



## Short Report on Activities at TÜBİTAK UME Ulusal Metroloji Enstitüsü in the Fields of Mass and Related Quantities

Dr Yasin Durgut

TÜBİTAK Ulusal Metroloji Enstitüsü  
Barış Mahallesi, Dr.Zeki Acar Caddesi No:1  
P.K. 54, 41470, Gebze – Kocaeli / TÜRKİYE

### Introduction

This report is prepared to acknowledge the Consultative Committee of Mass and Related Quantities (CCM) with the related activities pursued in the National Metrology Institute (UME) of Türkiye. The report summarizes the status of national standards, as well as highlighting the recent activities within the framework of the CIPM MRA and R&D in the fields covered by the CCM.

### Organization

TÜBİTAK Ulusal Metroloji Enstitüsü (UME) is the national metrology institute and the highest technical authority in Türkiye for the field of scientific metrology. TÜBİTAK UME operates as a national reference laboratory in metrology under the auspices of the Scientific and Technological Research Council of Türkiye (TÜBİTAK) placed under the Ministry of Industry and Technology. It meets the requirements for calibration and testing laboratories as defined in the ISO/IEC 17025 standard. It is a fundamental task of TÜBİTAK UME to realize and maintain the standards of the measurement units in compliance with the International System of Units (SI) and to disseminate them, above all within the framework of legal and industrial metrology as well as persuading its scientific and technological development to anticipate new measurement and testing requirements in the areas of energy, safety, health, and environmental protection. TÜBİTAK UME provides government authorities and key economic players with the technical assistance they require to draft new regulations and standards at the national level.

It is worth mentioning that activity in the fields of mass and related quantities is shared by 8 laboratories of TÜBİTAK UME. They are the following: Acoustics Laboratory (Gravity), Electrodynamics Laboratory, Fluid Mechanics Laboratory, Force Laboratory (Force-Torque-Hardness), Mass Laboratory, Pressure Laboratory, Vacuum Laboratory, Volume, Density and Viscosity Laboratory.

### Status of National Standards

Being responsible for the realization, maintenance and dissemination of units TÜBİTAK UME has national measurement standards for the following quantities in the Mass and Related Quantities (MRQ) field:

- Low pressure (Vacuum) from  $1 \cdot 10^{-4}$  Pa to  $5 \cdot 10^3$  Pa
- Pressure from  $5 \cdot 10^3$  Pa Pa to 500 MPa both in hydraulic and pneumatic media

- Helium Leak rate detection in vacuum ( $2 \cdot 10^{-5}$  mbarl/s -  $2 \cdot 10^{-6}$  mbarl/s)
- Volume and density of solids in the range of 1 g – 50 kg
- Mass, from 1 mg to 50 kg E1 and E2 (over 50 kg) mass standards
- Kinematic viscosity of Newtonian liquids in the range from 0,5 mm<sup>2</sup>/s to 100000 mm<sup>2</sup>/s
- Dynamic viscosity of Newtonian liquids in the range 0,5 mPa·s - 100 000 mPa·s
- Force up to 3 MN
- Torque up to 1 kN·m
- Rockwell, Brinell and Vickers hardness
- Water flow from 0,01 m<sup>3</sup>/h to 2000 m<sup>3</sup>/h
- Gravity acceleration

## Staff

CCM related activities have been carried out by 35 employees working at 8 different laboratories of TÜBİTAK UME. Furthermore, 10 out of 35 people have PhD degree. The work experience of the senior staff working in the field of Mass and Related Quantities metrology is more than 19 years.

## Calibration/Testing Services

Calibration and measurement capabilities (CMCs) of TÜBİTAK UME in the fields of Mass and related quantities (MRQ) cover the sub-fields of mass standards, force, pressure, density, hardness, torque, gravity and viscosity. Currently, TÜBİTAK UME has a total of 108 CMC entries in the MRQ field. 14 new CMC entries in the field of hardness and a single entry in the field of density have been published on the BIPM Key Comparisons Database (KCDB) over the reporting period.

On average TÜBİTAK UME annually performs about 1200 calibrations for customers in the MRQ fields. Around 50% of certificates issued by TÜBİTAK UME bear the CIPM MRA logo.

As more than 100 accredited calibration laboratories became operational in Türkiye during the past ten years, a slight decrease in the number of calibrations performed by TÜBİTAK UME for customers occurred. These laboratories are accredited mainly for calibration of mass, pressure, force, torques, hardness, density and viscosity calibrations.

## Comparisons

TÜBİTAK UME has a total of 81 comparison records on the KCDB in the field of MRQs, 54 of which are key and 27 are supplementary comparisons. 6 RMO keys and 9 supplementary comparisons were/are piloted by TÜBİTAK UME.

In the last reporting period from 2021 to 2023, TÜBİTAK UME participated in 15 interlaboratory comparisons, 9 of which are key and 6 of them are supplementary comparisons. The breakdown of the comparisons participated between 2021 and 2023 according to their types and subject fields is presented in Table 1.

The number of comparisons piloted by TÜBİTAK UME is presented in Table 1 in brackets. The following key comparisons are piloted by TÜBİTAK UME: COOMET.M.P-K15, CCM.F-K1.a.2022, EURAMET.M.M-K7.

As TÜBİTAK UME has an important responsibility for the contribution of national quality infrastructure, the institute regularly organizes bilateral and multilateral comparisons for accredited laboratories inside the country in the field of mass and related quantities.

**Table 1.** Statistics of the participating comparisons in the framework of the CIPM MRA

Type of comparison	Density	Force	Fluid Flow	Gravity	Viscosity	Hardness	Mass standards	Pressure and Vacuum
CIPM key	1			1				
EURAMET key	4	1 (1)				1	1 (1)	1
EURAMET supplementary						2		
COOMET key								1 (1)
COOMET supplementary							1	
GULFMET key								
GULFMET supplementary	1							
<b>Total / key</b>	<b>5</b>	<b>1</b>		<b>1</b>		<b>1</b>	<b>1</b>	<b>2</b>
<b>Total/supplementary</b>	<b>1</b>					<b>2</b>	<b>1</b>	

### Research and Other Projects

Besides providing calibration services, TÜBİTAK UME is strongly involved in research work in all sub-fields falling into the CCM scope. R&D projects are the most important field of activity of the institute. TÜBİTAK UME plans and aligns its activities in line with priorities described in the CCM WG Strategy Document (<https://www.bipm.org/utis/en/pdf/CCM-strategy-document.pdf>) and EURAMET Strategic Research Agenda (<https://www.euramet.org/publications-media-centre/documents/>). Furthermore, TÜBİTAK UME has placed a growing emphasis on research activities that cross into areas that are outside its traditional remit as a national metrology institute. It is worth mentioning that TÜBİTAK UME is one of the active partners in joint research projects under the European Metrology Research Program managed by EURAMET and jointly funded by European Commission and participating states.

A summary of a few selected R&D projects is presented below.

#### **18SIB08 ComTraForce “Comprehensive Traceability for Force Metrology Services”.**

The aim of the joint research project in the framework of the EMPIR Program is to provide calibration services in the field of mechanical and material testing through the development of the methods and guidelines needed for comprehensive traceability of static, continuous and dynamic force measurements. TÜBİTAK UME has contributed to the project by developing infrastructure for continuous and dynamic force measurements under all work packages. The project was successfully completed in February 28, 2023. More details about the project can be found on the project website (<https://www.ptb.de/empir2019/comtraforce/home/>).

#### **20IND13 SAFEST “Sustainable advanced flow meter calibration for transport sector”**

The project started in June 2021. The aim of the joint research project in the framework of the EMPIR Program is to provide the foundation for advanced flow metrology in the transport sector ensuring reliable fuel consumption measurements as needed in road and maritime transport. By enabling characterizations of flow meters closer to operational conditions and a better

consideration of the impact of the fuel properties on the flow measurement innovation in the transport sector will be fostered and the increased deployment of sustainable alternative transport fuels supported. Moreover, the results will contribute to appropriate emission calculations.

TÜBİTAK UME is involved in realization of the density and viscosity measurements within the capability of its laboratory. Of particular relevance for this project is TÜBİTAK UME's long-term experience in density and viscosity measurements of a broad range of liquids which was further expanded by 17RPT02 RhoLiq project within the EMPIR Programme and its know-how and capabilities of measurements at temperatures up to 100 °C for viscosity and 200 °C for density, and insights into the realization of density measurements at high pressures. More details about the projects can be found on the project website (<https://www.ptb.de/empir2021/safest/the-project/>)

### **20NRM2 MFMET “Establishing metrology standards in microfluidic devices”**

The project started in June 2021. The aim of the joint research project in the framework of the EMPIR Programme is to establish metrology standards in microfluidic devices with the primary objective to contribute to the development of globally accepted standards for microfluidics and disseminate them to end-users in the industry (health, pharmaceutical) and academia.

TÜBİTAK UME contributes to the project for the development of flow control concepts, terms and components to be used in microfluidics. The flow quantities and liquid properties to be used for the development of test protocols will be identified and prioritized. The test protocols for at least 3 flow-related quantities (such as flow rate, flow speed, liquid volume) relevant to microfluidic devices and at least 3 liquid properties (such as density, viscosity, and refractive index) will be developed within the frame of the project.

More details about the projects can be found on the project website (<https://mfmet.eu/>)

### **22RPT01 Tracind BVK-H, Traceability for Indentation Measurements in Brinell-Vickers-Knoop Hardness**

The project to be coordinated by the TÜBİTAK UME will start in September 2023. The joint research project in the framework of the European Partnership on Metrology (EPM) Programme aims at investigation of the indentation measurement phenomena and providing a better-defined, more consistent, unified and reliable measurement and traceability methodology to overcome the inconsistency between the NMIs and lower levels of indentation (hardness) measurements as well as inter-NMIs problem. The project outcomes will be used in the next-generation hardness definition, instrumentation and standardization to improve the accuracy of testing material in all engineering fields; aerospace, automotive, health, industry and research-development studies.

### **Development of Transfer Standards for Traceability of Hardness Diamond Indenter Calibration Systems**

The project financially supported by GSO/GULFMET aims at the development and metrological characterization of transfer standards to be used for constitution of the traceability of every component of Rockwell and Vickers hardness diamond indenter calibration systems present at NMIs of the GULF countries. The design of the transfer standards has been completed and the production process is still ongoing. The project is scheduled to be completed by the end of 2023.

### **Kibble Balance Project at TUBITAK UME**

The work on the establishment of the Kibble Balance system has been continued. Currently, UME Kibble Balance-3 (UME KB-3) system is installed for realizing kilograms via the Planck constant.

The distinctive features of the UME KB-3 experiment regarding its design and operation are given below:

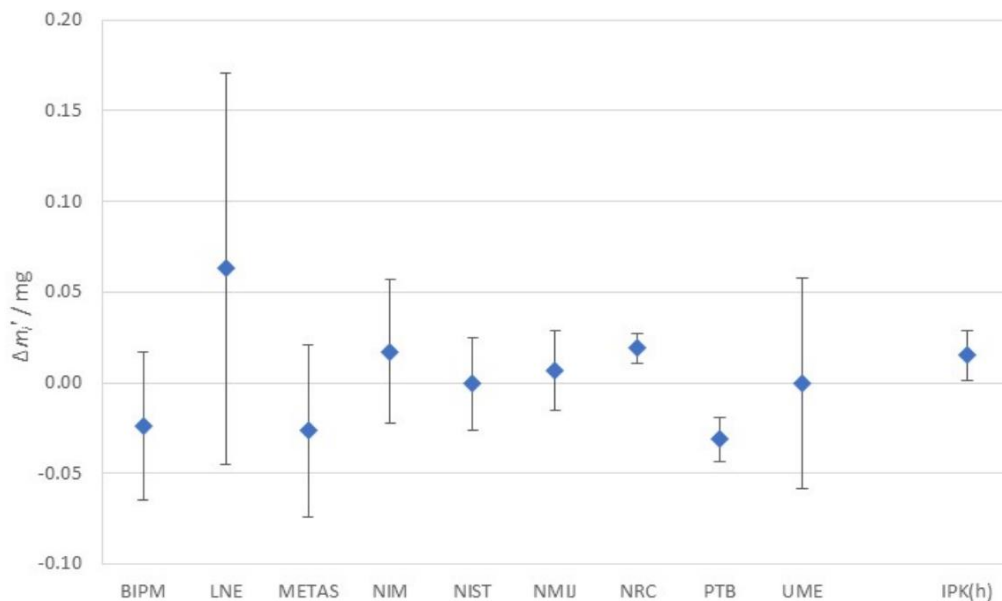
- Novel dynamical measurement procedure
- Local vacuum around the cubic mirror on the top of the moving magnet for determination of the displacement of the magnetic circuit concerning the coil with sufficient accuracy
- Compact design including a moving magnetic circuit and a stationary coil
- Simultaneous testing of Faraday's Law of Induction and Ampere's Law of Force

The Kibble Balance system established at TÜBİTAK UME is presented in Fig. 1. The current relative uncertainty is  $7.7 \cdot 10^{-8}$ .



**Fig. 1.** Air operating UME Kibble Balance

UME has participated in the 2<sup>nd</sup> CCM key comparison of realizations of the kilogram (CCM.M-K8.2021), which results are presented in Fig. 2.



**Fig. 2.** CCM.M-K8.2021 results

Differences  $\Delta m_i'$  between mass values attributed to 1 kg mass standards using the realization experiment of the participants and the KCRV as well as associated standard uncertainties are presented on Fig. 2. The difference between mass values based on the BIPM working standards, traceable to the Planck constant through the IPK, and those based on the reference value is also indicated on the Fig. 2.

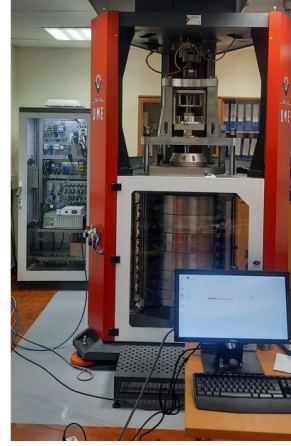
Preparations for the 3<sup>rd</sup> CCM key comparison of realizations of the kilogram (2023) are in progress.

## **Design and Development of Rockwell-Brinell-Vickers Hardness Standards**

In the framework of the internally supported project, two primary hardness standard machines were designed, produced and established at TÜBİTAK UME. One is Rockwell-Brinell-Vickers Hardness Standard Machine and the other one is High Load Brinell Hardness Standard Machine. Both machines are with dead-weight force application system and a laser interferometer optic system for the realization of the measurement cycle and indentation depth measurement. The designed and established machines are shown on Fig. 3 and Fig. 4.



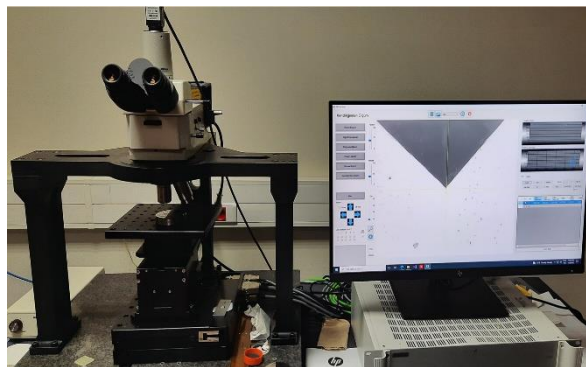
**Fig. 3.** Rockwell-Brinell-Vickers Hardness Standard Machine



**Fig. 4.** High Load Brinell Hardness Standard Machine

## **Constituting Traceability in Brinell and Vickers Indentation Measurements**

Under an internally supported project, an indentation measurement system was designed and established to provide traceability for Brinell and Vickers hardness indentation measurements. The system picture is given in Fig. 5.



**Fig. 5.** Brinell and Vickers Hardness Indentation Measurement System

## **Other Activities**

### **BIPM-TÜBİTAK UME project placements**

TÜBİTAK UME is running a joint training together with the BIPM entitled “BIPM-TÜBİTAK UME project placements” for transferring knowledge and experience to young metrologists from the

BIPM Member States or Associates. Lectures are delivered by experts both from TÜBİTAK UME and BIPM. The participants have the opportunity to enrich their technical skills via training in the laboratories of TÜBİTAK UME. Overall, 47 participants from 29 countries took part in the initiative. 6 participants passed training in various TÜBİTAK UME laboratories involved in activities in the fields covered by mass and related quantities.

Information about participants of the period from 2021 to 2023 of the program is summarized in Table 2.

**Table 2.** Information about participants of the BIPM-TÜBİTAK UME project placements

<b>Year</b>	<b>Cycle</b>	<b>Participant's Institute</b>	<b>Country</b>	<b>Laboratory</b>
2022	5 <sup>th</sup>	NMIE	Ethiopia	Force
2022	5 <sup>th</sup>	Tanzania Bureau of Standard	Tanzania	Mass

The applications for the 6<sup>th</sup> cycle of the placements will be collected until the 30<sup>th</sup> of April 2023 and the training within the 6<sup>th</sup> cycle will start on-site on the 4<sup>th</sup> of September 2023.

More details about the joint training can be found on the following website (<https://www.bipm.org/en/committees/cb/cbkt/wg/cbkt-project-tubitak>)

### **Publications**

The outcomes of activities carried out in the field of Mass and Related Quantities over the period from 2021 to 2023 have been published in more than 50 publications in international, national journals and proceedings of national and international conferences.