INTERNATIONAL COMPARISON OF PLATINUM RESISTANCE THERMOMETERS BETWEEN CHILE AND ECUADOR

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Abstract. An International Bilateral Comparison of Platinum Resistance Thermometers was performed between the National Metrology Institutes of Chile (LCPNT-CESMEC) and the Ecuadorian Standardization Institute of Ecuador (INEN), both represented by their National Laboratories of Temperature. This comparison was carried out in the range from -39 °C up to 232 °C. The final results obtained by each laboratory showed to be equivalent (En < 1) in the measured temperature range.

Keywords: Temperature, comparison, LCPNT-CESMEC, Chile, Ecuador, INEN, SIM.

INTRODUCTION

This comparison was developed under the technical and quality cooperation project signed between the government of Ecuador and the European Union, executed between 2007 and 2008, in which the national temperature laboratory of INEN participated.

The three main objectives were: to evaluate the performance of the temperature measurements that the national temperature laboratory of INEN was running, to propose actions for improvement, and to perform subsequent comparisons for verifying the effectiveness of such improvements.

Two steps were agreed and the whole process was completed between 2007 and 2008.

The pilot laboratory was the National Temperature Laboratory of Chile (LCPNT-CESMEC), which is accredited by the German Accreditation Body DAkkS (earlier DKD) since 2001.

COMPARISON

General guidelines.

A measurement protocol was given to each participant. It stated the following relevant technical aspects:

The first step was performed to compare the calibration of two Industrial Platinum Resistance Thermometer IPRT of 100 Ohm, covering the temperature range from -39 °C up to 232 °C. These artifacts are calibrated using the reference thermometers of each participant. The working instructions of each participant comply with the International Temperature Scale of 1990 (EIT 90) [1] general recommendations.

Calibrations of each participant were performed by direct comparison in stirred liquid baths. Results were analyzed using the difference in temperature obtained for each artifact when using the calibration coefficients determined for the participants and the Normalized Error (E_N). Only one measurement at -39 °C showed an $E_N > 1$ and corrective actions were agreed. A final report for this first step was emitted and signed by both participants.

The second step consisted in a comparison of an Standard Platinum Resistance Thermometer of 25,5 Ohm, covering the temperature range from -39 °C up to 232 °C. The same first step protocol to complete the measurements and analyze the results was followed. All temperatures show an $E_N < 1$. A final report for this second step was emitted and signed by both participants.

Uncertainties were evaluated according to the ISO *Guide to the Expression of Uncertainty in Measurement* [2].

Artifacts.

The LCPNT-CESMEC provided the artifacts to be compared in both steps. Artifacts features are shown in table 1.

Standards and Equipment

Features about standards and equipment are shown in table 2. Complementary equipment is shown in table 3.

TABLE 1. Comparison artifacts features.

Manufacturer	Model	Series	Range of measurement, °C	R(0 °C)	Nominal Alpha Coefficient .	Date of measurement
Isotech	T100-NTS587	K0812A	-40 a 232	100 Ω	0,00392	2007
ASL	T100-450-3	B595354	-40 a 232	100 Ω	0,00392	2007
Hart Scientific	5628	61084	-40 a 232	25 Ω	0,00392	2008

TABLE 2. Standards and equipment

Laboratory	Model	Manufacturer	Model	Series	Measure /Calibration Range	Traceability
LCPNT-CESMEC	SPRT 25 Ohm	Rosemount	162 GC	4592	PT-Hg … PF-Ga PT-water .PS-Zn	CENAM
	SPRT 25 Ohm	Rosemount	162 GC	4593	PT-Hg … PF-Ga PT-water . PS-Zn	CENAM
	Resistor 100 Ohm	Tinsley	5685 A	274560	100 Ohm	CENAM
	Bridge	ASL	F18	4135-001-163	0 …1,2999999	--
	Triple point of water	NPL	Type 32	1064	0,01 °C	NPL
INEN	SPRT 25 Ohm	Hart Scientific	5681	4592	PT-Hg … PF-Ga PT-water .PS-Zn	Hart Scientific
	SPRT 25 Ohm	Hart Scientific	5681	4593	PT-Hg … PF-Ga PT-water . PS-Zn	Hart Scientific
	Bridge	Fluke- Hart Scientific	1590	A63325	1Ω…10KΩ	---
	Triple point of water	Hart Scientific	Type B	D-G 1096	0,01 °C	---

TABLE 3.. Complementary equipment

Laboratory **r**	Description	Manufacturer	Model	Medium
LCPNT-CESMEC	Stirred liquid bath	Hart Scientific	7037	Alcohol / water
	Stirred liquid bath	Hart Scientific	6022	Silicon oil
INEN	Stirred liquid bath	Hart Scientific	7312	Alcohol / water
	Stirred liquid bath	Isotech	915	Alcohol
	Stirred liquid bath	Hart Scientific	6022	Silicon oil

Comparison round.

The comparison sequence for both steps was performed as follows:

- LCPNT-CESMEC performs the initial measure,
- LCPNT-CESMEC transports the artifacts by hand to INEN,
- INEN performs its measure,
- LCPNT-CESMEC transports the artifacts by hand (return),
- LCPNT-CESMEC checks the artifact to complete its measure.

RESULTS

Each participant documents their results in a traceable calibration certificate. To evaluate the temperature difference **ΔT(INEN - LCPNT)** between each participant, the **R [Ohm]** reported in the calibration certificate by the INEN is used to fix a temperature point to be compared. The temperature **t_{90} [°C]** calculated by each participant for each artifact was obtained using the coefficients informed in the individual calibration certificate. The uncertainties **U [mK]** used to evaluate de normalized **E_N** error correspond to the uncertainties informed by each participant in the individual calibration certificate for each artifact.

At the firth step, results showed to be equivalent for both IPRTs Isotech (see table 4) and ASL (see table 5) in the measured temperature range. Only at the nominal temperature equal to -38 °C, the EN > 1 was obtained for both artifacts. Investigation showed that the stirred liquid bath used by the INEN had an agitation problem.

Corrective actions were agreed for the second step. IPRTs instability measured at the triple point of water R0.01 [Ohm] for both artifact at the complete comparison round at the first step showed to be < 4 mK (see table 6).

In the case of the second step, results showed to be equivalent for the Hart Scientific SPRT (see table 7) in the measured temperature range. All measured temperatures showed EN < 1.

Corrective actions agreed in the first step showed to be appropriate. SPRTs instability measured at the triple point of water R0.01 [Ohm] at the complete comparison round at the second step showed to be < 2,5 mK (see table 8).

TABLE 4.. Results for Isotech IPRT, s/n K0812A

R, Ohm	Nominal Value	t_{90}/INEN, °C	U/INEN, mK	t_{90}/CESMEC, °C	U/CESMEC, mK	ΔT(INEN - LCPNT)	En
189.051 86	232	231.505	30	231.493	15	11.8	0.35
177.080 36	200	199.393	30	199.382	15	10.6	0.32
160.950 66	157	156.639	30	156.622	15	17.5	0.52
131.611 89	80	80.275	20	80.269	12	6.1	0.26
111.973 75	30	30.151	20	30.147	12	3.6	0.15
106.143 11	15	15.417	20	15.413	12	3.8	0.16
100.014 02	0	0.001	10	-0.004	10	5.0	0.35
92.078 92	-20	-19.850	30	-19.856	15	6.2	0.19
84.457 88	-40	-38.768	30	-38.809	15	40.5	1.21

TABLE 5.. Results for ASL IPRT, s/n B535954

R, Ohm	Nominal Value	t_{90}/INEN °C	U/INEN mK	t_{90}/CESMEC °C	U/CESMEC mK	ΔT(INEN - LCPNT)	En
189.147 43	232	231.506	30	231.501	15	4.8	0.14
177.167 37	200	199.395	30	199.391	15	3.9	0.12
160.023 38	157	156.631	30	156.624	15	6.8	0.20
131.661 90	80	80.276	20	80.270	12	5.8	0.25
112.00845	30	30.151	20	30.148	12	2.9	0.13
106.173 23	15	15.417	20	15.413	12	3.6	0.15
100.039 59	0	0.001	10	-0.004	10	4.1	0.29
92.097 74	-20	-19.850	30	-19.857	15	7.2	0.21
84.471 65	-40	-38.768	30	-38.808	15	40.5	1.21

TABLE 6. IPRTs instability at the firth step

Artifact	Manufacturer	Model	Medium*
Isotech	LCPNT-CESMEC (initial)	100.019 60	3.8
	INEN	100.018 07	
	LCPNT-CESMEC (final)	100.018 60	
ASL	LCPNT-CESMEC (initial)	100.044 80	2.0
	INEN	100.043 99	
	LCPNT-CESMEC (final)	100.044 20	

*The Δ**T(max – min)** absolute value is calculated with de difference between the **R0.01 maximum – R0.01 minimum** measured for each artifact by each participant.

TABLE 7. Results for Hart Scientific SPRT, s/n 61084

R, Ohm	Nominal Value	t_{90}/INEN °C	U/INEN mK	t_{90}/CESMEC °C	U/CESMEC mK	ΔT(INEN - LCPNT)	En
47.143 986	232	232.111	25	232.109	15	2,3	0.08
44.167 191	200	200.066	25	200.064	15	1,7	0.06
40.126 042	157	157.070	25	157.068	15	1,2	0.04
32.789 211	80	80.445	15	80.444	12	1,0	0.05
27.868 946	30	30.052	15	30.051	12	1,6	0.08
26.393 262	15	15.089	15	15.087	12	1,9	0.10
24.899 335	0	0,010	4	0.008	9	2,3	0.24
22.902 602	-20	-20.037	20	-20.038	15	1,4	0.06
20.980 237	-40	-39.220	20	-39.220	15	0,5	0.02

TABLE 8. SPRTs instability at the second step

Artifact	Manufacturer	Model	Medium*
Hart Scientific	LCPNT-CESMEC (initial)	24.899 58	2.4
	INEN	24.899 34	
	LCPNT-CESMEC (final)	24.899 46	

*The Δ**T(max – min)** absolute value is calculated with de difference between the **R0.01 maximum – R0.01 minimum** measured

CONCLUSION

Concluded the bilateral comparison, final results in the second step (see table 7) showed an improvement respect the results in the first step (see table 5 and 6). Improvement proposed by the LCPNT-CESMEC to INEN in its measurement system and its working instructions showed to be effective.

Calibration performed by comparison in the range -40 °C to 232 °C by the participant showed to be equivalent in accordance with the claimed CMCs.

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REFERENCES

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