BIPM Capacity Building & Knowledge Transfer Programme

2021 BIPM - TÜBİTAK UME Project Placement

REPORT

Project Name	Strengthening of IMBiH capacities in the field of temperature measurement
Description	Construction and characterization of platinum-based thermocouples and calibration of constructed thermocouples by fixed point method
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Date	06.09.2021.-06.10.2021.

Motivation & Introduction

The proposed project is needed for improvement of measurement capabilities at Institute of Metrology of Bosnia and Herzegovina (IMBIH) in the field of temperature measurements based on existing equipment. The basic task of the Laboratory for Temperature is the realization of the temperature unit and the international temperature scale ITS-90, dissemination of the traceability in temperature measurement and calibration of primary and secondary level contact type temperature measuring instruments. Measurement and calibration capabilities are confirmed at the International Bureau of Weights and Measures (BIPM) for calibration of the resistance, digital and glass thermometers in the range of -40 °C to 250 °C. From the beginning of activities in the field of temperature at IMBiH, laboratory staff have actively participated in different intercomparisons, international research EURAMET, EMRP and EMPIR projects in this field. The laboratory offers calibration at the fixed points of the temperature in the range of -38.8344 ˚C to 961.78 ˚C (AgFP) and at the secondary level, the laboratory offers calibration by comparison of sensors and temperature measuring instruments in the range of -40 °C to 1300 °C, but unfortunately without published CMCs at BIPM KCDB.

On the other side the Contact Temperature Laboratory within TÜBİTAK UME has published the CMCs in various temperature ranges what will ensure IMBIH to improve the scientific/research capabilities and technical competence in this area. The realization of the project is aimed at improvement of existing and acquisition of new knowledge and gaining the practical skills, what will contribute to the further development of the Institute of Metrology of Bosnia and Herzegovina, it's scientific/research potential and publication of new CMCs in near future.

Research

The project was designed to consist of two parts: construction and characterization of two platinum-based R type thermocouples at TÜBİTAK UME and calibration of constructed thermocouples by fixed point method in the range from 230 °C to 1084 °C, which are explained in the following subsections.

Construction of UME made R type thermocouples

Noble metal thermocouple is one of the common secondary level interpolation instruments for the contact thermometry. As one of the best-known members of the group of thermocouples employing platinum in combination with platinum-rhodium alloys is platinum-13% rhodium alloy versus platinum (or type R) thermocouple, we constructed 2 thermocouples (R1 and R2) of this type during the project realization. R type thermocouple can be used at very high temperatures up to about 1450 ^{0}C.

The thermocouples were constructed according to the following procedure:

- Cleaning of the thermoelements which are pure 99.999% with pure ethanol and distilled water
- Electrical anneal of each thermoelement by 50 Hz alternating current of 13 A for 4 h which can be seen in the figure 1
- Mounting and construction of reference, shown in figure 2
- Furnace anneal of the thermocouples at 1144 ^{0}C for 12 h to improve thermoelectric stability

Figure 1 Electrical annealing

Figure 2 Mounting

Characterization of UME made R type thermocouples

Characterisation was done according to ITS-90 at the fixed points copper, silver, aluminium, zinc and tin with a high precision nanovoltmeter. Repeatability of measurements was checked at the Ag before and after 62 h furnace anneal, we got repeated measurements of the thermocouples emf with difference lower than $\pm$0.5 µV. Immersion profiles of both thermocouples at Ag plateau before and after furnace anneal are presented in figure 4 which demonstrates a good homogeneity with maximum emf deviations of $\pm$ 0.7 µV over the length in withdrawal range 0 cm – 10 cm, indicating sufficient thermoelectric stability.

Figure 3 Constructed thermocouple – measurement on Ag fixed point

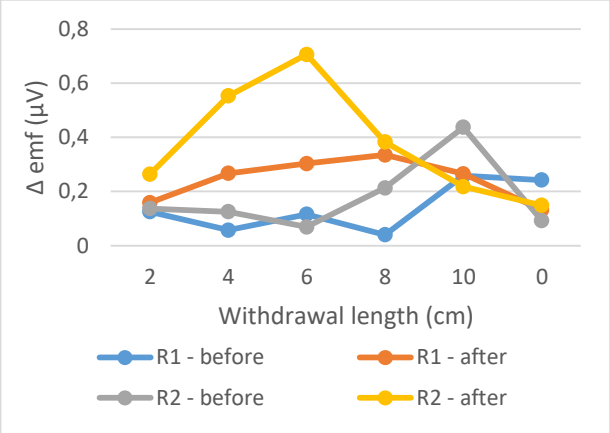

Figure 4 Immersion profiles of thermocouples at Ag

Calibration of constructed thermocouples by fixed point method

Calibrations were done on the fixed points which are stable temperature sources. The obtained average values of both thermocouples at each fixed point and thermocouples reference values are presented in the table 1. The deviation of the average values obtained at each fixed point for both thermocouples from the reference table values can be seen in the table 2. Immersion tests were performed at all fixed points in the range from 0 cm to 10 cm, whose results are presented in the figure 5. Additionally, during 2021 "BIPM - TÜBİTAK UME project placements" we took e-learning course and participate webinar on CIPM MRA which helped me to better understand overall CIPM MRA processes.

Table 1 Thermocouples reference and obtained average values

Fixed points	Temperature (°C)	Emf (μV)	R1 - average (μV)	R2 - average (μV)	Seebeck Coefficient (mV/°C)
Tin	231.928	1756.23	1754.05	1756.23	9.2
Zinc	419.527	3611.3	3610.32	3612.38	10.5
Aluminum	660.323	6277.09	6279.44	6280.28	11.6
Silver	961.78	10003.43	10012.25	10012.14	13.1
Copper	1084.62	11640.43	11651.56	11651.35	13.6

Table 2 The deviation of thermocouples in μV and °C

Thermocouple	Tin FP	Zinc FP	Aluminum FP	Silver FP	Copper FP
R1 - deviation (μV)	-2.18	-0.98	2.35	8.82	11.13
R1 - deviation (˚C)	-0.24	-0.09	0.20	0.67	0.82
R2 - deviation (μV)	0.00	1.08	3.19	8.71	10.92
R2 - deviation (˚C)	0.00	0.10	0.28	0.66	0.80

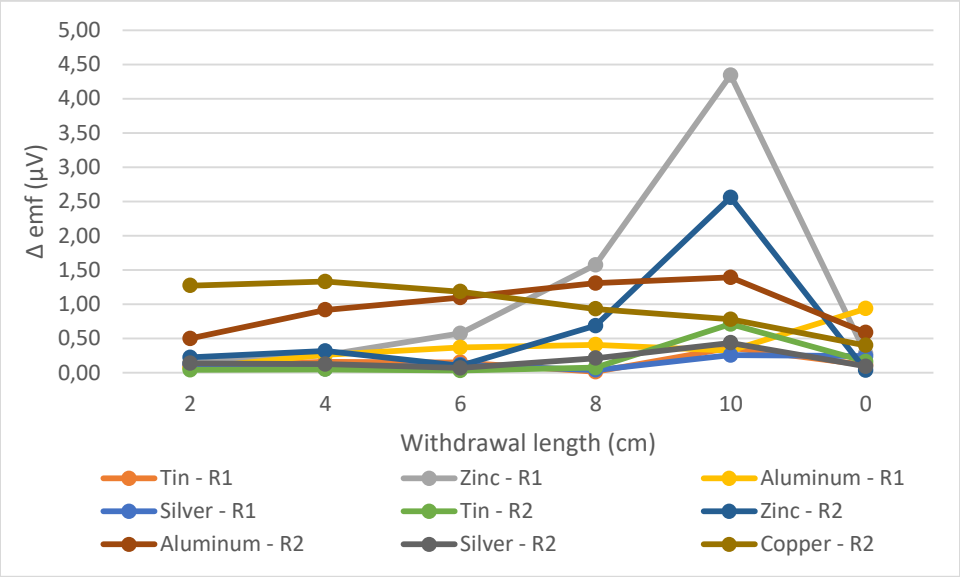

Figure 5 Immersion profiles of thermocouples at each fixed point

Conclusions and Future Work

This project was great opportunity to see and work with facilities which IMBiH does not have for construction of thermocouples and fixed point of the copper. By the realisation of the project I learned calibration on the fixed points, whose knowledge will be implemented at IMBiH for high temperature measurements. As a result I acquired valuable knowledge and experience.

Acknowledgements

I would like to thank the BIPM and TÜBİTAK UME for the opportunity to participate in this project. It was a pleasure to work in UME together with people who were willing to help. I would particularly like to thank my lecturer MSc Narcisa Arifović, Head Senior Researcher in Temperature laboratory for her unselfish transfer of knowledge and for all help and effort she made to be sure all my needs were met.