mK	rectangular	0,3	1	mK	0,3
Bath uniformity	3,0	mK	rectangular	1,7	1	mK	1,7
Combined			2,7	mK	Expanded	5,4	mK
Thermometer under calibration alibración							
Reading	0,5	mK	normal	0,5	1	mK	0,5
Stability	2,0	mK	rectangular	1,2	1	mK	1,2
Combined			1,3	mK	Expanded	2,5	mK

IBMETRO

CALCULO DE INCERTIDUMBRES

Nombre del Laboratorio **Instituto Boliviano de Metrología**
Termómetro: 16004/1
Punto/s de calibración: -10 ºC, -20 ºC y -30 ºC

Magnitud Xi		Estimación de la Magnitud Xi	Unidad	Distribución de probabilidad	Incertidumbre típica	Coeficiente de Sensibilidad ci	Unidad	Contribución a la incertidumbre combinada ci·u(xi)	
DEL SISTEMA DE MEDIDA DEL LABORATORIO								K	
Multímetro	**X1**								
Certificado	**X1.1**	0	Ω	Normal	0.00015	10	K/Ω	0.0015	
Deriva	**X1.2**	0	Ω	Rectangular	0.00086	10	K/Ω	0.0086	
Linealidad	**X1.3**	0	Ω	Rectangular	0.00003	10	K/Ω	0.0003	
Error de Interpolación	**X1.4**	0	Ω	Rectangular	0.00006	10	K/Ω	0.0006	
Resolución	**X1.5**	0	Ω	Rectangular	0.00003	10	K/Ω	0.0003	
Inversión de canales	**X1.6**	0	Ω	Rectangular	0.00014	10	K/Ω	0.0014	
Corrientes parásitas por Scanner	**X1.7**	0	Ω	Rectangular	0.00017	10	K/Ω	0.0017	
Patrón		0							
Certificado (ITS-90)	**X2**	0	K	Normal	0.00300	1	1	0.0030	
Deriva	**X3**	0	K	Rectangular	0.00144	1	1	0.0014	
Repetibilidad		0	K	Rectangular	0.00029	1	1	0.0003	
Baño		0							
Uniformidad	**X5**	0	K	Normal	0.00600	1	1	0.0060	
Estabilidad	**X4**	0	K	Normal	0.00400	1	1	0.0040	
DE LA LECTURA DEL TERMÓMETRO EN CALIBRACIÓN								Ω	K
Multímetro									
Certificado	**X2.1**	0	Ω	Normal	0.00058	1	1	0.0006	0.0014
Deriva	**X2.2**	0	Ω	Rectangular	0.00169	1	1	0.0017	0.0042
Linealidad	**X2.3**	0	Ω	Rectangular	0.00003	1	1	0.0000	0.0001
Error de Interpolación	**X2.4**	0	Ω	Rectangular	0.00006	1	1	0.0001	0.0001
Resolución	**X2.5**	0	Ω	Rectangular	0.00003	1	1	0.0000	0.0001
Inversión de canales	**X2.6**	0	Ω	Rectangular	0.00014	1	1	0.0001	0.0003
Corrientes parásitas por Scanner	**X2.7**	0	Ω	Rectangular	0.00017	1	1	0.0002	0.0004
DE LAS CARACTERÍSTICAS PROPIAS DEL TERMÓMETRO EN CALIBRACIÓN									
Histéresis y Repetibilidad	**X7**	0	Ω	Normal	0.001	1	1	0.0010	0.0025

Incertidumbre Combinada 0.017 ºC

Incertidumbre Expandida para k = 2 0.035 ºC

CALCULO DE INCERTIDUMBRES

Nombre del Laboratorio **Instituto Boliviano de Metrología**
Termómetro: 16004/6
Punto/s de calibración: -10 ºC, -20 ºC y -30 ºC

Magnitud Xi		Estimación de la Magnitud Xi	Unidad	Distribución de probabilidad	Incertidumbre típica	Coeficiente de Sensibilidad ci	Unidad	Contribución a la incertidumbre combinada ci·u(xi)	
DEL SISTEMA DE MEDIDA DEL LABORATORIO								K	
Multímetro	**X1**								
Certificado	**X1.1**	0	Ω	Normal	0.00015	10	K/Ω	0.0015	
Deriva	**X1.2**	0	Ω	Rectangular	0.00086	10	K/Ω	0.0086	
Linealidad	**X1.3**	0	Ω	Rectangular	0.00003	10	K/Ω	0.0003	
Error de Interpolación	**X1.4**	0	Ω	Rectangular	0.00006	10	K/Ω	0.0006	
Resolución	**X1.5**	0	Ω	Rectangular	0.00003	10	K/Ω	0.0003	
Inversión de canales	**X1.6**	0	Ω	Rectangular	0.00014	10	K/Ω	0.0014	
Corrientes parásitas por Scanner	**X1.7**	0	Ω	Rectangular	0.00017	10	K/Ω	0.0017	
Patrón		0							
Certificado (ITS-90)	**X2**	0	K	Normal	0.00300	1	1	0.0030	
Deriva	**X3**	0	K	Rectangular	0.00144	1	1	0.0014	
Repetibilidad		0	K	Rectangular	0.00029	1	1	0.0003	
Baño		0							
Uniformidad	**X5**	0	K	Normal	0.00600	1	1	0.0060	
Estabilidad	**X4**	0	K	Normal	0.00400	1	1	0.0040	
DE LA LECTURA DEL TERMÓMETRO EN CALIBRACIÓN								Ω	K
Multímetro									
Certificado	**X2.1**	0	Ω	Normal	0.00058	1	1	0.0006	0.0014
Deriva	**X2.2**	0	Ω	Rectangular	0.00169	1	1	0.0017	0.0042
Linealidad	**X2.3**	0	Ω	Rectangular	0.00003	1	1	0.0000	0.0001
Error de Interpolación	**X2.4**	0	Ω	Rectangular	0.00006	1	1	0.0001	0.0001
Resolución	**X2.5**	0	Ω	Rectangular	0.00003	1	1	0.0000	0.0001
Inversión de canales	**X2.6**	0	Ω	Rectangular	0.00014	1	1	0.0001	0.0003
Corrientes parásitas por Scanner	**X2.7**	0	Ω	Rectangular	0.00017	1	1	0.0002	0.0004
DE LAS CARACTERÍSTICAS PROPIAS DEL TERMÓMETRO EN CALIBRACIÓN									
									0
Histéresis y Repetibilidad	**X7**	0	Ω	Normal	0.002	1	1	0.0020	0.005

Incertidumbre Combinada 0.020 ºC

Incertidumbre Expandida para k = 2 0.040 ºC

CALCULO DE INCERTIDUMBRES

Nombre del Laboratorio **Instituto Boliviano de Metrología**
Termómetro: 16004/1
Punto/s de calibración: 50 ºC y 100 ºC

Magnitud		Estimación de la Magnitud	Unidad	Distribución de probabilidad	Incertidumbre típica	Coeficiente de Sensibilidad	Unidad	Contribución a la incertidumbre combinada	
Xi		Xi				ci		ci·u(xi)	
DEL SISTEMA DE MEDIDA DEL LABORATORIO								K	
Multímetro	**X1**								
Certificado	**X1.1**	0	Ω	Normal	0.00021	10	K/Ω	0.0021	
Deriva	**X1.2**	0	Ω	Rectangular	0.00099	10	K/Ω	0.0099	
Linealidad	**X1.3**	0	Ω	Rectangular	0.00003	10	K/Ω	0.0003	
Error de Interpolación	**X1.4**	0	Ω	Rectangular	0.00006	10	K/Ω	0.0006	
Resolución	**X1.5**	0	Ω	Rectangular	0.00003	10	K/Ω	0.0003	
Inversión de canales	**X1.6**	0	Ω	Rectangular	0.00014	10	K/Ω	0.0014	
Corrientes parásitas por Scanner	**X1.7**	0	Ω	Rectangular	0.00017	10	K/Ω	0.0017	
Patrón		0							
Certificado (ITS-90)	**X2**	0	K	Normal	0.00300	1	1	0.0030	
Deriva	**X3**	0	K	Rectangular	0.00144	1	1	0.0014	
Repetibilidad		0	K	Rectangular	0.00029	1	1	0.0003	
Baño		0							
Uniformidad	**X5**	0	K	Normal	0.00600	1	1	0.0060	
Estabilidad	**X4**	0	K	Normal	0.00400	1	1	0.0040	
DE LA LECTURA DEL TERMÓMETRO EN CALIBRACIÓN								Ω	K
Multímetro									
Certificado	**X2.1**	0	Ω	Normal	0.00083	1	1	0.0008	0.0021
Deriva	**X2.2**	0	Ω	Rectangular	0.00238	1	1	0.0024	0.0060
Linealidad	**X2.3**	0	Ω	Rectangular	0.00029	1	1	0.0003	0.0007
Error de Interpolación	**X2.4**	0	Ω	Rectangular	0.00006	1	1	0.0001	0.0001
Resolución	**X2.5**	0	Ω	Rectangular	0.00003	1	1	0.0000	0.0001
Inversión de canales	**X2.6**	0	Ω	Rectangular	0.00014	1	1	0.0001	0.0003
Corrientes parásitas por Scanner	**X2.7**	0	Ω	Rectangular	0.00017	1	1	0.0002	0.0004
DE LAS CARACTERÍSTICAS PROPIAS DEL TERMÓMETRO EN CALIBRACIÓN									
									0
Histéresis y Repetibilidad	**X7**	0	Ω	Normal	0.001	1	1	0.0010	0.0025

Incertidumbre Combinada 0.020 ºC
Incertidumbre Expandida para k = 2 0.040 ºC

CALCULO DE INCERTIDUMBRES

Nombre del Laboratorio **Instituto Boliviano de Metrología**
Termómetro: 16004/1
Punto/s de calibración: 150 ºC y 200 ºC

Magnitud		Estimación de la Magnitud	Unidad	Distribución de probabilidad	Incertidumbre típica	Coeficiente de Sensibilidad	Unidad	Contribución a la incertidumbre combinada	
Xi		Xi				ci		ci·u(xi)	
DEL SISTEMA DE MEDIDA DEL LABORATORIO								K	
Multímetro	**X1**								
Certificado	**X1.1**	0	Ω	Normal	0.00027	10	K/Ω	0.0027	
Deriva	**X1.2**	0	Ω	Rectangular	0.00110	10	K/Ω	0.0110	
Linealidad	**X1.3**	0	Ω	Rectangular	0.00003	10	K/Ω	0.0003	
Error de Interpolación	**X1.4**	0	Ω	Rectangular	0.00006	10	K/Ω	0.0006	
Resolución	**X1.5**	0	Ω	Rectangular	0.00003	10	K/Ω	0.0003	
Inversión de canales	**X1.6**	0	Ω	Rectangular	0.00014	10	K/Ω	0.0014	
Corrientes parásitas por Scanner	**X1.7**	0	Ω	Rectangular	0.00017	10	K/Ω	0.0017	
Patrón		0							
Certificado (ITS-90)	**X2**	0	K	Normal	0.00300	1	1	0.0030	
Deriva	**X3**	0	K	Rectangular	0.00144	1	1	0.0014	
Repetibilidad		0	K	Rectangular	0.00029	1	1	0.0003	
Baño		0							
Uniformidad	**X5**	0	K	Normal	0.00600	1	1	0.0060	
Estabilidad	**X4**	0	K	Normal	0.00400	1	1	0.0040	
DE LA LECTURA DEL TERMÓMETRO EN CALIBRACIÓN								Ω	K
Multímetro									
Certificado	**X2.1**	0	Ω	Normal	0.00105	1	1	0.0010	0.0026
Deriva	**X2.2**	0	Ω	Rectangular	0.00289	1	1	0.0029	0.0072
Linealidad	**X2.3**	0	Ω	Rectangular	0.00029	1	1	0.0003	0.0007
Error de Interpolación	**X2.4**	0	Ω	Rectangular	0.00006	1	1	0.0001	0.0001
Resolución	**X2.5**	0	Ω	Rectangular	0.00003	1	1	0.0000	0.0001
Inversión de canales	**X2.6**	0	Ω	Rectangular	0.00014	1	1	0.0001	0.0003
Corrientes parásitas por Scanner	**X2.7**	0	Ω	Rectangular	0.00017	1	1	0.0002	0.0004
DE LAS CARACTERÍSTICAS PROPIAS DEL TERMÓMETRO EN CALIBRACIÓN									
		0							0
Histéresis y Repetibilidad	**X7**	0	Ω	Normal	0.001	1	1	0.0010	0.0025

Incertidumbre Combinada 0.022 ºC
Incertidumbre Expandida para k = 2 0.045 ºC

CALCULO DE INCERTIDUMBRES

Nombre del Laboratorio **Instituto Boliviano de Metrología**
Termómetro: 16004/6
Punto/s de calibración: 150 ºC y 200 ºC

Magnitud	Xi	Estimación de la Magnitud Xi	Unidad	Distribución de probabilidad	Incertidumbre típica	Coeficiente de Sensibilidad ci	Unidad	Contribución a la incertidumbre combinada ci·u(xi)	
DEL SISTEMA DE MEDIDA DEL LABORATORIO								**K**	
Multímetro	**X1**								
Certificado	**X1.1**	0	Ω	Normal	0.00027	10	K/Ω	0.0027	
Deriva	**X1.2**	0	Ω	Rectangular	0.00110	10	K/Ω	0.0110	
Linealidad	**X1.3**	0	Ω	Rectangular	0.00003	10	K/Ω	0.0003	
Error de Interpolación	**X1.4**	0	Ω	Rectangular	0.00006	10	K/Ω	0.0006	
Resolución	**X1.5**	0	Ω	Rectangular	0.00003	10	K/Ω	0.0003	
Inversión de canales	**X1.6**	0	Ω	Rectangular	0.00014	10	K/Ω	0.0014	
Corrientes parásitas por Scanner	**X1.7**	0	Ω	Rectangular	0.00017	10	K/Ω	0.0017	
Patrón		0							
Certificado (ITS-90)	**X2**	0	K	Normal	0.00300	1	1	0.0030	
Deriva	**X3**	0	K	Rectangular	0.00144	1	1	0.0014	
Repetibilidad		0	K	Rectangular	0.00029	1	1	0.0003	
Baño		0							
Uniformidad	**X5**	0	K	Normal	0.00600	1	1	0.0060	
Estabilidad	**X4**	0	K	Normal	0.00400	1	1	0.0040	
DE LA LECTURA DEL TERMÓMETRO EN CALIBRACIÓN								**Ω**	**K**
Multímetro									
Certificado	**X2.1**	0	Ω	Normal	0.00105	1	1	0.0010	0.0026
Deriva	**X2.2**	0	Ω	Rectangular	0.00289	1	1	0.0029	0.0072
Linealidad	**X2.3**	0	Ω	Rectangular	0.00029	1	1	0.0003	0.0007
Error de Interpolación	**X2.4**	0	Ω	Rectangular	0.00006	1	1	0.0001	0.0001
Resolución	**X2.5**	0	Ω	Rectangular	0.00003	1	1	0.0000	0.0001
Inversión de canales	**X2.6**	0	Ω	Rectangular	0.00014	1	1	0.0001	0.0003
Corrientes parásitas por Scanner	**X2.7**	0	Ω	Rectangular	0.00017	1	1	0.0002	0.0004
DE LAS CARACTERÍSTICAS PROPIAS DEL TERMÓMETRO EN CALIBRACIÓN									
		0							0
Histéresis y Repetibilidad	**X7**	0	Ω	Normal	0.0024	1	1	0.0024	0.006

Incertidumbre Combinada	**0.025** °C
Incertidumbre Expandida para k = 2	**0.050** °C

Thermometer: 9351461
-20 ºC y 0 ºC

X_i	Value	Unit	Probability Distribution	Standard Uncertainty	Sensitivity coefficient	Unit	Contribution to the combined Uncertainty
From Laboratory Measurement System							
$X_{1,1}$		ºC	Rectangular	0,0001/√3	1	ºC	0,0001
$X_{1,2}$		ºC	Rectangular	0,006/√3	1	ºC	0,0035
$X_{1,3}$		ºC	Normal	0,0006/2	1	ºC	0,0003
X_2		ºC	Normal	0,008/2	1	ºC	0,0040
X_3		ºC	Rectangular	0,018/√3	1	ºC	0,0104
X_4		ºC	Rectangular	0,005/√3	1	ºC	0,0029
X_5		ºC	Rectangular	0,005/√3	1	ºC	0,0029
From reading of the thermometer under calibration							
$X_{6,1}$		ºC	Rectangular	0,0001/√3	1	ºC	0,0001
$X_{6,2}$		ºC	Rectangular	0,006/√3	1	ºC	0,0035
$X_{6,3}$		ºC	Normal	0,0006/2	1	ºC	0,0003
From Characteristics of the thermometer under calibration							
X_7		ºC	Rectangular	0,001/√3	1	ºC	0,0005

Combined Uncertainty	/ºC =	0,0128
Expanded uncertainty $k = 2$	/ºC =	0,026

Thermometer: 9351461
50 ºC y 100 ºC

X_i	Value	Unit	Probability Distribution	Standard Uncertainty	Sensitivity coefficient	Unit	Contribution to the combined Uncertainty
From Laboratory Measurement System							
$X_{1,1}$		ºC	Rectangular	0,0001/√3	1	ºC	0,0001
$X_{1,2}$		ºC	Rectangular	0,009/√3	1	ºC	0,0052
$X_{1,3}$		ºC	Normal	0,0006/2	1	ºC	0,0003
X_2		ºC	Normal	0,009/2	1	ºC	0,0045
X_3		ºC	Rectangular	0,019/√3	1	ºC	0,0110
X_4		ºC	Rectangular	0,005/√3	1	ºC	0,0029
X_5		ºC	Rectangular	0,007/√3	1	ºC	0,0040
From reading of the thermometer under calibration							
$X_{6,1}$		ºC	Rectangular	0,0001/√3	1	ºC	0,0001
$X_{6,2}$		ºC	Rectangular	0,009/√3	1	ºC	0,0052
$X_{6,3}$		ºC	Normal	0,0006/2	1	ºC	0,0003
From Characteristics of the thermometer under calibration							
X_7		ºC	Rectangular	0,001/√3	1	ºC	0,0005

Combined Uncertainty	/ºC =	0,0148
Expanded uncertainty $k = 2$	/ºC =	0,027

Thermometer: 9351461
150 ºC

X_i	Value	Unit	Probability Distribution	Standard Uncertainty	Sensitivity coefficient	Unit	Contribution to the combined Uncertainty
From Laboratory Measurement System							
$X_{1,1}$		ºC	Rectangular	0,0001/√3	1	ºC	0,0001
$X_{1,2}$		ºC	Rectangular	0,012/√3	1	ºC	0,0069
$X_{1,3}$		ºC	Normal	0,0006/2	1	ºC	0,0003
X_2		ºC	Normal	0,009/2	1	ºC	0,0045
X_3		ºC	Rectangular	0,019/√3	1	ºC	0,0110
X_4		ºC	Rectangular	0,007/√3	1	ºC	0,004
X_5		ºC	Rectangular	0,010/√3	1	ºC	0,0053
From reading of the thermometer under calibration							
$X_{6,1}$		ºC	Rectangular	0,0001/√3	1	ºC	0,0001
$X_{6,2}$		ºC	Rectangular	0,0012/√3	1	ºC	0,0069
$X_{6,3}$		ºC	Normal	0,0006/2	1	ºC	0,0003
From Characteristics of the thermometer under calibration							
X_7		ºC	Rectangular	0,001/√3	1	ºC	0,0005

Combined Uncertainty	/ºC =	0,0169
Expanded uncertainty $k = 2$	/ºC =	0,034

Thermometer: 9351461
200 ºC y 250 ºC

X_i	Value	Unit	Probability Distribution	Standard Uncertainty	Sensitivity coefficient	Unit	Contribution to the combined Uncertainty
From Laboratory Measurement System							
$X_{1,1}$		ºC	Rectangular	0,0001/√3	1	ºC	0,0001
$X_{1,2}$		ºC	Rectangular	0,018/√3	1	ºC	0,0104
$X_{1,3}$		ºC	Normal	0,0006/2	1	ºC	0,0003
X_2		ºC	Normal	0,012/2	1	ºC	0,0060
X_3		ºC	Rectangular	0,019/√3	1	ºC	0,0110
X_4		ºC	Rectangular	0,015/√3	1	ºC	0,0087
X_5		ºC	Rectangular	0,015/√3	1	ºC	0,0087
From reading of the thermometer under calibration							
$X_{6,1}$		ºC	Rectangular	0,0001/√3	1	ºC	0,0001
$X_{6,2}$		ºC	Rectangular	0,0018/√3	1	ºC	0,0104
$X_{6,3}$		ºC	Normal	0,0006/2	1	ºC	0,0003
From Characteristics of the thermometer under calibration							
X_7		ºC	Rectangular	0,001/√3	1	ºC	0,0005

Combined Uncertainty	/ºC =	0,024
Expanded uncertainty $k = 2$	/ºC =	0,048

INDECOPI

Thermometer: *Both, below is splitted in two tables, each one for each PRT*

Calibration Point: ***´ -40 °C***

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mK)	Sensibility Coefficients c_i	Unity	Uncert. Contrib. $u_i = c_i \cdot u(x_i)$ (mK)	Weight in Percentage of u_i
From Laboratory Measurement System									
Mean value temperature of two SPRTs (n=12 measur)	t_N =	-39,98701396	°C	Normal	0,69661	1	adim	0,697	0,221%
Correct due uncert. in calibrat of SPRT Tinsley	δt_{Kal1} =	0	°C	Normal	0,12425	0,333	adim	0,041	0,001%
Correct due Historical Drift SPRT Tinsley	δt_{Drift1} =	0	°C	Normal	0,06653	0,333	adim	0,022	0,000%
Correct due Drift during tests SPRT Tinsley	$\delta t_{DriftTest1}$ =	0	°C	Normal	0,02343	0,333	adim	0,0078	0,000%
Corrects due Measuring Bridge for SPRT Tinsley	δt_{MB1} =	0	°C	Normal	1,55565	0,333	adim	0,519	0,123%
(includes Correcctions due to standard resistor)									
Correct due Heat dissipation of SPRT Tinsley	δt_{WaN1} =	0	°C	Rectangular	1,27546	0,333	adim	0,425	0,082%
Correct due Self Heating of SPRT Tinsley	δt_{EWN1} =	0	°C	Rectangular	0,00000	0,333	adim	0,000	0,000%
Correct due uncert. in calibrat of SPRT Hart	δt_{Kal2} =	0	°C	Normal	0,87928	0,667	adim	0,586	0,157%
Correct due Historical Drift SPRT Hart	δt_{Drift2} =	0	°C	Normal	0,83333	0,667	adim	0,556	0,141%
Correct due Drift during tests SPRT Hart	$\delta t_{DriftTest2}$ =	0	°C	Normal	1,48824	0,667	adim	0,992	0,449%
Corrects due Measuring Bridge for SPRT Hart	δt_{MB2} =	0	°C	Normal	3,11138	0,667	adim	2,074	1,961%
(includes Correcctions due to standard resistor)									
Correct due Heat Dissipation of SPRT Hart	δt_{WaN2} =	0	°C	Rectangular	2,55091	0,667	adim	1,701	1,318%
Correct due Self Heating of SPRT Hart	δt_{EWN2} =	0	°C	Rectangular	0,00000	0,667	adim	0,000	0,000%
Correct due Heat dissipation of PRT in calibration	δt_{WaP} =	0	°C	Rectangular	3,82637	1	adim	3,826	6,674%
Correct due Parasitic thermal voltages in SPRTs	δt_{Par} =	0	°C	Rectangular	0,01614	1	adim	0,016	0,000%
Correct due Bath´s inhomogeneities	δt_{Hom} =	0	°C	Rectangular	6,14105	1	adim	6,141	17,191%
Correct due Bath´s instabilities	δt_{Sta} =	0	°C	Rectangular	12,53990	1	adim	12,540	71,682%
Temperature Calibration Item (°C)	t_x =	**-39,9870**	**°C**		**STANDARD UNCERTAINTY**			**14,811**	**100,0%**
					COVERAGE FACTOR		***k*** **=**	**2**	
					EXPANDED UNCERTAINTY			**29,622**	**mK**

UNCERTAINTY BUDGET FOR RESISTANCE OF SHORT PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=12 measur)	R_{MB} =	84,26423812	Ω	Normal	0,87726	1	adim	0,87726	1,9%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB} =	0	mΩ	Normal	2,11421	1	adim	2,11421	11,3%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	0,12548	1	adim	0,12548	0,0%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,29732	1	adim	0,29732	0,2%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	$ct\ \delta T$ =	0	°C	Normal	14,811	0,39574452	mΩ /mK	5,86145	86,5%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**84,2642**	**Ω**		**STANDARD UNCERT (mΩ)**			**6,30081**	**100,0%**
					COVERAGE FACTOR		***k*** **=**	**2**	
					EXPANDED UNCERT (mΩ)			**12,60**	
					EXPANDED UNCERT (mK)			**31,84**	

UNCERTAINTY BUDGET FOR RESISTANCE OF LARGE PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=16 measur)	R_{MB} =	84,25187705	Ω	Normal	2,15871	1	adim	2,15871	10,4%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB} =	0	mΩ	Normal	2,11390	1	adim	2,11390	10,0%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	1,11615	1	adim	1,11615	2,8%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,32662	1	adim	0,32662	0,2%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	$ct\ \delta T$ =	0	°C	Normal	14,811	0,3957787	mΩ /mK	5,86195	76,6%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**84,2519**	**Ω**		**STANDARD UNCERT (mΩ)**			**6,69653**	**100,0%**
					COVERAGE FACTOR		***k*** **=**	**2**	
					EXPANDED UNCERT (mΩ)			**13,39**	
					EXPANDED UNCERT (mK)			**33,84**	

Thermometer: *Both, below is splitted in two tables, each one for each PRT*

Calibration Point: ***´ -30 °C***

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mK)	Sensibility Coefficients c_i	Unity	Uncert. Contrib. $u_i = c_i \cdot u(x_i)$ (mK)	Weight in Percentage of u_i
From Laboratory Measurement System									
Mean value temperature of two SPRTs (n=12 measur)	t_N =	-29,97653973	°C	Normal	1,33975	1	adim	1,340	0,997%
Correct due uncert. in calibrat of SPRT Tinsley	δt_{Kal1} =	0	°C	Normal	0,12497	0,333	adim	0,042	0,001%
Correct due Historical Drift SPRT Tinsley	δt_{Drift1} =	0	°C	Normal	0,10470	0,333	adim	0,035	0,001%
Correct due Drift during tests SPRT Tinsley	$\delta t_{DriftTest1}$ =	0	°C	Normal	0,02343	0,333	adim	0,0078	0,000%
Corrects due Measuring Bridge for SPRT Tinsley (includes Correcctions due to standard resistor)	δt_{MB1} =	0	°C	Normal	1,64104	0,333	adim	0,547	0,166%
Correct due Heat dissipation of SPRT Tinsley	δt_{WaN1} =	0	°C	Rectangular	1,27546	0,333	adim	0,425	0,100%
Correct due Self Heating of SPRT Tinsley	δt_{EWN1} =	0	°C	Rectangular	0,00000	0,333	adim	0,000	0,000%
Correct due uncert. in calibrat of SPRT Hart	δt_{Kal2} =	0	°C	Normal	0,72989	0,667	adim	0,487	0,132%
Correct due Historical Drift SPRT Hart	δt_{Drift2} =	0	°C	Normal	0,83333	0,667	adim	0,556	0,171%
Correct due Drift during tests SPRT Hart	$\delta t_{DriftTest2}$ =	0	°C	Normal	1,48824	0,667	adim	0,992	0,547%
Corrects due Measuring Bridge for SPRT Hart (includes Correcctions due to standard resistor)	δt_{MB2} =	0	°C	Normal	3,28206	0,667	adim	2,188	2,660%
Correct due Heat Dissipation of SPRT Hart	δt_{WaN2} =	0	°C	Rectangular	2,55091	0,667	adim	1,701	1,607%
Correct due Self Heating of SPRT Hart	δt_{EWN2} =	0	°C	Rectangular	0,00000	0,667	adim	0,000	0,000%
Correct due Heat dissipation of PRT in calibration	δt_{WaP} =	0	°C	Rectangular	3,82637	1	adim	3,826	8,135%
Correct due Parasitic thermal voltages in SPRTs	δt_{Par} =	0	°C	Rectangular	2,59535	1	adim	2,595	3,743%
Correct due Bath´s inhomogeneities	δt_{Hom} =	0	°C	Rectangular	7,12103	1	adim	7,121	28,175%
Correct due Bath´s instabilities	δt_{Sta} =	0	°C	Rectangular	9,81862	1	adim	9,819	53,565%
Temperature Calibration Item (°C)	t_x =	**-29,9765**	**°C**		**STANDARD UNCERTAINTY**			**13,416**	**100,0%**
					COVERAGE FACTOR k=			**2**	
					EXPANDED UNCERTAINTY			**26,831**	**mK**

UNCERTAINTY BUDGET FOR RESISTANCE OF SHORT PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=12 measur)	R_{MB} =	88,22311347	Ω	Normal	0,52857	1	adim	0,52857	0,8%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB} =	0	mΩ	Normal	2,21807	1	adim	2,21807	14,8%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	0,05006	1	adim	0,05006	0,0%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,29732	1	adim	0,29732	0,3%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	$ct\ \delta T$ =	0	°C	Normal	13,416	0,39443855	mΩ /mK	5,29163	84,1%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**88,2231**	**Ω**		**STANDARD UNCERT (mΩ)**			**5,76988**	**100,0%**
					COVERAGE FACTOR k =			**2**	
					EXPANDED UNCERT (mΩ)			**11,54**	
					EXPANDED UNCERT (mK)			**29,26**	

UNCERTAINTY BUDGET FOR RESISTANCE OF LARGE PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=16 measur)	R_{MB} =	88,21478262	Ω	Normal	0,54727	1	adim	0,54727	0,9%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB} =	0	mΩ	Normal	2,21786	1	adim	2,21786	14,5%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	0,79003	1	adim	0,79003	1,8%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,32662	1	adim	0,32662	0,3%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	$ct\ \delta T$ =	0	°C	Normal	13,416	0,39447262	mΩ /mK	5,29209	82,5%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**88,2148**	**Ω**		**STANDARD UNCERT (mΩ)**			**5,82713**	**100,0%**
					COVERAGE FACTOR k =			**2**	
					EXPANDED UNCERT (mΩ)			**11,65**	
					EXPANDED UNCERT (mK)			**29,54**	

Thermometer: *Both, below is splitted in two tables, each one for each PRT*

Calibration Point: ***´ -20 °C***

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mK)	Sensibility Coefficients c_i	Unity	Uncert. Contrib. $u_i = c_i \cdot u(x_i)$ (mK)	Weight in Percentage of u_i
From Laboratory Measurement System									
Mean value temperature of two SPRTs (n=12 measur)	t_N =	-19,97002287	°C	Normal	0,42868	1	adim	0,429	0,134%
Correct due uncert. in calibrat of SPRT Tinsley	δt_{Kal1}=	0	°C	Normal	0,08843	0,333	adim	0,029	0,001%
Correct due Historical Drift SPRT Tinsley	δt_{Drift1} =	0	°C	Normal	0,14285	0,333	adim	0,048	0,002%
Correct due Drift during tests SPRT Tinsley	$\delta t_{DriftTest1}$ =	0	°C	Normal	0,02343	0,333	adim	0,0078	0,000%
Corrects due Measuring Bridge for SPRT Tinsley	δt_{MB1} =	0	°C	Normal	1,72644	0,333	adim	0,575	0,242%
(includes Correcctions due to standard resistor)									
Correct due Heat dissipation of SPRT Tinsley	δt_{WaN1} =	0	°C	Rectangular	1,27546	0,333	adim	0,425	0,132%
Correct due Self Heating of SPRT Tinsley	δt_{EWN1} =	0	°C	Rectangular	0,00000	0,333	adim	0,000	0,000%
Correct due uncert. in calibrat of SPRT Hart	δt_{Kal2}=	0	°C	Normal	0,66511	0,667	adim	0,443	0,144%
Correct due Historical Drift SPRT Hart	δt_{Drift2} =	0	°C	Normal	0,83333	0,667	adim	0,556	0,225%
Correct due Drift during tests SPRT Hart	$\delta t_{DriftTest2}$ =	0	°C	Normal	1,48824	0,667	adim	0,992	0,719%
Corrects due Measuring Bridge for SPRT Hart	δt_{MB2} =	0	°C	Normal	1,54767	0,667	adim	1,032	0,777%
(includes Correcctions due to standard resistor)									
Correct due Heat Dissipation of SPRT Hart	δt_{WaN2} =	0	°C	Rectangular	2,55091	0,667	adim	1,701	2,112%
Correct due Self Heating of SPRT Hart	δt_{EWN2} =	0	°C	Rectangular	0,00000	0,667	adim	0,000	0,000%
Correct due Heat dissipation of PRT in calibration	δt_{WaP} =	0	°C	Rectangular	3,82637	1	adim	3,826	10,692%
Correct due Parasitic thermal voltages in SPRTs	δt_{Par} =	0	°C	Rectangular	0,27077	1	adim	0,271	0,054%
Correct due Bath´s inhomogeneities	δt_{Hom} =	0	°C	Rectangular	8,09769	1	adim	8,098	47,886%
Correct due Bath´s instabilities	δt_{Sta} =	0	°C	Rectangular	7,10657	1	adim	7,107	36,881%
Temperature Calibration Item (°C)	t_x =	**-19,9700**	**°C**		**STANDARD UNCERTAINTY**			**11,702**	**100,0%**
					COVERAGE FACTOR *k* =			**2**	
					EXPANDED UNCERTAINTY			**23,404**	**mK**

UNCERTAINTY BUDGET FOR RESISTANCE OF SHORT PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=12 measur)	R_{MB} =	92,16562988	Ω	Normal	0,41875	1	adim	0,41875	0,7%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB}=	0	mΩ	Normal	2,32151	1	adim	2,32151	20,0%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	0,25672	1	adim	0,25672	0,2%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,29732	1	adim	0,29732	0,3%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	$c t \delta T$ =	0	°C	Normal	11,702	0,39318837	mΩ /mK	4,60107	78,7%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**92,1656**	**Ω**		**STANDARD UNCERT (mΩ)**			**5,18545**	**100,0%**
					COVERAGE FACTOR *k* =			**2**	
					EXPANDED UNCERT (mΩ)			**10,37**	
					EXPANDED UNCERT (mK)			**26,38**	

UNCERTAINTY BUDGET FOR RESISTANCE OF LARGE PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=16 measur)	R_{MB} =	92,16416005	Ω	Normal	0,62973	1	adim	0,62973	1,5%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB}=	0	mΩ	Normal	2,32147	1	adim	2,32147	19,8%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	0,38142	1	adim	0,38142	0,5%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,32662	1	adim	0,32662	0,4%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	$c t \delta T$ =	0	°C	Normal	11,702	0,39322233	mΩ /mK	4,60146	77,8%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**92,1642**	**Ω**		**STANDARD UNCERT (mΩ)**			**5,21646**	**100,0%**
					COVERAGE FACTOR *k* =			**2**	
					EXPANDED UNCERT (mΩ)			**10,43**	
					EXPANDED UNCERT (mK)			**26,53**	

Thermometer: *Both, below is splitted in two tables, each one for each PRT*

Calibration Point: ***´ -10 °C***

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mK)	Sensibility Coefficients c_i	Unity	Uncert. Contrib. $u_i = c_i \cdot u(x_i)$ (mK)	Weight in Percentage of u_i
From Laboratory Measurement System									
Mean value temperature of two SPRTs (n=12 measur)	t_N =	-9,960402668	°C	Normal	1,29070	1	adim	1,291	0,978%
Correct due uncert. in calibrat of SPRT Tinsley	δt_{Kal1} =	0	°C	Normal	0,05917	0,333	adim	0,020	0,000%
Correct due Historical Drift SPRT Tinsley	δt_{Drift1} =	0	°C	Normal	0,18102	0,333	adim	0,060	0,002%
Correct due Drift during tests SPRT Tinsley	$\delta t_{DriftTest1}$ =	0	°C	Normal	0,02343	0,333	adim	0,0078	0,000%
Corrects due Measuring Bridge for SPRT Tinsley	δt_{MB1} =	0	°C	Normal	1,81188	0,333	adim	0,604	0,214%
(includes Correcctions due to standard resistor)									
Correct due Heat dissipation of SPRT Tinsley	δt_{WaN1} =	0	°C	Rectangular	1,27546	0,333	adim	0,425	0,106%
Correct due Self Heating of SPRT Tinsley	δt_{EWN1} =	0	°C	Rectangular	0,00000	0,333	adim	0,000	0,000%
Correct due uncert. in calibrat of SPRT Hart	δt_{Kal2} =	0	°C	Normal	0,65395	0,667	adim	0,436	0,112%
Correct due Historical Drift SPRT Hart	δt_{Drift2} =	0	°C	Normal	0,83333	0,667	adim	0,556	0,181%
Correct due Drift during tests SPRT Hart	$\delta t_{DriftTest2}$ =	0	°C	Normal	1,48824	0,667	adim	0,992	0,578%
Corrects due Measuring Bridge for SPRT Hart	δt_{MB2} =	0	°C	Normal	3,62364	0,667	adim	2,416	3,426%
(includes Correcctions due to standard resistor)									
Correct due Heat Dissipation of SPRT Hart	δt_{WaN2} =	0	°C	Rectangular	2,55091	0,667	adim	1,701	1,698%
Correct due Self Heating of SPRT Hart	δt_{EWN2} =	0	°C	Rectangular	0,00000	0,667	adim	0,000	0,000%
Correct due Heat dissipation of PRT in calibration	δt_{WaP} =	0	°C	Rectangular	3,82637	1	adim	3,826	8,594%
Correct due Parasitic thermal voltages in SPRTs	δt_{Par} =	0	°C	Rectangular	2,57246	1	adim	2,572	3,884%
Correct due Bath´s inhomogeneities	δt_{Hom} =	0	°C	Rectangular	9,07664	1	adim	9,077	48,359%
Correct due Bath´s instabilities	δt_{Sta} =	0	°C	Rectangular	7,36835	1	adim	7,368	31,869%
Temperature Calibration Item (°C)	t_x =	**-9,9604**	**°C**		**STANDARD UNCERTAINTY**			**13,052**	**100,0%**
					COVERAGE FACTOR		***k* =**	**2**	
					EXPANDED UNCERTAINTY			**26,105**	**mK**

UNCERTAINTY BUDGET FOR RESISTANCE OF SHORT PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=12 measur)	R_{MB} =	96,09915721	Ω	Normal	0,65290	1	adim	0,65290	1,3%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB} =	0	mΩ	Normal	2,42473	1	adim	2,42473	17,6%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	0,86577	1	adim	0,86577	2,2%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,29732	1	adim	0,29732	0,3%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	$ct\ \delta T$ =	0	°C	Normal	13,052	0,39198302	mΩ /mK	5,11629	78,6%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**96,0992**	**Ω**		**STANDARD UNCERT (mΩ)**			**5,77235**	**100,0%**
					COVERAGE FACTOR		***k* =**	**2**	
					EXPANDED UNCERT (mΩ)			**11,54**	
					EXPANDED UNCERT (mK)			**29,45**	

UNCERTAINTY BUDGET FOR RESISTANCE OF LARGE PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=16 measur)	R_{MB} =	96,10124663	Ω	Normal	0,50488	1	adim	0,50488	0,8%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB} =	0	mΩ	Normal	2,42478	1	adim	2,42478	17,6%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	0,96451	1	adim	0,96451	2,8%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,32662	1	adim	0,32662	0,3%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	$ct\ \delta T$ =	0	°C	Normal	13,052	0,39201688	mΩ /mK	5,11673	78,5%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**96,1012**	**Ω**		**STANDARD UNCERT (mΩ)**			**5,77515**	**100,0%**
					COVERAGE FACTOR		***k* =**	**2**	
					EXPANDED UNCERT (mΩ)			**11,55**	
					EXPANDED UNCERT (mK)			**29,46**	

Thermometer: *Both, below is splitted in two tables, each one for each PRT*

Calibration Point: ***50 °C***

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mK)	Sensibility Coefficients c_i	Unity	Uncert. Contrib. $u_i = c_i \cdot u(x_i)$ (mK)	Weight in Percentage of u_i
From Laboratory Measurement System									
Mean value temperature of two SPRTs (n=12 measur)	t_N =	50,00442682	°C	Normal	0,26443	1	adim	0,264	0,042%
Correct due uncert. in calibrat of SPRT Tinsley	δt_{Kal1} =	0	°C	Normal	0,22509	0,333	adim	0,075	0,003%
Correct due Historical Drift SPRT Tinsley	δt_{Drift1} =	0	°C	Normal	0,40966	0,333	adim	0,137	0,011%
Correct due Drift during tests SPRT Tinsley	$\delta t_{DriftTest1}$ =	0	°C	Normal	0,02343	0,333	adim	0,0078	0,000%
Corrects due Measuring Bridge for SPRT Tinsley	δt_{MB1} =	0	°C	Normal	2,32226	0,333	adim	0,774	0,363%
(includes Correcctions due to standard resistor)									
Correct due Heat dissipation of SPRT Tinsley	δt_{WaN1} =	0	°C	Rectangular	1,32544	0,333	adim	0,442	0,118%
Correct due Self Heating of SPRT Tinsley	δt_{EWN1} =	0	°C	Rectangular	0,00000	0,333	adim	0,000	0,000%
Correct due uncert. in calibrat of SPRT Hart	δt_{Kal2} =	0	°C	Normal	1,04663	0,667	adim	0,698	0,295%
Correct due Historical Drift SPRT Hart	δt_{Drift2} =	0	°C	Normal	0,83333	0,667	adim	0,556	0,187%
Correct due Drift during tests SPRT Hart	$\delta t_{DriftTest2}$ =	0	°C	Normal	1,48824	0,667	adim	0,992	0,597%
Corrects due Measuring Bridge for SPRT Hart	δt_{MB2} =	0	°C	Normal	4,64441	0,667	adim	3,096	5,809%
(includes Correcctions due to standard resistor)									
Correct due Heat Dissipation of SPRT Hart	δt_{WaN2} =	0	°C	Rectangular	2,65089	0,667	adim	1,767	1,893%
Correct due Self Heating of SPRT Hart	δt_{EWN2} =	0	°C	Rectangular	0,00000	0,667	adim	0,000	0,000%
Correct due Heat dissipation of PRT in calibration	δt_{WaP} =	0	°C	Rectangular	3,97633	1	adim	3,976	9,581%
Correct due Parasitic thermal voltages in SPRTs	δt_{Par} =	0	°C	Rectangular	0,39160	1	adim	0,392	0,093%
Correct due Bath´s inhomogeneities	δt_{Hom} =	0	°C	Rectangular	8,07395	1	adim	8,074	39,503%
Correct due Bath´s instabilities	δt_{Sta} =	0	°C	Rectangular	8,27587	1	adim	8,276	41,504%
Temperature Calibration Item (°C)	t_x =	**50,0044**	**°C**		**STANDARD UNCERTAINTY**			**12,846**	**100,0%**
					COVERAGE FACTOR		**k =**	**2**	
					EXPANDED UNCERTAINTY			**25,692**	**mK**

UNCERTAINTY BUDGET FOR RESISTANCE OF SHORT PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=12 measur)	R_{MB} =	119,403724	Ω	Normal	0,16096	1	adim	0,16096	0,1%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB} =	0	mΩ	Normal	2,46106	1	adim	2,46106	19,7%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	0,30463	1	adim	0,30463	0,3%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,29732	1	adim	0,29732	0,3%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	$ct\ \delta T$ =	0	°C	Normal	12,846	0,38504319	mΩ /mK	4,94630	79,6%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**119,4037**	**Ω**		**STANDARD UNCERT (mΩ)**			**5,54345**	**100,0%**
					COVERAGE FACTOR		**k =**	**2**	
					EXPANDED UNCERT (mΩ)			**11,09**	
					EXPANDED UNCERT (mK)			**28,79**	

UNCERTAINTY BUDGET FOR RESISTANCE OF LARGE PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=16 measur)	R_{MB} =	119,4397641	Ω	Normal	0,10892	1	adim	0,10892	0,0%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB} =	0	mΩ	Normal	2,46181	1	adim	2,46181	19,8%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	0,18512	1	adim	0,18512	0,1%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,32662	1	adim	0,32662	0,3%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	$ct\ \delta T$ =	0	°C	Normal	12,846	0,38507644	mΩ /mK	4,94672	79,8%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**119,4398**	**Ω**		**STANDARD UNCERT (mΩ)**			**5,53926**	**100,0%**
					COVERAGE FACTOR		**k =**	**2**	
					EXPANDED UNCERT (mΩ)			**11,08**	
					EXPANDED UNCERT (mK)			**28,77**	

Thermometer: *Both, below is splitted in two tables, each one for each PRT*

Calibration Point: ***100 °C***

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mK)	Sensibility Coefficients c_i	Unity	Uncert. Contrib. $u_i = c_i \cdot u(x_i)$ (mK)	Weight in Percentage of u_i
From Laboratory Measurement System									
Mean value temperature of two SPRTs (n=12 measur)	t_N =	100,0034532	°C	Normal	0,43033	1	adim	0,430	0,089%
Correct due uncert. in calibrat of SPRT Tinsley	δt_{Kal1} =	0	°C	Normal	0,42266	0,333	adim	0,141	0,010%
Correct due Historical Drift SPRT Tinsley	δt_{Drift1} =	0	°C	Normal	0,60031	0,333	adim	0,200	0,019%
Correct due Drift during tests SPRT Tinsley	$\delta t_{DriftTest1}$ =	0	°C	Normal	0,02343	0,333	adim	0,008	0,000%
Corrects due Measuring Bridge for SPRT Tinsley	δt_{MB1} =	0	°C	Normal	2,74398	0,333	adim	0,915	0,402%
(includes Correcctions due to standard resistor)									
Correct due Heat dissipation of SPRT Tinsley	δt_{WaN1} =	0	°C	Rectangular	1,34563	0,333	adim	0,449	0,097%
Correct due Self Heating of SPRT Tinsley	δt_{EWN1} =	0	°C	Rectangular	0,00000	0,333	adim	0,000	0,000%
Correct due uncert. in calibrat of SPRT Hart	δt_{Kal2} =	0	°C	Normal	1,45611	0,667	adim	0,971	0,453%
Correct due Historical Drift SPRT Hart	δt_{Drift2} =	0	°C	Normal	0,83333	0,667	adim	0,556	0,148%
Correct due Drift during tests SPRT Hart	$\delta t_{DriftTest2}$ =	0	°C	Normal	1,48824	0,667	adim	0,992	0,473%
Corrects due Measuring Bridge for SPRT Hart	δt_{MB2} =	0	°C	Normal	5,48785	0,667	adim	3,659	6,438%
(includes Correcctions due to standard resistor)									
Correct due Heat Dissipation of SPRT Hart	δt_{WaN2} =	0	°C	Rectangular	2,69125	0,667	adim	1,794	1,548%
Correct due Self Heating of SPRT Hart	δt_{EWN2} =	0	°C	Rectangular	0,00000	0,667	adim	0,000	0,000%
Correct due Heat dissipation of PRT in calibration	δt_{WaP} =	0	°C	Rectangular	4,03688	1	adim	4,037	7,838%
Correct due Parasitic thermal voltages in SPRTs	δt_{Par} =	0	°C	Rectangular	0,40567	1	adim	0,406	0,079%
Correct due Bath´s inhomogeneities	δt_{Hom} =	0	°C	Rectangular	11,17600	1	adim	11,176	60,077%
Correct due Bath´s instabilities	δt_{Sta} =	0	°C	Rectangular	6,81303	1	adim	6,813	22,326%
Temperature Calibration Item (°C)	t_x =	**100,0035**	**°C**				**STANDARD UNCERTAINTY**	**14,419**	**100,0%**
							COVERAGE FACTOR k =	**2**	
							EXPANDED UNCERTAINTY	**28,838**	**mK**

UNCERTAINTY BUDGET FOR RESISTANCE OF SHORT PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=12 measur)	R_{MB} =	138,5024839	Ω	Normal	0,16524	1	adim	0,16524	0,1%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB} =	0	mΩ	Normal	2,90169	1	adim	2,90169	21,9%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	0,10291	1	adim	0,10291	0,0%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,29732	1	adim	0,29732	0,2%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	$ct\ \delta T$ =	0	°C	Normal	14,419	0,37926847	mΩ /mK	5,46862	77,8%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**138,5025**	**Ω**				**STANDARD UNCERT (mΩ)**	**6,20096**	**100,0%**
							COVERAGE FACTOR k =	**2**	
							EXPANDED UNCERT (mΩ)	**12,40**	
							EXPANDED UNCERT (mK)	**32,70**	

UNCERTAINTY BUDGET FOR RESISTANCE OF LARGE PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=16 measur)	R_{MB} =	138,573234	Ω	Normal	0,16169	1	adim	0,16169	0,1%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB} =	0	mΩ	Normal	2,90317	1	adim	2,90317	21,9%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	0,04258	1	adim	0,04258	0,0%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,32662	1	adim	0,32662	0,3%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	$ct\ \delta T$ =	0	°C	Normal	14,419	0,37930123	mΩ /mK	5,46909	77,7%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**138,5732**	**Ω**				**STANDARD UNCERT (mΩ)**	**6,20274**	**100,0%**
							COVERAGE FACTOR k =	**2**	
							EXPANDED UNCERT (mΩ)	**12,41**	
							EXPANDED UNCERT (mK)	**32,71**	

Thermometer: *Both, below is splitted in two tables, each one for each PRT*

Calibration Point: ***150 °C***

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mK)	Sensibility Coefficients c_i	Unity	Uncert. Contrib. $u_i = c_i \cdot u(x_i)$ (mK)	Weight in Percentage of u_i
From Laboratory Measurement System									
Mean value temperature of two SPRTs (n=12 measur)	t_N =	150,0025898	°C	Normal	0,96894	1	adim	0,969	0,504%
Correct due uncert. in calibrat of SPRT Tinsley	δt_{Kal1} =	0	°C	Normal	0,49002	0,333	adim	0,163	0,014%
Correct due Historical Drift SPRT Tinsley	δt_{Drift1} =	0	°C	Normal	0,79095	0,333	adim	0,264	0,037%
Correct due Drift during tests SPRT Tinsley	$\delta t_{DriftTest1}$ =	0	°C	Normal	0,02343	0,333	adim	0,008	0,000%
Corrects due Measuring Bridge for SPRT Tinsley (includes Correcctions due to standard resistor)	δt_{MB1} =	0	°C	Normal	3,16088	0,333	adim	1,054	0,596%
Correct due Heat dissipation of SPRT Tinsley	δt_{WaN1} =	0	°C	Rectangular	1,36643	0,333	adim	0,455	0,111%
Correct due Self Heating of SPRT Tinsley	δt_{EWN1} =	0	°C	Rectangular	0,00000	0,333	adim	0,000	0,000%
Correct due uncert. in calibrat of SPRT Hart	δt_{Kal2} =	0	°C	Normal	1,75223	0,667	adim	1,168	0,732%
Correct due Historical Drift SPRT Hart	δt_{Drift2} =	0	°C	Normal	0,83333	0,667	adim	0,556	0,166%
Correct due Drift during tests SPRT Hart	$\delta t_{DriftTest2}$ =	0	°C	Normal	1,48824	0,667	adim	0,992	0,528%
Corrects due Measuring Bridge for SPRT Hart (includes Correcctions due to standard resistor)	δt_{MB2} =	0	°C	Normal	6,32173	0,667	adim	4,214	9,529%
Correct due Heat Dissipation of SPRT Hart	δt_{WaN2} =	0	°C	Rectangular	2,73286	0,667	adim	1,822	1,781%
Correct due Self Heating of SPRT Hart	δt_{EWN2} =	0	°C	Rectangular	0,00000	0,667	adim	0,000	0,000%
Correct due Heat dissipation of PRT in calibration	δt_{WaP} =	0	°C	Rectangular	4,09929	1	adim	4,099	9,015%
Correct due Parasitic thermal voltages in SPRTs	δt_{Par} =	0	°C	Rectangular	1,81193	1	adim	1,812	1,761%
Correct due Bath´s inhomogeneities	δt_{Hom} =	0	°C	Rectangular	10,22000	1	adim	10,220	56,033%
Correct due Bath´s instabilities	δt_{Sta} =	0	°C	Rectangular	5,98140	1	adim	5,981	19,193%
Temperature Calibration Item (°C)	t_x =	**150,0026**	**°C**		**STANDARD UNCERTAINTY**			**13,653**	**100,0%**
					COVERAGE FACTOR		***k* =**	**2**	
					EXPANDED UNCERTAINTY			**27,306**	**mK**

UNCERTAINTY BUDGET FOR RESISTANCE OF SHORT PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=12 measur)	R_{MB} =	157,3024245	Ω	Normal	0,39866	1	adim	0,39866	0,4%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB} =	0	mΩ	Normal	3,35271	1	adim	3,35271	29,6%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	0,73808	1	adim	0,73808	1,4%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,29732	1	adim	0,29732	0,2%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	$ct\ \delta T$ =	0	°C	Normal	13,653	0,37349374	mΩ /mK	5,09931	68,4%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**157,3024**	**Ω**		**STANDARD UNCERT (mΩ)**			**6,16731**	**100,0%**
					COVERAGE FACTOR		**k=**	**2**	
					EXPANDED UNCERT (mΩ)			**12,33**	
					EXPANDED UNCERT (mK)			**33,02**	

UNCERTAINTY BUDGET FOR RESISTANCE OF LARGE PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=16 measur)	R_{MB} =	157,4089939	Ω	Normal	2,87114	1	adim	2,87114	15,9%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB} =	0	mΩ	Normal	3,35498	1	adim	3,35498	21,8%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	2,46893	1	adim	2,46893	11,8%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,32662	1	adim	0,32662	0,2%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	$ct\ \delta T$ =	0	°C	Normal	13,653	0,373526	mΩ /mK	5,09975	50,3%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**157,4090**	**Ω**		**STANDARD UNCERT (mΩ)**			**7,19090**	**100,0%**
					COVERAGE FACTOR		**k=**	**2**	
					EXPANDED UNCERT (mΩ)			**14,38**	
					EXPANDED UNCERT (mK)			**38,50**	

Thermometer: *Both, below is splitted in two tables, each one for each PRT*

Calibration Point: ***200 °C***

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mK)	Sensibility Coefficients c_i	Unity	Uncert. Contrib. $u_i = c_i \cdot u(x_i)$ (mK)	Weight in Percentage of u_i
From Laboratory Measurement System									
Mean value temperature of two SPRTs (n=12 measur)	t_N =	199,966067	°C	Normal	0,58609	1	adim	0,586	0,278%
Correct due uncert. in calibrat of SPRT Tinsley	δt_{Kal1} =	0	°C	Normal	0,50809	0,333	adim	0,169	0,023%
Correct due Historical Drift SPRT Tinsley	δt_{Drift1} =	0	°C	Normal	0,98146	0,333	adim	0,327	0,087%
Correct due Drift during tests SPRT Tinsley	$\delta t_{DriftTest1}$ =	0	°C	Normal	0,02343	0,333	adim	0,008	0,000%
Corrects due Measuring Bridge for SPRT Tinsley	δt_{MB1} =	0	°C	Normal	3,57213	0,333	adim	1,191	1,147%
(includes Correcctions due to standard resistor)									
Correct due Heat dissipation of SPRT Tinsley	δt_{WaN1} =	0	°C	Rectangular	1,38787	0,333	adim	0,463	0,173%
Correct due Self Heating of SPRT Tinsley	δt_{EWN1} =	0	°C	Rectangular	0,00000	0,333	adim	0,000	0,000%
Correct due uncert. in calibrat of SPRT Hart	δt_{Kal2} =	0	°C	Normal	1,92975	0,667	adim	1,286	1,339%
Correct due Historical Drift SPRT Hart	δt_{Drift2} =	0	°C	Normal	0,83333	0,667	adim	0,556	0,250%
Correct due Drift during tests SPRT Hart	$\delta t_{DriftTest2}$ =	0	°C	Normal	1,48824	0,667	adim	0,992	0,797%
Corrects due Measuring Bridge for SPRT Hart	δt_{MB2} =	0	°C	Normal	7,14423	0,667	adim	4,763	18,359%
(includes Correcctions due to standard resistor)									
Correct due Heat Dissipation of SPRT Hart	δt_{WaN2} =	0	°C	Rectangular	2,77575	0,667	adim	1,850	2,771%
Correct due Self Heating of SPRT Hart	δt_{EWN2} =	0	°C	Rectangular	0,00000	0,667	adim	0,000	0,000%
Correct due Heat dissipation of PRT in calibration	δt_{WaP} =	0	°C	Rectangular	4,16400	1	adim	4,164	14,033%
Correct due Parasitic thermal voltages in SPRTs	δt_{Par} =	0	°C	Rectangular	0,06980	1	adim	0,070	0,004%
Correct due Bath´s inhomogeneities	δt_{Hom} =	0	°C	Rectangular	4,05595	1	adim	4,056	13,314%
Correct due Bath´s instabilities	δt_{Sta} =	0	°C	Rectangular	7,65500	1	adim	7,655	47,425%
Temperature Calibration Item (°C)	t_x =	**199,9661**	**°C**		**STANDARD UNCERTAINTY**			**11,116**	**100,0%**
					COVERAGE FACTOR		***k*** **=**	**2**	
					EXPANDED UNCERTAINTY			**22,232**	**mK**

UNCERTAINTY BUDGET FOR RESISTANCE OF SHORT PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=12 measur)	R_{MB} =	175,800172	Ω	Normal	0,304526	1	adim	0,30453	0,3%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB} =	0	mΩ	Normal	3,8072797	1	adim	3,80728	46,9%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	0,1181	1	adim	0,11810	0,0%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,2973	1	adim	0,29730	0,3%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	$ct\,\delta T$ =	0	°C	Normal	11,116	0,36194328	mΩ /mK	4,02330	52,4%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**175,8002**	**Ω**		**STANDARD UNCERT (mΩ)**			**5,55674**	**100,0%**
					COVERAGE FACTOR		***k*** **=**	**2**	
					EXPANDED UNCERT (mΩ)			**11,11**	
					EXPANDED UNCERT (mK)			**30,71**	

UNCERTAINTY BUDGET FOR RESISTANCE OF LARGE PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=16 measur)	R_{MB} =	175,94701	Ω	Normal	0,8406	1	adim	0,84057	2,2%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB} =	0	mΩ	Normal	3,8105	1	adim	3,81046	45,3%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	0,1441	1	adim	0,14409	0,1%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,3266	1	adim	0,32662	0,3%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	$ct\,\delta T$ =	0	°C	Normal	11,116	0,36775489	mΩ /mK	4,08790	52,1%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**175,9470**	**Ω**		**STANDARD UNCERT (mΩ)**			**5,66255**	**100,0%**
					COVERAGE FACTOR		***k*** **=**	**2**	
					EXPANDED UNCERT (mΩ)			**11,33**	
					EXPANDED UNCERT (mK)			**30,80**	

NAME OF LABORATORY: *INDECOPI*
Thermometer: *Both, below is splitted in two tables, each one for each PRT*
Calibration Point: ***250 °C***

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mK)	Sensibility Coefficients c_i	Unity	Uncert. Contrib. $u_i = c_i \cdot u(x_i)$ (mK)	Weight in Percentage of u_i
From Laboratory Measurement System									
Mean value temperature of two SPRTs (n=12 measur)	t_N =	250,009517	°C	Normal	2,68614	1	adim	2,686	1,325%
Correct due uncert. in calibrat of SPRT Tinsley	δt_{Kal1} =	0	°C	Normal	0,49353	0,333	adim	0,165	0,005%
Correct due Historical Drift SPRT Tinsley	δt_{Drift1} =	0	°C	Normal	1,17227	0,333	adim	0,391	0,028%
Correct due Drift during tests SPRT Tinsley	$\delta t_{DriftTest1}$ =	0	°C	Normal	0,02343	0,333	adim	0,008	0,000%
Corrects due Measuring Bridge for SPRT Tinsley	δt_{MB1} =	0	°C	Normal	3,97837	0,333	adim	1,326	0,323%
(includes Correcctions due to standard resistor)									
Correct due Heat dissipation of SPRT Tinsley	δt_{WaN1} =	0	°C	Rectangular	1,09667	0,333	adim	0,366	0,025%
Correct due Self Heating of SPRT Tinsley	δt_{EWN1} =	0	°C	Rectangular	4,00000	0,333	adim	1,333	0,327%
Correct due uncert. in calibrat of SPRT Hart	δt_{Kal2} =	0	°C	Normal	2,02449	0,667	adim	1,350	0,335%
Correct due Historical Drift SPRT Hart	δt_{Drift2} =	0	°C	Normal	0,83333	0,667	adim	0,556	0,057%
Correct due Drift during tests SPRT Hart	$\delta t_{DriftTest2}$ =	0	°C	Normal	1,48824	0,667	adim	0,992	0,181%
Corrects due Measuring Bridge for SPRT Hart	δt_{MB2} =	0	°C	Normal	7,95668	0,667	adim	5,304	5,168%
(includes Correcctions due to standard resistor)									
Correct due Heat Dissipation of SPRT Hart	δt_{WaN2} =	0	°C	Rectangular	2,19333	0,667	adim	1,462	0,393%
Correct due Self Heating of SPRT Hart	δt_{EWN2} =	0	°C	Rectangular	4,00000	0,667	adim	2,667	1,306%
Correct due Heat dissipation of PRT in calibration	δt_{WaP} =	0	°C	Rectangular	3,29000	1	adim	3,290	1,988%
Correct due Parasitic thermal voltages in SPRTs	δt_{Par} =	0	°C	Rectangular	3,65923	1	adim	3,659	2,459%
Correct due Bath´s inhomogeneities	δt_{Hom} =	0	°C	Rectangular	12,00900	1	adim	12,009	26,489%
Correct due Bath´s instabilities	δt_{Sta} =	0	°C	Rectangular	18,01198	1	adim	18,012	59,591%
Temperature Calibration Item (°C)	t_x =	**250,0095**	**°C**		**STANDARD UNCERTAINTY**			**23,333**	**100,0%**
					COVERAGE FACTOR		***k*** =	**2**	
					EXPANDED UNCERTAINTY			**46,666**	**mK**

UNCERTAINTY BUDGET FOR RESISTANCE OF SHORT PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ or mK)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=12 measur)	R_{MB} =	194,04096	Ω	Normal	0,7430025	1	adim	0,74300	0,6%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB} =	0	mΩ	Normal	4,2626626	1	adim	4,26266	20,1%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	0,6162	1	adim	0,61620	0,4%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,2973	1	adim	0,29730	0,1%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	δt_x =	0	°C	Normal	23,333	0,36194328	mΩ /mK	8,44522	78,8%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**194,0410**	**Ω**		**STANDARD UNCERT (mΩ)**			**9,51378**	**100,0%**
					COVERAGE FACTOR		***k*** =	**2**	
					EXPANDED UNCERT (mΩ)			**19,03**	
					EXPANDED UNCERT (mK)			**52,57**	

UNCERTAINTY BUDGET FOR RESISTANCE OF LARGE PRT

QUANTITY X_i	Specific Symbol for X_i	Estimation x_i	Unity	Probability Distribution	Standard Uncert. $u(x_i)$ (mΩ or mK)	Sensibility Coefficients c_i	Unity	Uncert Contrib $u_i = c_i \cdot u(x_i)$ (mΩ)	Weight in Percentage of u_i
From Reading of the Thermometer Under Calibration									
Mean value Resistance PRT (ohms) (n=16 measur)	R_{MB} =	194,22652	Ω	Normal	0,8405711	1	adim	0,84057	0,8%
Corrects due Measuring Bridge for PRT & stand resistor	δR_{MB} =	0	mΩ	Normal	4,2667389	1	adim	4,26674	20,0%
Correct due Parasitic Thermal voltages	δR_{Par} =	0	mΩ	Rectangular	0,8537	1	adim	0,85370	0,8%
From Characteristics of the Thermometer under Calibration									
Correct due Hysteresis of PRT	δR_{Hyst} =	0	mΩ	Normal	0,3266	1	adim	0,32660	0,1%
From Laboratory Measurement System (first above table)									
Correct due Uncert of Temper of Calibrat Item	δt_x =	0	°C	Normal	23,333	0,36197454	mΩ /mK	8,44594	78,3%
Resistance of Calibration Item (Ω)	$R(t_x)$ =	**194,2265**	**Ω**		**STANDARD UNCERT (mΩ)**			**9,54364**	**100,0%**
					COVERAGE FACTOR		***k*** =	**2**	
					EXPANDED UNCERT (mΩ)			**18,96**	
					EXPANDED UNCERT (mK)			**52,39**	

SENCAMER

-40 ºC – 0 ºC

Quantity	Description	Value	Standard Uncertainty $u(x_i)$	Probability distribution	Sensitivity coefficient	Contribution to the combined Uncertainty $u(y_i)$, mK	$u(y_i)^2$
From Laboratory Measurement System							
$X_{1,1}$	Bridge resolution	0	5,77E-06	Rectangular	9,81E+01	0,57	0,32
$X_{1,2}$	Bridge drift	0	1,48E-06	Rectangular	9,81E+01	0,15	0,02
$X_{1,3}$	Bridge accuracy	0	1,48E-05	Rectangular	9,81E+01	1,45	2,10
$X_{1,4}$	Repeatability	0	1,38E-04	Normal	9,81E+01	13,57	184,04
$X_{1,5}$	Standard resistor accuracy	0	5,00E-05	Normal	4,92E+01	2,46	6,05
$X_{1,6}$	Standard resistor drift	0	5,00E-05	Rectangular	4,92E+01	2,46	6,05
X_2	SPRT calibration	t_r(°C)	2,05E-03	Normal	1	2,05	4,20
$X_{3,1}$	SPRT drift	0	2,60E-04	Rectangular	9,81E+00	2,55	6,50
$X_{3,2}$	SPRT instabilities	0	2,30E-04	Rectangular	1	0,23	0,05
$X_{3,3}$	SPRT selfheating	0	1,05E-04	Rectangular	1	0,11	0,01
$X_{3,4}$	SPRT heat conduction	0	1,50E-02	Rectangular	1	15,00	225,00
X_4	Bath stability	0	1,50E-02	Rectangular	1	15,00	225,00
$X_{5,1}$	Bath axial uniformity	0	1,50E-02	Rectangular	1	15,00	225,00
$X_{5,2}$	Bath radial uniformity	0	1,50E-02	Rectangular	1	15,00	225,00
READING OF THERMOMETER UNDER CALIBRATION							
$X_{6,1}$	F150 resolution	0	5,77E-04	Rectangular	2,5000	1,44	2,1
$X_{6,2}$	F150 drift	0	1,33E-03	Rectangular	2,5000	3,32	11,0
$X_{6,3}$	F150 accuracy	0	1,44E-03	Rectangular	2,5000	3,61	13,0
From Characteristics of the thermometer under calibration							
$X_{7,1}$	Hysteresis	0	2,00E-03	Rectangular	2,5000	5,00	25,0
$X_{7,2}$	Repeatability	$R_c(t)$	1,00E-02	Normal	2,5000	25,00	625,0
$X_{7,3}$	PRT drift	0	8,66E-04	Rectangular	1	0,87	0,8
$X_{7,4}$	PRT selfheating	0	2,17E-03	Rectangular	1	2,17	4,7
$X_{7,5}$	PRT heat conduction	0	1,50E-02	Rectangular	1	15,00	225,0
OTHER CONTRIBUTIONS							
X_8	AC/DC differences	0	1,2E-06	Rectangular	1,01E+02	0,12	0,01
X_9	ITS-90 ecuation	0	0,7	Rectangular	1	0,70	0,49
				Combined uncertainty		$u(t_c)$	**44,9** mK
				Expanded uncertainty		$U(t_c)$	**89,8** mK

0 ºC – 100 ºC

Quantity	Description	Value	Standard Uncertainty $u(x_i)$	Probability distribution	Sensitivity coefficient	Contribution to the combined Uncertainty $u(y_i)$, mK	$u(y_i)^2$	
From Laboratory Measurement System								
$X_{1,1}$	Bridge resolution	0	5,77E-06	Rectangular	1,01E+02	0,58	0,34	
$X_{1,2}$	Bridge drift	0	2,31E-06	Rectangular	1,01E+02	0,23	0,05	
$X_{1,3}$	Bridge accuracy	0	2,31E-05	Rectangular	1,01E+02	2,34	5,47	
$X_{1,4}$	Repeatability	0	2,00E-06	Normal	1,01E+02	0,20	0,04	
$X_{1,5}$	Standard resistor accuracy	0	5,00E-05	Normal	5,07E+01	2,54	6,44	
$X_{1,6}$	Standard resistor drift	0	5,00E-05	Rectangular	5,07E+01	2,54	6,44	
X_2	SPRT calibration	t_r(°C)	2,15E-03	Normal	1	2,15	4,62	
$X_{3,1}$	SPRT drift	0	8,66E-05	Rectangular	1,01E+01	0,88	0,77	
$X_{3,2}$	SPRT instabilities	0	2,30E-04	Rectangular	1	0,23	0,05	
$X_{3,3}$	SPRT selfheating	0	8,66E-05	Rectangular	1	0,09	0,01	
$X_{3,4}$	SPRT heat conduction	0	2,89E-03	Rectangular	1	2,89	8,33	
X_4	Bath stability	0	5,00E-03	Rectangular	1	5,00	25,00	
$X_{5,1}$	Bath axial uniformity	0	2,00E-03	Rectangular	1	2,00	4,00	
$X_{5,2}$	Bath radial uniformity	0	2,00E-03	Rectangular	1	2,00	4,00	
READING OF THERMOMETER UNDER CALIBRATION								
$X_{6,1}$	F150 resolution	0	5,77E-04	Rectangular	2,5000	1,44	2,1	
$X_{6,2}$	F150 drift	0	1,33E-03	Rectangular	2,5000	3,32	11,0	
$X_{6,3}$	F150 accuracy	0	1,44E-03	Rectangular	2,5000	3,61	13,0	
From Characteristics of the thermometer under calibration								
$X_{7,1}$	Hysteresis	0	2,00E-03	Rectangular	2,5000	5,00	25,0	
$X_{7,2}$	Repeatability	$R_c(t)$	7,00E-04	Normal	2,5000	1,75	3,1	
$X_{7,3}$	PRT drift	0	8,66E-04	Rectangular	1	0,87	0,8	
$X_{7,4}$	PRT selfheating	0	2,17E-03	Rectangular	1	2,17	4,7	
$X_{7,5}$	PRT heat conduction	0	2,89E-03	Rectangular	1	2,89	8,3	
OTHER CONTRIBUTIONS								
X_8	AC/DC differences	0	1,2E-06	Rectangular	1,01E+02	0,12	0,01	
X_9	ITS-90 equation	0	0,7	Rectangular	1	0,70	0,49	
				Combined uncertainty		$u(t_C)$	**11,6**	mK
				Expanded uncertainty		$U(t_C)$	**23,15438**	**mK**

100 ºC -150 ºC

Quantity	Description	Value	Standard Uncertainty $u(x_i)$	Probability distribution	Sensitivity coefficient	Contribution to the combined Uncertainty $u(y_i)$, mK
From Laboratory Measurement System						
Bridge resolution	0	5,77E-06	Rectangular	1,06E+03	6,12	37,42
Bridge drift	0	2,31E-06	Rectangular	1,06E+03	2,45	5,99
Bridge accuracy	0	2,89E-06	Rectangular	1,06E+03	3,06	9,36
Repeatability	0	3,05E-06	Normal	1,06E+03	3,23	10,44
Standard resistor accuracy	0	5,77E-04	Rectangular	5,31E+00	3,07	9,40
Standard resistor drift	0	2,89E-04	Rectangular	5,31E+00	1,53	2,35
SPRT calibration	t_r(°C)	2,15E-03	Normal	1	2,15	4,62
SPRT drift	0	8,66E-05	Rectangular	1,06E+01	0,92	0,84
SPRT instabilities	0	2,30E-04	Rectangular	1	0,23	0,05
SPRT selfheating	0	8,66E-05	Rectangular	1	0,09	0,01
SPRT heat conduction	0	5,77E-03	Rectangular	1	5,77	33,33
Bath stability	0	1,00E-02	Rectangular	1	10,00	100,00
Bath axial uniformity	0	3,00E-03	Rectangular	1	3,00	9,00
Bath radial uniformity	0	3,00E-03	Rectangular	1	3,00	9,00
READING OF THERMOMETER UNDER CALIBRATION						
F150 resolution	0	5,77E-04	Rectangular	2,5000	1,44	2,1
F150 drift	0	1,33E-03	Rectangular	2,5000	3,32	11,0
F150 accuracy	0	1,44E-03	Rectangular	2,5000	3,61	13,0
From Characteristics of the thermometer under calibration						
Hysteresis	0	2,00E-03	Rectangular	2,5000	5,00	25,0
Repeatability	$R_c(t)$	3,20E-03	Normal	2,5	8,00	64,0
PRT drift	0	8,66E-04	Rectangular	1	0,87	0,8
PRT selfheating	0	2,17E-03	Rectangular	1	2,17	4,7
PRT heat conduction	0	0,0058	Rectangular	1	5,77	33,3
OTHER CONTRIBUTIONS						
AC/DC differences	0	1,1547E-06	Rectangular	101,2628533	0,12	0,01
ITS-90 equation	0	0,7	Rectangular	1	0,70	0,49

			Combined uncertainty	$u(t_C)$	**19,65232407**	**mK**
			Expanded uncertainty	$U(t_C)$	**39,30464815**	**mK**

SIC

Thermometer s/n: **9351416** large

Calibration Point: 0 °C

Quantity X_i	Value x_i	Unit	Probability distribution	Standard Uncertainty	Sensitivity Coefficient c_i	Unit	Contribution to the combined uncertainty $c_i \cdot u(x_i)$ °C	Contribution to the combined uncertainty
From Laboratory Measurement System								
Standard	*0,005*	°C	rectangular	0,002886751	1	°C	2,89E-03	8,33333E-06
Standard Drift	*0,001*	°C	rectangular	0,00057735	1	°C	5,77E-04	3,33333E-07
Standard reading	*0,00005*	°C	rectangular	2,88675E-05	1	°C	2,89E-05	8,33333E-10
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Triple point of water	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Homogeneity	*0*	°C	rectangular	0	1	°C	0,00E+00	0
Stability	*0*	°C	rectangular	0	1	°C	0,00E+00	0
Reading of the thermometer under calibration								
Thermometer reading	*0,000128*	°C	rectangular	7,38621E-05	1	°C	7,39E-05	5,45561E-09
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Standard deviation	*0,000205*	°C	normal	0,000204693	1	°C	2,05E-04	4,18991E-08
From characteristics of the thermometer under calibration								
Thermometer drift	*0,002048*	°C	normal	0,002048058	1	°C	2,05E-03	4,19454E-06

Combined uncertainty: *u* / ºC = 0,0037

Expanded uncertainty *k* = 2 : *U* / ºC = 0,0073

Thermometer s/n: **9351416** large

Calibration Point: 50 °C

Quantity X_i	Value x_i	Unit	Probability distribution	Standard Uncertainty	Sensitivity Coefficient c_i	Unit	Contribution to the combined uncertainty $c_i \cdot u(x_i)$ °C	Contribution to the combined uncertainty
From Laboratory Measurement System								
Standard	*0,005*	°C	rectangular	0,002886751	1	°C	2,89E-03	8,33333E-06
Standard Drift	*0,001*	°C	rectangular	0,00057735	1	°C	5,77E-04	3,33333E-07
Standard reading	*0,00005*	°C	rectangular	2,88675E-05	1	°C	2,89E-05	8,33333E-10
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Triple point of water	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Homogeneity	*0,001*	°C	rectangular	0,00057735	1	°C	5,77E-04	3,33333E-07
Stability	*0,0007*	°C	rectangular	0,000404145	1	°C	4,04E-04	1,63333E-07
Reading of the thermometer under calibration								
Thermometer reading	*0,000128*	°C	rectangular	7,38621E-05	1	°C	7,39E-05	5,45561E-09
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Standard deviation	*0,000742*	°C	normal	0,000742011	1	°C	7,42E-04	5,5058E-07
From characteristics of the thermometer under calibration								
Thermometer drift	*0,002048*	°C	normal	0,002048058	1	°C	2,05E-03	4,19454E-06

Combined uncertainty: *u* / ºC = 0,0038

Expanded uncertainty *k* = 2 : *U* / ºC = 0,0076

Thermometer s/n: **9351416** large

Calibration Point: 100 °C

Quantity X_i	Value x_i	Unit	Probability distribution	Standard Uncertainty	Sensitivity Coefficient c_i	Unit	Contribution to the combined uncertainty $c_i \cdot u(x_i)$ °C	Contribution to the combined uncertainty
From Laboratory Measurement System								
Standard	*0,005*	°C	rectangular	0,002886751	1	°C	2,89E-03	8,33333E-06
Standard Drift	*0,001*	°C	rectangular	0,00057735	1	°C	5,77E-04	3,33333E-07
Standard reading	*0,00005*	°C	rectangular	2,88675E-05	1	°C	2,89E-05	8,33333E-10
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Triple point of water	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Homogeneity	*0,002375*	°C	rectangular	0,001371207	1	°C	1,37E-03	1,88021E-06
Stability	*0,0082*	°C	rectangular	0,004734272	1	°C	4,73E-03	2,24133E-05
Reading of the thermometer under calibration								
Thermometer reading	*0,000128*	°C	rectangular	7,38621E-05	1	°C	7,39E-05	5,45561E-09
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Standard deviation	*0,005527*	°C	normal	0,0055267	1	°C	5,53E-03	3,05444E-05
From characteristics of the thermometer under calibration								
Thermometer drift	*0,002048*	°C	normal	0,002048058	1	°C	2,05E-03	4,19454E-06
				Combined uncertainty:	u / ºC =			0,0083
				Expanded uncertainty k = 2 :	U / ºC =			0,0165

Thermometer s/n: **9351416** large

Calibration Point: 150 °C

Quantity X_i	Value x_i	Unit	Probability distribution	Standard Uncertainty	Sensitivity Coefficient c_i	Unit	Contribution to the combined uncertainty $c_i \cdot u(x_i)$ °C	Contribution to the combined uncertainty
From Laboratory Measurement System								
Standard	*0,005*	°C	rectangular	0,002886751	1	°C	2,89E-03	8,33333E-06
Standard Drift	*0,001*	°C	rectangular	0,00057735	1	°C	5,77E-04	3,33333E-07
Standard reading	*0,00005*	°C	rectangular	2,88675E-05	1	°C	2,89E-05	8,33333E-10
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Triple point of water	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Homogeneity	*0,0009125*	°C	rectangular	0,000526832	1	°C	5,27E-04	2,77552E-07
Stability	*0,00685*	°C	rectangular	0,003954849	1	°C	3,95E-03	1,56408E-05
Reading of the thermometer under calibration								
Thermometer reading	*0,000128*	°C	rectangular	7,38621E-05	1	°C	7,39E-05	5,45561E-09
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Standard deviation	*0,002815*	°C	normal	0,002814523	1	°C	2,81E-03	7,92154E-06
From characteristics of the thermometer under calibration								
Thermometer drift	*0,002048*	°C	normal	0,002048058	1	°C	2,05E-03	4,19454E-06
				Combined uncertainty:	u / ºC =			0,0061
				Expanded uncertainty k = 2 :	U / ºC =			0,0122

Thermometer s/n: **9351416** large

Calibration Point: 200 °C

Quantity X_i	Value x_i	Unit	Probability distribution	Standard Uncertainty	Sensitivity Coefficient c_i	Unit	Contribution to the combined uncertainty $c_i \cdot u(x_i)$ °C	Contribution to the combined uncertainty
From Laboratory Measurement System								
Standard	*0,005*	°C	rectangular	0,002886751	1	°C	2,89E-03	8,33333E-06
Standard Drift	*0,001*	°C	rectangular	0,00057735	1	°C	5,77E-04	3,33333E-07
Standard reading	*0,00005*	°C	rectangular	2,88675E-05	1	°C	2,89E-05	8,33333E-10
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Triple point of water	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Homogeneity	*0,008125*	°C	rectangular	0,004690971	1	°C	4,69E-03	2,20052E-05
Stability	*0,01685*	°C	rectangular	0,009728352	1	°C	9,73E-03	9,46408E-05
Reading of the thermometer under calibration								
Thermometer reading	*0,000128*	°C	rectangular	7,38621E-05	1	°C	7,39E-05	5,45561E-09
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Standard deviation	*0,011412*	°C	normal	0,011411611	1	°C	1,14E-02	0,000130225
From characteristics of the thermometer under calibration								
Thermometer drift	*0,002048*	°C	normal	0,002048058	1	°C	2,05E-03	4,19454E-06

Combined uncertainty: u / ºC = 0,0161

Expanded uncertainty k = 2 : U / ºC = 0,0323

Thermometer s/n: **9351416** large

Calibration Point: 250 °C

Quantity X_i	Value x_i	Unit	Probability distribution	Standard Uncertainty	Sensitivity Coefficient c_i	Unit	Contribution to the combined uncertainty $c_i \cdot u(x_i)$ °C	Contribution to the combined uncertainty
From Laboratory Measurement System								
Standard	*0,005*	°C	rectangular	0,002886751	1	°C	2,89E-03	8,33333E-06
Standard Drift	*0,001*	°C	rectangular	0,00057735	1	°C	5,77E-04	3,33333E-07
Standard reading	*0,00005*	°C	rectangular	2,88675E-05	1	°C	2,89E-05	8,33333E-10
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Triple point of water	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Homogeneity	*0,0106*	°C	rectangular	0,006119913	1	°C	6,12E-03	3,74533E-05
Stability	*0,01245*	°C	rectangular	0,007188011	1	°C	7,19E-03	5,16675E-05
Reading of the thermometer under calibration								
Thermometer reading	*0,000128*	°C	rectangular	7,38621E-05	1	°C	7,39E-05	5,45561E-09
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Standard deviation	*0,004657*	°C	normal	0,004656756	1	°C	4,66E-03	2,16854E-05
From characteristics of the thermometer under calibration								
Thermometer drift	*0,002048*	°C	normal	0,002048058	1	°C	2,05E-03	4,19454E-06

Combined uncertainty: u / ºC = 0,0111

Expanded uncertainty k = 2 : U / ºC = 0,0223

Thermometer s/n: **9351461** Short

Calibration Point: 0 °C

Quantity X_i	Value x_i	Unit	Probability distribution	Standard Uncertainty	Sensitivity Coefficient c_i	Unit	Contribution to the combined uncertainty $c_i \cdot u(x_i)$ °C	Contribution to the combined uncertainty $(c_i \cdot u(x_i))^2$ °C
From Laboratory Measurement System								
Standard	*0,005*	°C	rectangular	0,002886751	1	°C	2,89E-03	8,33333E-06
Standard Drift	*0,001*	°C	rectangular	0,00057735	1	°C	5,77E-04	3,33333E-07
Standard reading	*0,00005*	°C	rectangular	2,88675E-05	1	°C	2,89E-05	8,33333E-10
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Triple point of water	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Homogeneity	*0*	°C	rectangular	0	1	°C	0,00E+00	0
Stability	*0*	°C	rectangular	0	1	°C	0,00E+00	0
Reading of the thermometer under calibration								
Thermometer reading	*0,000128*	°C	rectangular	7,38621E-05	1	°C	7,39E-05	5,45561E-09
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Standard deviation	*0,000128*	°C	normal	0,000127933	1	°C	1,28E-04	1,63668E-08
From characteristics of the thermometer under calibration								
Thermometer drift	**0,0023039**	°C	normal	0,002303897	1	°C	2,30E-03	5,30794E-06
						Combined uncertainty: *u* / ºC =		0,0038
						Expanded uncertainty *k* = 2 : *U* / ºC =		0,0076

Thermometer s/n: **9351461** Short

Calibration Point: 50 °C

Quantity X_i	Value x_i	Unit	Probability distribution	Standard Uncertainty	Sensitivity Coefficient c_i	Unit	Contribution to the combined uncertainty $c_i \cdot u(x_i)$ °C	Contribution to the combined uncertainty
From Laboratory Measurement System								
Standard	*0,005*	°C	rectangular	0,002886751	1	°C	2,89E-03	8,33333E-06
Standard Drift	*0,001*	°C	rectangular	0,00057735	1	°C	5,77E-04	3,33333E-07
Standard reading	*0,00005*	°C	rectangular	2,88675E-05	1	°C	2,89E-05	8,33333E-10
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Triple point of water	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Homogeneity	*0,000975*	°C	rectangular	0,000562917	1	°C	5,63E-04	3,16875E-07
Stability	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Reading of the thermometer under calibration								
Thermometer reading	*0,000128*	°C	rectangular	7,38621E-05	1	°C	7,39E-05	5,45561E-09
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Standard deviation	*0,000614*	°C	normal	0,000614078	1	°C	6,14E-04	3,77091E-07
From characteristics of the thermometer under calibration								
Thermometer drift	**0,0023039**	°C	normal	0,002303897	1	°C	2,30E-03	5,30794E-06
						Combined uncertainty: *u* / ºC =		0,0039
						Expanded uncertainty *k* = 2 : *U* / ºC =		0,0078

Thermometer s/n: **9351461** Short

Calibration Point: 100 °C

Quantity X_i	Value x_i	Unit	Probability distribution	Standard Uncertainty	Sensitivity Coefficient c_i	Unit	Contribution to the combined uncertainty $c_i \cdot u(x_i)$ °C	Contribution to the combined uncertainty
From Laboratory Measurement System								
Standard	*0,005*	°C	rectangular	0,002886751	1	°C	2,89E-03	8,33333E-06
Standard Drift	*0,001*	°C	rectangular	0,00057735	1	°C	5,77E-04	3,33333E-07
Standard reading	*0,00005*	°C	rectangular	2,88675E-05	1	°C	2,89E-05	8,33333E-10
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Triple point of water	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Homogeneity	*0,002375*	°C	rectangular	0,001371207	1	°C	1,37E-03	1,88021E-06
Stability	*0,0082*	°C	rectangular	0,004734272	1	°C	4,73E-03	2,24133E-05
Reading of the thermometer under calibration								
Thermometer reading	*0,000128*	°C	rectangular	7,38621E-05	1	°C	7,39E-05	5,45561E-09
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Standard deviation	*0,006448*	°C	normal	0,006447816	1	°C	6,45E-03	4,15743E-05
From characteristics of the thermometer under calibration								
Thermometer drift	**0,0023039**	°C	normal	0,002303897	1	°C	2,30E-03	5,30794E-06

Combined uncertainty: u / ºC = 0,0090

Expanded uncertainty k = 2 : U / ºC = 0,0179

Thermometer s/n: **9351461** Short

Calibration Point: 150 °C

Quantity X_i	Value x_i	Unit	Probability distribution	Standard Uncertainty	Sensitivity Coefficient c_i	Unit	Contribution to the combined uncertainty $c_i \cdot u(x_i)$ °C	Contribution to the combined uncertainty
From Laboratory Measurement System								
Standard	*0,005*	°C	rectangular	0,002886751	1	°C	2,89E-03	8,33333E-06
Standard Drift	*0,001*	°C	rectangular	0,00057735	1	°C	5,77E-04	3,33333E-07
Standard reading	*0,00005*	°C	rectangular	2,88675E-05	1	°C	2,89E-05	8,33333E-10
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Triple point of water	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Homogeneity	*0,0000*	°C	rectangular	0	1	°C	0,00E+00	0
Stability	*0,0100*	°C	rectangular	0,005773503	1	°C	5,77E-03	3,33333E-05
Reading of the thermometer under calibration								
Thermometer reading	*0,000128*	°C	rectangular	7,38621E-05	1	°C	7,39E-05	5,45561E-09
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Standard deviation	*0,010874*	°C	normal	0,010874293	1	°C	1,09E-02	0,00011825
From characteristics of the thermometer under calibration								
Thermometer drift	**0,0023039**	°C	normal	0,002303897	1	°C	2,30E-03	5,30794E-06

Combined uncertainty: u / ºC = 0,0129

Expanded uncertainty k = 2 : U / ºC = 0,0258

Thermometer s/n: **9351461** Short

Calibration Point: 200 °C

Quantity X_i	Value x_i	Unit	Probability distribution	Standard Uncertainty	Sensitivity Coefficient c_i	Unit	Contribution to the combined uncertainty $c_i \cdot u(x_i)$ °C	Contribution to the combined uncertainty
From Laboratory Measurement System								
Standard	*0,005*	°C	rectangular	0,002886751	1	°C	2,89E-03	8,33333E-06
Standard Drift	*0,001*	°C	rectangular	0,00057735	1	°C	5,77E-04	3,33333E-07
Standard reading	*0,00005*	°C	rectangular	2,88675E-05	1	°C	2,89E-05	8,33333E-10
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Triple point of water	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Homogeneity	*0,0052625*	°C	rectangular	0,003038306	1	°C	3,04E-03	9,2313E-06
Stability	*0,0102*	°C	rectangular	0,005888973	1	°C	5,89E-03	3,468E-05
Reading of the thermometer under calibration								
Thermometer reading	*0,000128*	°C	rectangular	7,38621E-05	1	°C	7,39E-05	5,45561E-09
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Standard deviation	*0,016171*	°C	normal	0,016170714	1	°C	1,62E-02	0,000261492
From characteristics of the thermometer under calibration								
Thermometer drift	**0,0023039**	°C	normal	0,002303897	1	°C	2,30E-03	5,30794E-06

Combined uncertainty: u / ºC = 0,0179

Expanded uncertainty k = 2 : U / ºC = 0,0358

Thermometer s/n: **9351461** Short

Calibration Point: 250 °C

Quantity X_i	Value x_i	Unit	Probability distribution	Standard Uncertainty	Sensitivity Coefficient c_i	Unit	Contribution to the combined uncertainty $c_i \cdot u(x_i)$ °C	Contribution to the combined uncertainty
From Laboratory Measurement System								
Standard	*0,005*	°C	rectangular	0,002886751	1	°C	2,89E-03	8,33333E-06
Standard Drift	*0,001*	°C	rectangular	0,00057735	1	°C	5,77E-04	3,33333E-07
Standard reading	*0,00005*	°C	rectangular	2,88675E-05	1	°C	2,89E-05	8,33333E-10
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Triple point of water	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Homogeneity	*0,011275*	°C	rectangular	0,006509624	1	°C	6,51E-03	4,23752E-05
Stability	*0,00595*	°C	rectangular	0,003435234	1	°C	3,44E-03	1,18008E-05
Reading of the thermometer under calibration								
Thermometer reading	*0,000128*	°C	rectangular	7,38621E-05	1	°C	7,39E-05	5,45561E-09
Bridge	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Bridge drift	*0,0005*	°C	rectangular	0,000288675	1	°C	2,89E-04	8,33333E-08
Standard deviation	*0,009365*	°C	normal	0,009364685	1	°C	9,36E-03	8,76973E-05
From characteristics of the thermometer under calibration								
Thermometer drift	**0,0023039**	°C	normal	0,002303897	1	°C	2,30E-03	5,30794E-06

Combined uncertainty: u / ºC = 0,0125

Expanded uncertainty k = 2 : U / ºC = 0,0250

ANNEX 2

COMPARISON PROTOCOL

Protocol

Comparison of 100 Ω platinum resistance thermometers

Edition 1

May 27th, 2004

1. PURPOSE

This document sets out the instructions for carrying out the comparison of 100 Ω (at 0 ºC) platinum resistance thermometers for which the Centro Español de Metrología (Spanish Metrology Center) will act as the pilot laboratory and the Servicio Autónomo Nacional de Metrología (National Autonomous Service of Metrology, SENCAMER) of Venezuela will act as laboratory coordinator, with the possibility of participation of CENAM of Mexico as the co-pilot laboratory and representative of SIM.

2. INTRODUCTION

The purpose of the comparison is to check the equivalency between the participant laboratories (see Annex 1) in the calibration of platinum resistance thermometers by comparison.

The calibration method of the traveler instruments will be by comparison in stable isothermal media against the reference standards of the laboratory.

Temperature values will be referred to the International Temperature Scale of 1990 (ITS-90).

The pilot laboratory will characterize and calibrate the two thermometers at the beginning and at the end of the comparison, will include the results of all participating laboratories and will issue a draft report that, after exposure and feedback from participants, will rise to the final report with the results of the comparison.

The co-pilot laboratory will calibrate both thermometers just after the initial calibration and before the final calibration of the pilot.

The coordinating laboratory is responsible for the proper movement between the laboratories and within the deadlines established in this protocol. If a participant had troubles for meeting the deadlines, it must notify the affected laboratories, remaining the responsibility of coordinating laboratory for reorganizing new deadlines, and inform to the pilot.

Participating laboratories must perform the measurements following the indications of this protocol and sending their results to the pilot laboratory in a time period not exceeding three weeks after of ending the calibration. Each laboratory will be responsible for PRT transporting up to the next laboratory according to the agreed circulation scheme (figure 1).

3. TRAVELER STANDARDS AND TRANSPORT METHOD

The traveler standards will be two 100 Ω (at 0ºC) platinum resistance thermometers of four reading terminals, length of 450 mm and diameter of 6,5 mm.

It is the responsibility of each participating laboratory the thermometers transportation up to the next laboratory, either by hand or using a professional carrier. In the latter case it shall notify the means of transport to the receiving laboratory. The receiving laboratory will send by fax or e-mail to the pilot laboratory the format shown in annex 2 once the first measurement at 0ºC be done and shall notify to the coordinating laboratory the date of reception of equipments.

4. CIRCULATION SCHEME

The circulation scheme (see figure 1) will be a single loop, the traveler thermometers begin and end at CEM.

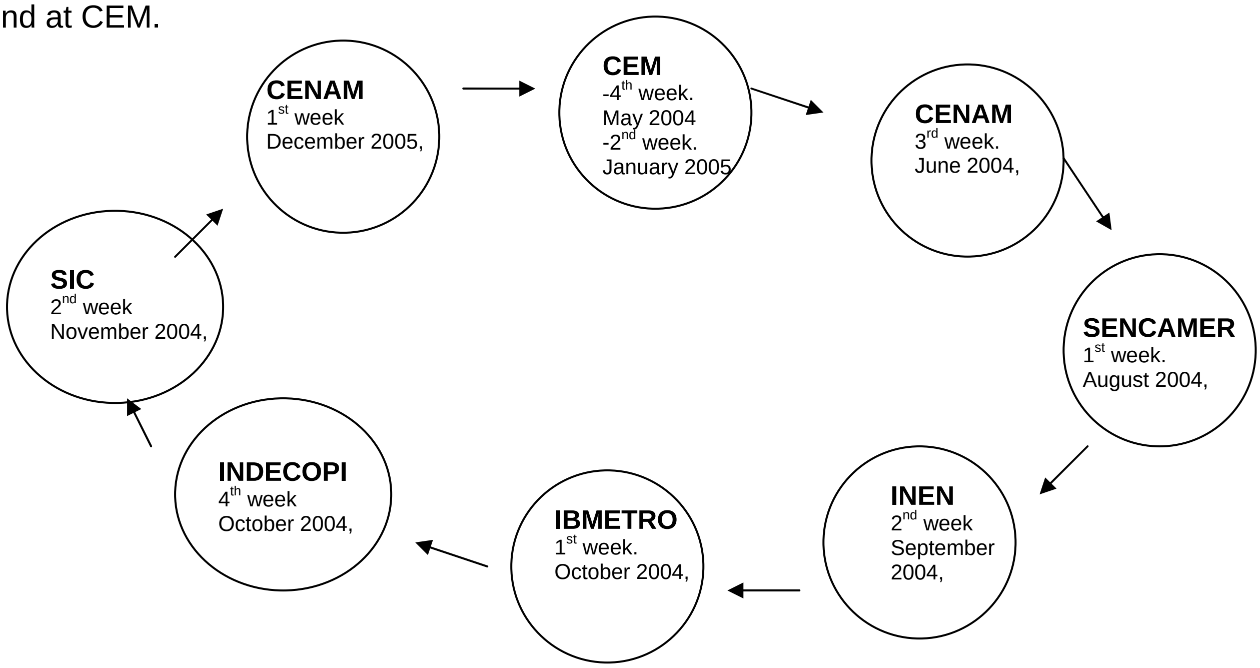

Figure 1, Circulation Scheme

The maximum time allowed to each laboratory for calibration of the two thermometers will be 20 working days, 15 for calibration and 5 for shipping and receiving for the next laboratory.

5. MEASUREMENT PROCEDURE

The measurand will be the electrical resistance of the thermometer, with four terminals at the temperatures shown below.

Each laboratory must follow their own procedures, using the media to get their best measurement capability for the calibration of platinum resistance thermometers by comparison. The measurements were performed in temperature values closed to:

0 ºC; 250 ºC; 200 ºC; 150 ºC; 50 ºC; 0 ºC; -20 ºC; -10 ºC, -30 ºC; -40 ºC;, 0 ºC

The calibration points will be done in the order shown, from the highest temperature to the lowest, including values of 0 ºC at the start of the calibration, at the middle and at the end.

The electrical resistance measurement will be performed with four terminals with 1mA current. If other current were used, it must be specified and determined the self-heating.

Each laboratory should measure the resistance value of the thermometers at 0 ºC upon reception; it must send its result to the pilot laboratory by fax or e-mail using the format shown in annex 2.

The values of resistance of the traveler thermometers at 0 ºC could be determined by each laboratory at the water triple point or at the ice point. In the latter case, the ice bath temperature must be measured with their working standards.

The self-heating of the thermometer will be determined at 0ºC.

6. EXPRESSION OF RESULTS

Each participant laboratory will send a report by fax or e-mail to the pilot laboratory within three weeks once calibration is complete, following the format shown in annex 3 including:

- Values of temperature and resistance in the calibration points of paragraph 5, uncertainty assigned and measurement current.
- Immersion depth of the thermometers in the isothermal media.
- Standards and equipment used.

7. CALCULATION OF UNCERTAINTIES

Each participant laboratory must complete the format shown in annex 3 for calculation of uncertainties. At least, the causes given below shall be quantified:

- X_1 : Reading of standards.
- X_2 : Calibration of standards.
- X_3 : Drift of standards.
- X_4 : Stability of isothermal media.

- X_5 : Uniformity of isothermal media.
- X_6 : Reading of thermometer under calibration.
- X_7 : Repeatability and/or hysteresis of the thermometer under calibration.

The report should explain briefly how estimate each of these causes (annex 4 shows an example of a complete uncertainty table).

8. EVALUATION OF RESULTS

The pilot laboratory will prepare a report about the comparison results maintaining the anonymity of the laboratories. They will be identified by a number, unless all participants agree otherwise.

In the evaluation of results is being sought the equivalence between the participating laboratories. For this purpose the reduced resistance values $W_{L,t}$ of each laboratory will be compared with the calibration obtained by the pilot laboratory $W_{R,t}$:

$$\Delta W_{\mathrm{L},t} = W_{\mathrm{L},t} - W_{\mathrm{R},t} \qquad (1)$$

where:

- $W_{L,\mathrm{t}}$:Value of R_t / $R_{0,01\,°\mathrm{C}}$ of laboratory L at temperature *t.*
- $W_{\mathrm{R},t}$: Value for R_t / $R_{0,01\,°\mathrm{C}}$ of pilot laboratory at temperature *t.*

Also for each laboratory in each calibration point the value of its standardized deviation coefficient will be calculated. It is defined as:

$$E_{\mathrm{L}t} = \frac{\left|W_{\mathrm{L}t} - W_{\mathrm{R}t}\right|}{\sqrt{U_{\mathrm{L}t}^2 + U_{\mathrm{R}t}^2}} \qquad (2)$$

where:

- $U_{\mathrm{L,t}}$: Expanded uncertainty of laboratory L at temperature *t.*
- $U_{\mathrm{R},t}$:Expanded uncertainty of pilot laboratory L at temperature *t*

ANNEX 1

PARTICIPANT LABORATORIES

- Centro Español de Metrología –CEM
  Área de Temperatura
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  Ph:
  Fax:
  Contact:
  E-Mail:

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  Fax: +591 237 0936
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- Servicio Autónomo Nacional de Metrología –SENCAMER
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ANNEX 2

RECEPTION FORMAT

In order to have information about the progress of the comparison and, if were necessary to take appropriate corrective actions, please the receiving laboratory will send by e-mail this form to the pilot laboratory, once the first measurement at 0 ºC be done and will communicate the date of receipt to the coordinator laboratory.

Thanks for your collaboration.

The traveler thermometers were received ____________________

There were no signs of damage in transport ☐

Observed damages:

- Are they serious? Yes/No
- Is it probably that the thermometers are still valid for use? Yes/No

Measurements at 0ºC:

- Temperature:________________________ ºC
- Resistance:__________________________ Ω
- Uncertainty: _________________________ ºC

Comments:

Participant:

E-mail:

ANNEX 3

DATA PRESENTATION FORMATS

INSTRUMENTATION USED

Name of the laboratory:

Equipment	Description	Mark	Model	Observations
Standard thermometers				
Measurement equipment				
Isothermal media				

RESULTS

NAME OF LABORATORY:

Temperature **0ºC**	**Resistance** **Ω**	**Uncertainty** **0ºC**	**Immersion depth** **cm**

Current intensity: [ ] mA

Self-heating at 0ºC : [ ] mºC

UNCERTAINTY CALCULATION

NAME OF LABORATORY:

Thermometer:

Calibration point(s):

Quantity X_i	Estimation of the quantity X_i	Unit	Probability Distribution	Standard Uncertainty	Sensitivity coefficients c_i	Unit	Contribution to the Combined Uncertainty $c_i.\ u(x_i)$ ºC
From laboratory measurement system							
X_1							
X_2							
X_3							
X_4							
X_5							
From reading of the thermometer under calibration							
X_6							
From characteristics of the thermometer under calibration							
X_7							
Others							

Combined uncertainty: u/ºC=

Expanded uncertainty for k=___: U/ºC=

ANNEX 4

EXAMPLE OF UNCERTAINTY CALCULATION

Name of laboratory: CEM

Thermometer: XXX

Point(s) of calibration: 90 ºC to 250 ºC

Quantity X_i	Estimation of the quantity X_i	Unit	Probability Distribution	Standard Uncertainty	Sensitivity coefficients c_i	Unit	Contribution to the Combined Uncertainty $c_i. u(x_i)$ ºC
From laboratory measurement system							
[(1)]$X_{1,1}$	2,0	Ω/Ω	Rectangular	$1{,}00x10^{-6}/\sqrt{3}$	[(2)]$R_s. S_t/\sqrt{2}$	ºC	0,000 1
$X_{1,2}$	0	Ω/Ω	Normal	$3{,}00x10^{-6}/2$	$R_s. S_t/\sqrt{2}$	ºC	0,000 3
$X_{1,3}$	0	Ω/Ω	Rectangular	$4{,}00x10^{-6}/\sqrt{3}$	$R_s. S_t/\sqrt{2}$	ºC	0,000 4
$X_{1,4}$	100	Ω	Normal	$2{,}80x10^{-4}/\sqrt{3}$	$L. S_t/\sqrt{2}$	ºC/Ω	0,000 1
$X_{1,5}$	0	Ω	Rectangular	$1{,}00x10^{-4}/\sqrt{3}$	$L. S_t/\sqrt{2}$	ºC/Ω	0,000 1
X_2	0	ºC	Normal	0,02/2	1	Dimensionless	0,010 0
X_3	0	ºC	Rectangular	$0{,}015/\sqrt{3}$	1	Dimensionless	0,010 0
X_4	0	ºC	Rectangular	$0{,}05/\sqrt{3}$	1	Dimensionless	0,002 9
X_5	0	ºC	Rectangular	$0{,}009/\sqrt{3}$	1	Dimensionless	0,005 2
From reading of the thermometer under calibration							
[(1)]$X_{6,1}$	2,0	Ω/Ω	Rectangular	$1{,}00x10^{-6}/\sqrt{3}$	[(2)]$R_s. S_t$	ºC	0,000 1
$X_{6,2}$	0	Ω/Ω	Normal	$3{,}00x10^{-6}/2$	$R_s. S_t$	ºC	0,000 4
$X_{6,3}$	0	Ω/Ω	Rectangular	$4{,}00x10^{-6}/\sqrt{3}$	$R_s. S_t$	ºC	0,000 6
$X_{6,4}$	100	Ω	Normal	$2{,}80x10^{-4}/\sqrt{3}$	$L. S_t$	ºC/Ω	0,000 7
$X_{6,5}$	0	Ω	Rectangular	$1{,}00x10^{-4}/\sqrt{3}$	$L. S_t$	ºC/Ω	0,000 3
From characteristics of the thermometer under calibration							
X_7	0	Ω	Normal	$3{,}7x10^{-3}$	s	ºC/Ω	0,009 5
Others	------	------	------	------	------	------	------

Combined uncertainty: u/ºC=0,017 4

Expanded uncertainty for k=2: U/ºC=0,035

[(1)]The uncertainty of the measurements of the resistance thermometers is estimated to be produced for many causes. By one side the resolution, drift and calibration ($X_{i,1}$, $X_{i,2}$,and $X_{i,3}$) of the comparator bridge and, by other side, calibration and drift of the standard electrical resistance ($X_{i,4}$,and $X_{i,5}$). A maximum correlation between the standards is considered.

[(2)]R_s: standard electrical resistance; L: reading of comparator bridge; S: thermometer sensitivity in ºC/Ω.