BIPM Capacity Building & Knowledge Transfer Programme

2022 BIPM - TÜBİTAK UME Project Placement

REPORT

Project Name	Knowledge transfer on High-Temperature Thermocouple Measurement, Humidity Measurement, and Infrared Temperature Measurement for use in the measurement and calibration services provided by the National Metrology Laboratory of the Philippines (NML)
Description	This project aims to establish the participant's knowledge and expertise in radiation thermometry, humidity, and contact thermometry to develop systems and standards to address the high-level traceability needs of local industries.
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Motivation & Introduction

As the de-facto NMI of the Philippines, the NML provides metrological traceability needed by industry through its measurement and calibration services which include temperature measurements and humidity measurements using thermocouples and IR thermometers and chilled mirror hygrometers/dew-point meters, respectively.

While the NML has acquired standards and equipment to perform these services, the personnel performing the measurement and calibration work still have limited knowledge and practical experience, and training in these measurement areas. Also, to better serve the calibration needs of the Philippine industry, the NML has applied for accreditation by DAkkS Germany under the terms of ISO 17025 wherein a nonconformity was issued because of a lack of training on aforementioned measurement scopes. With this, the BIPM – TUBITAK UME Project Placement is a timely opportunity to help equip the NML personnel with the required skills, hands-on calibration experience, and technical know-how to provide the much-needed service of high-temperature measurements and humidity.

Research

My project started in the Radiation thermometry laboratory with the initial introduction to methodology in general and in temperature metrology. The first part of the practical training is the calibration of infrared thermometer calibrators. Infrared calibrators are served as the blackbody sources (i.e., a gray body with known emissivity) for the calibration of Thermal Infrared Radiation Thermometers (TIRTs). Infrared calibrators, due to their wide active area are good sources for calibration of TIRTs, while most industrial TIRTs have large spot sizes and this spot size (up to several tens of cm) varies with the distance between the target and the thermometer. In more advanced TIRTs, such as Heitronics TRT IV.82 there is a small spot size (about 7 mm) at a focal distance. A laser pointer is used to align and center the IR Thermometer or Pyrometer to the blackbody target. The distance between the optical sensor of the IR thermometer and the blackbody target must be the focal distance of the IR thermometer.

The Emissivity determination of the Infrared calibrators is the first measurement needed in the calibration of IR thermometer calibrators. The measurement was done using a reference IR Thermometer and a contact thermometer such as a Digital Thermometer with a Thermocouple probe or an RTD. The IR Thermometer and the Digital Contact Thermometer reading must be the same or close to each other. To reach this at a certain set temperature of the Infrared calibrator (let's say at 300 °C), the readings of the Contact Thermometer and IR Thermometer are compared when the emissivity of the latter is set to 1. If the readings of the IR Thermometer are lower than that of the contact thermometer the emissivity is changed to 0.99, 0.98, etc. while the readings will be the same or very close to one another. The emissivity at which the readings of the same values, are accepted as the emissivity of the IR calibrator. This measurement is repeated at different temperature settings as different temperatures may vary the emissivity of the IR thermometer calibrator.

The second important parameter of the IR calibrator that should be checked before the calibrations are the blackbody target surface uniformity. To check this the IR thermometer must be moved to the left, right, up, and down at least by 1 cm accordingly. The IR thermometer must be in a perpendicular position to the blackbody target.

The following measurement are taken during the calibration:

- Ref. Thermometer reading
- Device Under Calibration (DUC) reading
- Stability
- Uniformity
- Repeatability
- Reproducibility

I learned that the alignment of the reference thermometer to the surface of the blackbody calibrator and the determination of the IR thermometer calibrator's correct emissivity greatly affect the measurement results. This includes the uncertainty of temperature measurement and temperature stability. I also learned new calibration procedure, the calibration of IR Thermometer Calibrator, that will be a potential new calibration service that can be offered by our laboratory.

Apart from learning about radiation temperature measurement, a webinar for the CIPM MRA process was conducted by Mr. Chingis KUANBAYEV of BIPM expounding on the topics of how the measurement comparisons are coordinated following the guidelines stated in CIPM MRA-G-11, Quality management systems in CIPM MRA-G-12, and CIPM MRA-G-13 for the Calibration and measurement capabilities.

The next area of my project was about Humidity Measurement and Calibration. The program starts with the practical training on the calibration of hygrometer and humidity chamber. Humidity Chamber served as the humidity and temperature sources for the calibration of Hygrometers and testing of other materials, while Hygrometers are usually used to measure the ambient air temperature and humidity. Commercial hygrometers, due to their slow response time, long stabilization time are required before the measurement. Setting up the Reference Hygrometer/Dew-Point Meter and the Device Under Calibration (DUC) inside the Humidity Chamber, the distance between the dew point meter sensor and of the hygrometers or its sensor must be at the minimum distance to have the same measurement condition during calibration.

I learned that the stabilization time of the humidity and temperature inside the humidity chamber greatly affect the measurement results. This includes the uncertainty of temperature measurement and temperature stability. I also learned new calibration procedure, the characterization and calibration of Humidity/Climatic Chamber, that will be a potential new calibration service that can be offered by our laboratory.

The last part of my program was about Thermocouple calibration at the Contact Thermometry Laboratory. Practical training starts with calibration by fixed-point on different noble metals like Silver and copper. The second part of the practical training is the calibration by comparison using reference standard thermocouples. In the fixed-point calibration, melting or freezing plateau must be obtained before the measurement begins. The length of the plateau greatly depends on the furnace temperature setting. Setting the temperature too high above the melting point or too low below the freezing point will shorten the length of the plateau. For the calibration by comparison, reference thermocouple and DUC must be immersed together with the same immersion depth inside the furnace. After stabilization, the measurement readings were compared and if there's a difference of about 1 K, the immersion of one of the thermocouples is adjusted, this is due to the tip of the thermocouple might be the same immersion depth but the junction point inside the protection tube were on different location.

I learned that besides the temperature stabilization; immersion depth inside the furnace greatly affects the measurement results. This includes the uncertainty of temperature measurement and temperature stability.

Conclusions and Future Work

With the knowledge gained from this capacity building, I planned to:
1. Create a calibration procedure for the Calibration of the Infrared Thermometer Calibrator and Humidity Chamber as a new service of the NML of the Philippines.
2. Impart these new learnings to my dear colleagues in the Philippines. A presentation about the calibration of the IR thermometer calibrator using a Pyrometer, Humidity Chamber Calibration and Thermocouple Calibration shall be conducted.
3. Prepare a project proposal for the Philippines' realization of SI unit for the temperature, especially for radiation thermometry.

Acknowledgments

I would like to express sincerest thanks and appreciation to the people behind this joint training initiative, for allowing me to learn from the expert and experience the state-of-the-art laboratories of an advanced NMI like UME through participating in this 5th cycle of BIPM-TUBITAK UME Project Placements.

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Aside from the new experience and learnings, I would like to commend the camaraderie from the UME staff, researchers, and linkages established with other colleagues coming from different NMIs through this capacity building. I am hoping for the continuation of the alike partnership and to be a gateway to more collaboration for developing a better world through the science of measurement. Hoping that this will not be our last in participating in the BIPM-TUBITAK UME Project Placement as we still have a lot of things to learn and implement in our NMIs.