

TUBITAK UME 2024-2026

As a first nontechnical but noteworthy remark, it should be noted that, within the scope of the BIPM–TÜBİTAK UME Project Placement Programme, twelve researchers from ten different countries and metrology institutes visited the Temperature and Thermodynamic Metrology Division of TÜBİTAK UME during the last six years. During their placements, they developed technical skills through various research and training activities, with an average stay exceeding two months per participant.

In Contact Thermometry field,

- The Acoustic Gas Thermometry system working in the range between $-40\text{ }^{\circ}\text{C}$ and $30\text{ }^{\circ}\text{C}$ was established. Preliminary studies on the estimation of T-T90 was carried out. Laboratory involved and contributed in EPM DireK-T project with the infrastructure.
- The studies on the manufacture and metrological characterization of CO₂ and SF₆ triple point cells was completed successfully and especially CO₂ triple point has been identified as a good candidate for a possible replacement of Triple point of Mercury. The most of the work was performed within the scope of EMPIR Real-K project.
- “Mini” cells for thermocouple calibrations and “self-validating” and “dual type” thermocouples to assess the drift of thermocouples were developed under EMPIR Metfor TC project which was coordinated by TUBITAK UME
- UME Contact Thermometry laboratory is coordinating the project EPM D4Temp project related to advanced digital infrastructure for harmonised temperature metrology.
- Maintenance of ITS-90 scale has been achieved through the inclusion of new UME-made fixed point cells (from In FP to Ag FP) and compared to current reference cells to establish traceability. The studies on the construction of Fe-C and Co-C eutectic fixed point cells for thermocouple calibrations were continued.
- TUBITAK UME participated in CCT.K7-2021, EURAMET.T-K9 comparisons and has been pilot laboratory for EURAMET.T-7.4 and GULFMET.T-K9 comparisons

In Radiation Thermometry Field,

- A Source Size Effect (SSE) measurement system for radiation thermometers has been developed to cover an aperture range of 3–100 mm using both direct and indirect methods.
- A system for the assessment of radiation thermometer detector linearity has been developed for the temperature range from $962\text{ }^{\circ}\text{C}$ to $3000\text{ }^{\circ}\text{C}$.
- A measurement benchmark for the radiometric calibration and metrological characterization (e.g., NETD) of thermal cameras, in accordance with the latest

standards, has been established. Continuous improvements to the system and associated software are ongoing.

- A calibration system compliant with the ITS-90 temperature scale has been established for infrared forehead thermometers. Participation in the CCT-K11 blackbody temperature comparison (34.5 °C to 41.5 °C) within the EURAMET framework has been completed.
- Within the EU-funded EMPIR “Real-K” project, thermodynamic temperature realization was established at TÜBİTAK UME in the range of approximately 1100 K to 3000 K. Through this project, TÜBİTAK UME, together with five other advanced NMIs, carried out scale realization and supported thermodynamic temperature assignments with associated uncertainties for three new high-temperature reference fixed points.
- A bilateral comparison with INRIM (Italy) in the temperature range from 150 °C to 1100 °C was successfully completed within the EURAMET project 1457 (EURAMET.T-S7).
- A fixed-point filling and construction system has been established for ITS-90 fixed-point blackbody cells as well as eutectic fixed-point blackbody cells.
- Within the EU-funded EMPIR “MultiFixRad” project, TÜBİTAK UME, together with LNE-CNAM as an advanced NMI, supported and trained other emerging NMIs in establishing their own radiation temperature scales.
- TÜBİTAK UME participated in the EURAMET comparison T-K10 and has completed the measurement campaign covering the temperature range of 962 °C to 2600 °C.
- Within the scope of the EMPIR “MultiFixRad” project, TÜBİTAK UME developed an open-source software package, disseminated worldwide via GitHub and Zenodo, for the complete evaluation of ITS-90 and primary relative radiometry routines for the realization of thermodynamic temperature from 1100 K to 3500 K. A working version for the 150 °C to 1100 °C range is currently under development.

In Humidity Field,

The Laboratory is extending its capability by:

- Calibration of dew-point hygrometers from 20 °C to 90 °C by using high-range dew-point generator system is under development
- FTIR spectroscopy infrastructure for low frost point gas measurement has been established under the 20IND06 PROMETH2O project.
- A new 2P–2T low frost point generator has been installed in the laboratory. It is traceable to temperature and pressure standards. It extends the current range from –95 °C FP to +10 °C DP.
- A new 2P–2T humidity generator has also been integrated into the laboratory with traceability to temperature and pressure standards. It extends primary-level humidity and air temperature calibration capability. It expands the air temperature range from –10 °C to +85 °C and the humidity range from 10 °C to 95 °C. Additionally, it extends the dew and frost point range from –35 °C FP to +80 °C DP.

- Within the scope of soil and solid (plant origin, paper and wood-based) materials moisture measurements:
 1. A Primary-Level Evolved Water Vapor Measurement System for simultaneous measurement of soil water and moisture has been developed and validated. The system is capable of providing measurement results simultaneously based on two different principles: one specifically for water content and the other based on loss-on-drying (LoD), including volatile substances.
 2. An LED-Based Multispectral Discrete Spectrometer has been designed, developed, and validated.
 3. Two portable transfer standards of different sizes, namely the Near-Range Soil Moisture System (NRSMS) based on fiber-coupled spectrometers operating in the Visible–Near Infrared (Vis-NIR) range, have been designed, implemented, and calibrated.
 4. Calibration procedures for point-scale TDR sensors have been established, and differences according to sensor type have been investigated. The calibration method has been validated using soils from the TÜBİTAK campus.
- CMC has been approved for the range of 10 %rh to 95 %rh at -10 °C, with the uncertainty of 0,8 %rh to 3,5 %rh.
- CMC has been approved for the range of 31 %rh to 50 %rh at between -10 °C and 70 °C, with the uncertainty of 0,75 %rh to 3 %rh.

UME Humidity Laboratory participated and completed the measurements of the following comparisons:

- Interlaboratory comparison, EURAMET project 1459 (Air temperature from -40 °C to 60 °C)
- Bilateral comparison (EURAMET Project 1434) from 10 °C to -80 °C with VTT MIKES is concluded
- Final Report of GULFMET.T-S1 Relative Humidity Comparison will be published in 2026.
- Interlaboratory comparison, EURAMET P1685 (Intercomparison of soil moisture measurement)
- Supplementary comparison, GULFMET.T-S1.2024 (Supplementary comparison of relative humidity) measurement in progress.

In Thermophysical Properties field,

- In the last year, a dilatometer based on the differential principle, operating over the temperature range from -180 to +2800, has been established, and the calibration service has commenced.
- A laser-induced thermographic phosphor thermometer has been built, characterized, calibrated, and validated for precision surface temperature measurements.