Comparison of the calibration of noble metal thermocouples up to 1100 °C. BoM, CEM and CESMEC-LCPNT

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INTRODUCTION

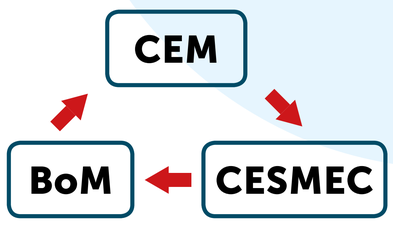
The key and supplementary comparisons between National Metrology Institutes (NMIs) is a fundamental tool for the establishment of the Calibration and Measurement Capabilities (CMCs) in the NMIs and they contributes in a definitive way to the homogenization and robustness of the world measurements. In this context, the National Metrology Institutes from the Republic of Macedonia (BoM) and Chile (CESMEC - LCPNT) agreed with the Spanish Metrology Centre (CEM) about the organization of a comparison on the calibration of noble metal thermocouples up to 1100 °C. The comparison was coordinated and evaluated by CEM that also provided a type R thermocouple to be compared and provided the comparison reference value.

The objective of this comparison was to establish the degree of equivalence in the calibration of thermocouples in fixed points and/or by comparison from 419.527 °C (freezing point of zinc) up to 1084.62 °C (fixed point of Cooper). The measurements of this comparison were performed from March 2016 to June 2017 and last participant report was received on December 2017.

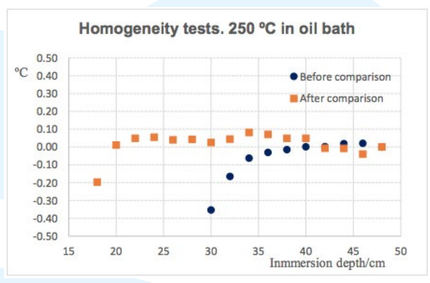
This comparison was registered in the BIPM Key Comparison data base as Euramet T.S5 and it was considered as a Euramet project with the number 1392.

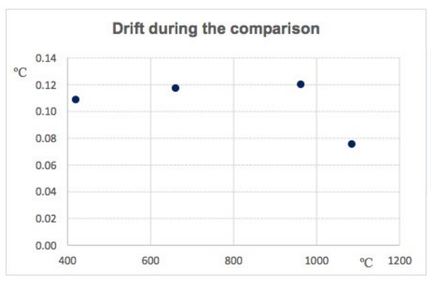
MEASUREMENTS

Schedule



Transfer standard:
type R thermocouple constructed by CEM





Uncertainties

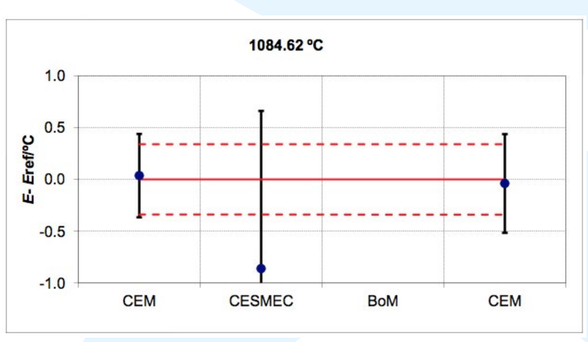
Description	Unit	Uncertainty contribution												
		Cu FP			Ag FP			Al FP				Zn FP			
		CEM (Initial)	CESMEC	CEM (Final)	CEM (Initial)	CESMEC	CEM (Final)	CEM (Initial)	CESMEC	BoM	CEM (Final)	CEM (Initial)	CESMEC	BoM	CEM (Final)
Determination of the calibration point temperature	µV	1.154	3.186	1.154	0.248	3.083	0.248	0.111	0.016	0.024	0.111	0.026	0.012	0.011	0.026
Drifts of the means used to determine the calibration point	µV	0.000	1.475	0.000	0.000	1.427	0.000	0.000	0.062	0.130	0.000	0.000	0.039	0.900	0.000
Voltmeter calibration	µV	0.001	2.610	0.001	0.001	2.570	0.001	0.001	2.480	0.500	0.001	0.001	2.410	0.500	0.001
Voltmeter resolution	µV	0.003	0.029	0.003	0.003	0.029	0.003	0.003	0.029	0.003	0.003	0.003	0.029	0.003	0.003
Voltmeter drift	µV	0.289	1.300	0.289	0.289	1.300	0.289	0.289	1.300	0.060	0.289	0.289	1.300	0.060	0.289
Thermocouple homogeneity	µV	0.738	1.805	1.846	0.633	1.827	1.584	0.394	1.809	0.400	0.986	0.224	1.803	0.400	0.558
Reference junction	µV	0.014	0.118	0.014	0.014	0.114	0.014	0.014	0.104	0.100	0.014	0.014	0.096	0.100	0.014
dispersion of the measurements	µV	0.459	0.000	0.587	0.282	0.000	0.135	0.110	0.000	0.000	0.049	0.100	0.000	0.000	0.184
other	µV	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.160	0.000	0.000	0.000	1.160	0.000
Source Homogeneity	µV	0.000	6.371	0.000	0.000	6.166	0.000	0.000	2.703	0.000	0.000	0.000	2.507	0.000	0.000
Source Stability	µV	0.000	3.422	0.000	0.000	3.312	0.000	0.000	0.270	0.000	0.000	0.000	0.251	0.000	0.000
Parasite fem	µV	0.000	0.300	0.000	0.000	0.300	0.000	0.000	0.300	0.000	0.000	0.000	0.300	0.000	0.000
Circuit Connections	µV	0.000	0.400	0.000	0.000	0.400	0.000	0.000	0.400	0.000	0.000	0.000	0.400	0.000	0.000
Combined Standard Uncertainty	µV	1.47	8.76	2.27	0.79	8.51	1.63	0.51	4.33	1.34	1.03	0.38	4.17	1.61	0.66
	ºC	0.17	1.02	0.26	0.09	1.01	0.19	0.06	0.55	0.17	0.13	0.05	0.54	0.21	0.09

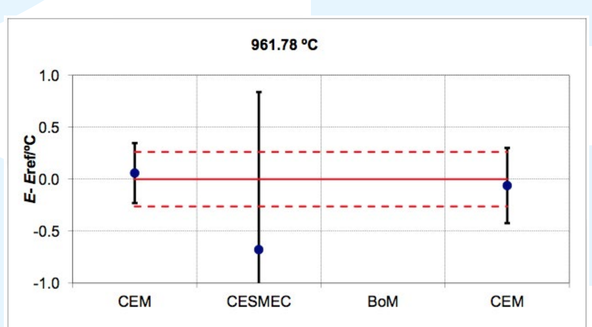
ANALYSIS

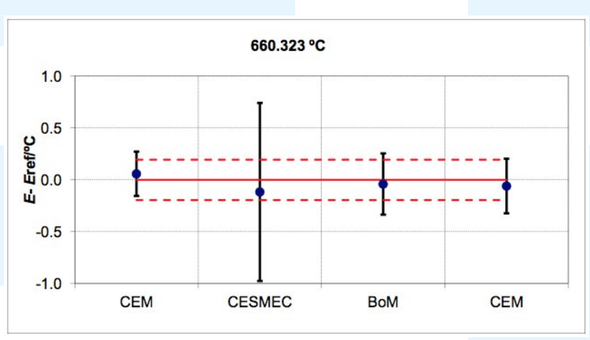
The reference value of the comparison has been calculated by the mean of the initial and final CEM calibrations results at each calibration point.

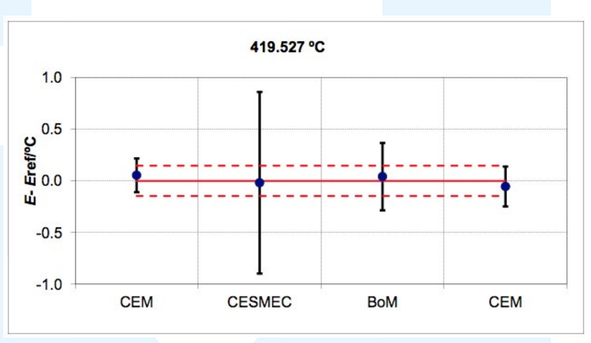
The uncertainty of the difference between the result of each participant and the corresponding reference value was estimated according to the following equation:

$$u(E(t_{ref}) - E_{ref}) = \sqrt{u_p^2 + u_{CEM}^2 + u_{drift}^2 + u_{interpol}^2}$$









CONCLUSIONS

The results of the comparison are satisfactory. The three institutes are compatible with a coverage factor $k = 2$ in all the calibration points and in the case of **aluminium** and **zinc** they are even compatible for a coverage factor $\boldsymbol{k} = 1$.

This comparison is already approved and published (Metrologia, Volume 56, Number 1A https://iopscience.iop.org/article/10.1088/0026-1394/56/1A/03002/meta).

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