TÜBİTAK

UME

TÜBİTAK UME
LABORATORIES

2013

Contents

FOREWORD

Dear Readers,

Metrology, the science of measurement, is the central nerve in the spine of our high-tech world. If we cannot measure properly, we also cannot understand nature and cannot control, manufacture or process reliably. The provision of measurement capability is part of the technical infrastructure that underpins a country's science, engineering, and technology landscape for government, industry, and academia. New measurement techniques and technologies stimulate and support innovation in products, processes and services.

For success in trade, companies must operate within a regulatory framework based upon measurement confidence, which ensures fairness in global markets and eliminates technical barriers to trade. This is supported by an established infrastructure of traceable measurements linked seamlessly to the national standards maintained in National Metrology Institutes in each country.

The first recorded metrology activities in our country date back to the 15th century. In 1481, during the reign of the Ottoman Empire, the Law on Commerce, Weights and Measures (the so called Municipality Law of Bursa) was put into force, particularly for silk products. The decimal metric system was introduced in 1869 and our country was one of the first signatories of the Metre Convention in 1875. After the establishment of the Republic of Turkey in 1923, the law on the adoption of the decimal metric system was put into force in 1931 and subsequent metrology activities were mostly centred on legal metrology. Rapid industrialisation during the 1960s and 1970s generated an urgent need for high level scientific metrology services in Turkey. After the establishment of the National Physical and Measurement Standards Centre in 1986, the first metrology activities for dissemination of traceability in the country were started. In 1992, the name of the centre was changed to the National Metrology Institute of Turkey (Ulusal Metroloji Enstitüsü - UME) and laboratories were moved to a newly constructed building. Implementation of one UNIDO and two consecutive World Bank projects aimed at improving the national quality infrastructure of Turkey allowed UME to develop the facilities available today. On 14 October 1999, UME signed the CIPM MRA and had one of the first calibration measurement capabilities (CMCs) listed in the Key Comparison Database on the BIPM website.

Today, UME operates under the administrative umbrella of the Scientific & Technological Research Council of Turkey (TÜBİTAK) and is therefore formally called TÜBİTAK UME. Its main duties are to establish and maintain national measurement standards in accordance with the SI Units, pursuing its scientific and technological research in order to anticipate new measurement and testing requirements in the areas of energy, safety, health, quality and environmental protection and to represent Turkey at an international level in the field of metrology. TÜBİTAK UME meets the requirements for calibration and testing laboratories as defined in the EN ISO/IEC 17025. Currently, a staff of more than 200 in different technical disciplines is employed across more than 40 laboratories.

April, 2013

Dr. Fatih ÜSTÜNER
Director (A.)

NATIONAL METROLOGY INSTITUTE of TURKEY

On January 14, 1982 the Prime Ministry issued a decision for the establishment of a national metrology centre for primary measurements in order to respond to increasingly sophisticated measurement needs of society and industry. As the nation's premier public scientific and tehnical research agency, TÜBİTAK was assigned to conduct a feasibility study for this purpose. In 1984, the Prime Ministry commissioned TÜBİTAK to establish a metrology centre upon the approval of the feasibility study and its conclusions.

In 1986, the National Physical and Technical Measurement Standards Centre was inaugurated and the first laboratories were put into operation in the same year.

In 1992 the National Physical and Technical Measurement Standards Centre was renamed as the National Metrology Institute (UME), and at the beginning of 1997, UME was administratively separated from the TÜBİTAK Marmara Research Centre to continue its activities as an autonomous unit of TÜBİTAK.

Investment in UME's metrology infrastructure has since continued without interruption parallel to the country's development goals and rapid economic growth. The institute now operates more than 40 laboratories, grouped into the three broad categories of physical, mechanical and chemical measurements, and employs a highly qualified staff of more than 200 persons.

TÜBİTAK UME has become a well developed institute with the new investments for measurements in the fields of chemistry, environment, bio-metrology, EMC, acoustics and high voltage providing traceability within the country and integration to the international metrology system.

MISSION

To conduct research and development in the area of metrology towards the establishment of uniformity and reliability in measurements through the development, improvement, maintenance and dissemination of internationally accepted reference measurement standards and techniques for the purpose of contributing to the nation's quality of life and economic competitiveness.

VISION

To become a worldwide solution provider in the area of metrology.

QUALITY MANAGEMENT SYSTEM

As an institution that conducts scientific research in line with technological developments with an awareness of its national and international responsibilities, TÜBİTAK UME is committed to:

- Ensure the highest levels of satisfaction by fully and duly meeting customer and stakeholder demands through a focus on anticipating their expectations and needs,

- Deliver services based on a quality management system that meets the requirements of TS EN ISO/IEC 17025 and ISO Guide 34 and whose effectiveness is under continual improvement,
- Conduct institutional activities in accordance with the quality management system and with conscientious employees whose skill development is assured,
- Abide by the principles of transparency, confidentiality and impartiality,
- Advance towards institutional objectives taking employee satisfaction into account.

All given services are under the TÜBİTAK UME Quality Management System that is set-up according to TS EN ISO/IEC 1725 “General requirements for the competence of testing and calibration laboratories”.

TÜBİTAK UME’s Quality Management System and proficiency in calibration and testing are assessed periodically by TC-Q (Technical Committee for Quality) under EURAMET (European Association of National Metrology Institutes).

In 2002 and 2008, the TÜBİTAK UME Quality Management System was peer reviewed by EURAMET TC-Q at pre-defined periods. Successful assessment resulted in international recognition of the TÜBİTAK UME Quality Management System.

TÜBİTAK UME and the Turkish Accreditation Agency (TÜRKAK) cooperate in the provision of measurement traceability to accredited calibration and test laboratories in Turkey.

The calibrations and test services of TÜBİTAK UME have also been accredited by the Turkish Accreditation Agency (TÜRKAK) according to the TS EN ISO/IEC 17025 standard.

TÜBİTAK UME AT THE INTERNATIONAL LEVEL

TÜBİTAK UME has achieved a high profile in the international metrology community with its rapid development. TÜBİTAK UME is a full member of the European Association of National Metrology Institutes (EURAMET), A Focus for Analytical Chemistry in Europe (EURACHEM) and the International Measurement Confederation (IMEKO). TÜBİTAK UME was one of the founding organisations of EURAMET and has been an active in its technical committees. In addition, TÜBİTAK UME takes part in 8 Consultative Committees (CCs) of the International Committee of Weights and Measures (CIPM). As of December 2012, TÜBİTAK UME has become an associate member of the Gulf Association for Metrology (GULFMET), a new regional metrology organization.

TÜBİTAK UME became one of original signatories of the CIPM Mutual Recognition Arrangement (CIPM MRA) on 14 October, 1999 and its Calibration and Measurement Capabilities (CMCs) were among the first published in the Key Comparison Database (KCDB). Calibration certificates issued by TÜBİTAK UME based on published CMCs are internationally recognised by all CIPM MRA signatory institutions.

With its state-of-the-art infrastructure and experienced staff, TÜBİTAK UME takes part in a number of collaborative metrology research projects under the European Metrology Research Programme (EMRP). An increasing amount of research activity is being directed towards areas that fall outside the usual concerns of metrology, such as the environment, energy and health, with the aim of improving quality of life through the development of novel measurement solutions.

TÜRKAK

TÜRK AKREDİTASYON KURUMU

AKREDİTASYON SERTİFİKASI

Kalibrasyon Laboratuvarı olarak faaliyet gösteren,

TÜBİTAK
Ulusal Metroloji Enstitüsü (UME)
PK. 54 41470 Gebze
41470 KOCAELİ / TÜRKİYE

TÜRKAK tarafından yapılan denetim sonucunda TS EN ISO/IEC 17025:2010 Standardına göre Ek'te yer alan kapsamlarda akredite edilmiştir.

Akreditasyon No : AB-0034-K

Akreditasyon Tarihi : 29-Ağustos-2006

Revizyon Tarihi / No : 02-Mart-2012 / 06

Bu Sertifika, yukarıda açık adı ve adresi yazılı Kuruluşun TS EN ISO/IEC 17025:2010 Standardına, ilgili Yönetmelik ve Tebliğlere uygunluğunu sürdürmesi halinde 09-Ağustos-2014 tarihine kadar geçerlidir.

H.İrfan AKSOY
Genel Sekreter Vekili

F701-040

+90 312 419 32 00 - www.turkak.org.tr

TÜRKAK

TÜRK AKREDİTASYON KURUMU

AKREDİTASYON SERTİFİKASI

Deney Laboratuvarı olarak faaliyet gösteren,

TÜBİTAK ULUSAL METROLOJİ ENSTİTÜSÜ (UME)
Deney Laboratuvarı
TÜBİTAK Gebze yerleşkesi Gebze
41470 KOCAELİ / TÜRKİYE

TÜRKAK tarafından yapılan denetim sonucunda TS EN ISO/IEC 17025:2005 Standardına göre Ek'te yer alan kapsamlarda akredite edilmiştir.

Akreditasyon No : AB-0092-T

Akreditasyon Tarihi : 16-Ekim-2006

Revizyon Tarihi / No : 10-Ağustos-2010 / 03

Bu Sertifika, yukarıda açık adı ve adresi yazılı Kuruluşun TS EN ISO/IEC 17025:2005 Standardına, ilgili Yönetmelik ve Tebliğlere uygunluğunu sürdürmesi halinde 09-Ağustos-2014, tarihine kadar geçerlidir.

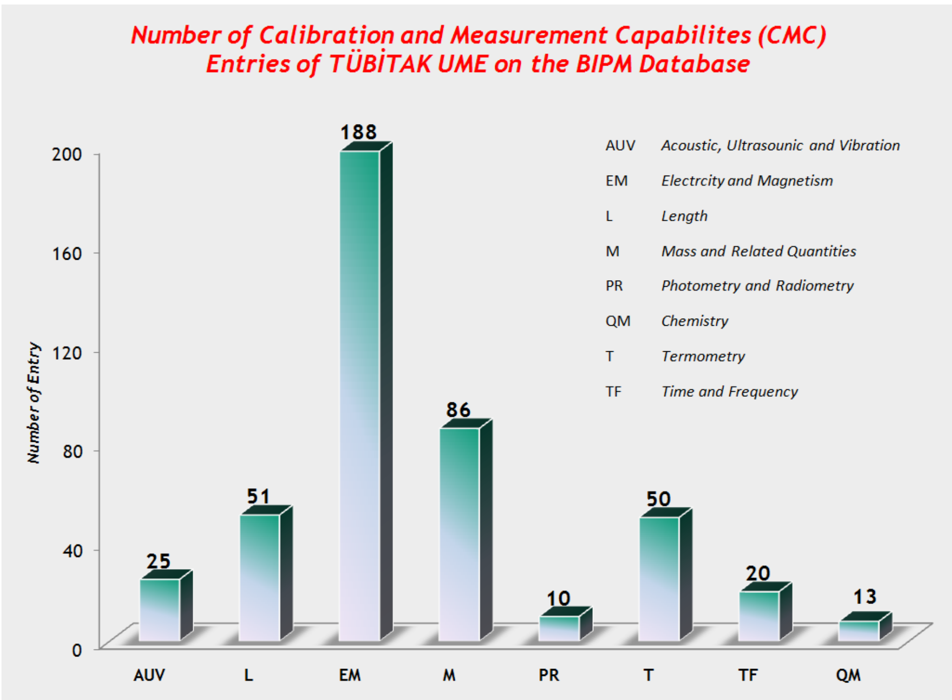
Ali BOĞA
Yönetim Kurulu Başkanı

Atakan BAŞTÜRK
Genel Sekreter

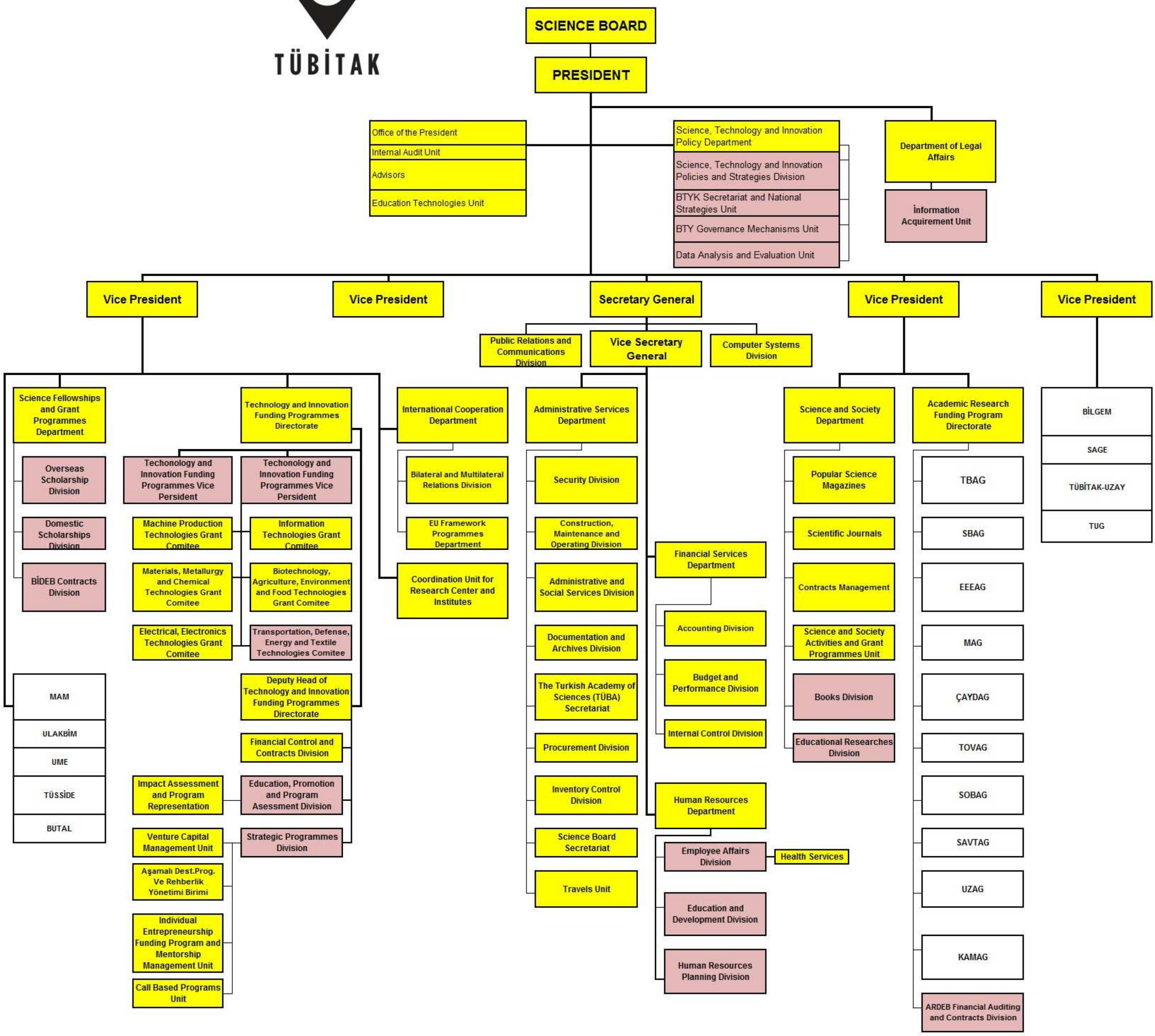
F701-040

+90 312 410 82 00 - www.turkak.org.tr

Turkey in the Key Comparison Database (CMCs)



Organization Chart of TÜBİTAK



Organization Chart of TÜBİTAK UME

- TÜBİTAK President and Scientific Board
- TÜBİTAK UME Management Board
- TÜBİTAK UME Director
  - Quality Board
  - Security
  - Coordination Committee
  - Advisory Board

Deputy Director (Technical) Physics Group
- Voltage Laboratory
- Power and Energy Laboratory
- High Voltage Laboratory
- Impedance Laboratories
  - Capa. & Inductuctance
  - Resistance
- Electromagnetic Laboratories
  - RF & Microwave
  - EMC 1 (Instrument)
  - EMC 2 (System)
- Magnetics Laboratory
- T&F and Wavelength Lab.
  - Time&Frequency
  - Wavelength
- Optics Laboratories
  - Fiber Optics
  - Spectro Photometry
  - Radiometry
  - Photovoltaic Perf.Tests
- Temperature Laboratories
  - Contact Temperature
  - Radiation Temperature
  - Humidty
- Workshops
  - Calibration/Test Automation
  - Mechanical&Carpentery Workshops
  - Electronics Workshop

Deputy Director (Technical) Mechanical Group
- Mass Laboratories
  - Mass
  - Volume & Density
  - Viscosity
- Force Laboratories
  - Force
  - Hardness
  - Torque
- Acoustics Laboratories
  - Acoustics
  - Ultrasonics
  - Vibration
- Pressure Laboratories
  - Pressure
  - Vacuum
- Dimenson Laboratories
  - Gauge Block, İnterferom.
  - Geom. Std. & Form
  - Angle
  - 3 D Measurement
  - Topographic& Ind. Meas
  - Surface Rough.& Nano
- Fluid Mechanics Laboratories
  - Gas Flow
  - Water & Other Liq Flw
  - Air Velocity Measurem.

Deputy Director (Technical) Chemistry Group
- Organic Chemistry Laboratory
- İnorganic Chemistry Lab.
- Electrochemistry Laboratory
- Biometrology Laboratory
- Gas Metrology Laboratory
- Reference Materials Lab.
- Photonics & Elect. Sens Lab.
  - OLED & OPV
  - DSSC
  - CIGS
  - Nano Technology

Deputy Director (Administrative)
- Strategic Planning and B D
- Computer & IT Center
- Building Maintanance&Opera.
- Documents, Arch. & Library
- Inventory and Stock
- Logistics and Social Services
- Human Resources
- Budget Management
- Accounting
- Procurement

CHEMICAL GROUP LABORATORIES

BIOANALYSIS LABORATORY

The Bioanalysis Laboratory of TÜBİTAK UME was established in 2011 as a branch of the Chemistry Group. The major working areas of Bioanalysis Laboratory are the development of primary reference measurement methods validated in life sciences; the production of Certified Reference Materials (CRM), for which is there is great demand in Turkey as well as in the world; and participation in international laboratory comparison studies and organization of national proficiency tests. In this context, the Bioanalysis Laboratory conducts quantitative measurements of biomolecules such as DNA, RNA and proteins with high accuracy and low uncertainty values. The main areas of interest are gene quantification of unknown samples of genetically modified organisms (GMO) in agricultural products, determination of relative messenger RNA (mRNA) levels and protein quantification of unknown samples using enzyme linked immunosorbent assay (ELISA) and proteomics studies. The overarching goal is to establish uniformity in measurements of biomolecules in the fields of food, environment and health at both national and international levels.

General View of the Bioanalysis Laboratory

Available equipment and systems in the laboratory:

- DNA and RNA Unit
  - DNA Synthesizer
  - DNA Sequencer
  - Real-Time PCR
  - PCR
  - NanoDrop
  - NanoFlorometer
  - DNA Gel Electrophoresis System
  - Centrifuges

- Protein Unit
  - MALDI-TOF MS
  - qTOF MS
  - Nano-LC
  - ELISA Plate Reader
  - 2D protein gel electrophoresis

Examples of Laboratory Projects

- FP7 EMRP Health Project, 2012-2015: "Metrology for Monitoring Infectious Diseases, Antimicrobial Resistance, and Harmful Micro-organisms"
- FP7 EMRP SI Project, 2013-2016: "Traceability for Biologically Relevant Molecules and Entities"
- TÜBİTAK 1001 Project, 2010-2012: "Generation of Aptamer Used for Biosensors to Diagnose Tuberculosis"
- TÜBİTAK 1001 Project, 2010-2013: "Proteomic Analysis of Protection Solutions Used for Organs Before Organ Transplantation"

The laboratory actively participates in the activities of the CCQM Bioanalysis Working Group (BAWG) and has participated in the following international comparison studies:

- CCQM-K86 :Relative Quantification of Genomic DNA Fragments Extracted From a Biological Tissue - GMO
- CCQM-P58.1 :cTnI ELISA Measurement
- CCQM- P103.1 :Measurement of Multiplexed Biomarker Panel of RNA Transcripts
- CCQM-K110/P113.2 :Relative Quantification of Bt63 in GM Rice Matrix Sample

ELECTROCHEMISTRY LABORATORY

The Electrochemistry Laboratory aims to meet scientific and industrial demand for reliable and traceable pH and conductivity measurements in Turkey by collaborating with relevant public and private institutions at the national and international level. To this end, the Electrochemistry Laboratory organizes Proficiency Testing (PT) schemes and training programs for the chemical, food and health sectors. The laboratory also performs studies to produce reference materials for pH and conductivity measurements at the national level to establish a traceability chain.

The Electrochemistry Laboratory was established in 2011. Available equipment and systems in the laboratory:

- Primary Level pH Measurement System (Harned Cell)
- High Accuracy Coulometer
- Potentiostat/Galvanostat
- Nanovoltmeter
- pH-meter and Electrolytic Conductivity Meter
- Variable Transformer

High Accuracy Coulometry System

Primary Level pH Measurement System

The laboratory participates in the activities of the CCQM Electrochemical Analysis Working Group (EAWG) and contributes to international comparison studies, among which are:

- CCQM-K91 : pH Measurement of Phthalate Buffer Solutions
- CCQM P37.2 : Ag/AgCl Electrode Preparation

The laboratory plans to participate in a bilateral or ternary comparison in 2013 in pH measurements. In the following years, the Electrochemistry Laboratory intends to participate in international comparison studies in sea water salinity. Work is continuing on establishing laboratory capability for Voltammetry as a new quantitative measurement method.

GAS METROLOGY LABORATORY

The ultimate objective of gas metrology can be given as identification, method development for the analyses, investigation and application of industrial gases, exhaust emission gases and atmospheric gas components, as well as establishing a traceability chain for gas measurements and providing support for scientific, legal and industrial activities involving gas measurements. Primary gas standards with very low uncertainty values can provide sustainable and traceable gas measurements required in the field of health, environment and safety. In the Gas Metrology Laboratory, primary gas standards are prepared and analyzed in order to establish a traceability chain for gas measurements and to perform related activities for traceable and reliable gas measurements in the country. The laboratory collaborates with related public and private institutions and performs the necessary activities to meet their demands for reliable gas measurements in scientific, legal and industrial areas at the national and international level.

The gas metrology laboratory was established in 2011. Available equipment and systems in the laboratory include the following:

- Gas Mixture Preparation Laboratory
  - Gas filling station
  - Turbo-molecular vacuum pump system
  - Cylinder roller
  - Cylinder weighing system

- Gas Analysis Laboratory
  - GC with FID/TCD
  - Gas analyzers for CO (carbon monoxide), CO_2 (carbon dioxide), NO_x (nitrogen oxides), SO_2 (sulfur dioxide)
  - Sample boxes for GC and gas analyzers

Gas Mixture Preparation Laboratory

Gas Analysis Laboratory

Examples of Laboratory Projects

- EU-IPA Project, 2008-2011: “Quality Infrastructure in the Western Balkans and Turkey”
- EU-IPA Project, 2011-2014: “Quality Infrastructure in the Western Balkans and Turkey”
- Ministry of National Defense Project, 2009: “Feasibility Study for Alternative Systems to Land Mines”
- FP7 EMRP Researcher Mobility Grant, 2012-2013: “Metrology for Chemical Pollutants in Air”

The laboratory actively participates in the activities of the CCQM Gas Analysis Working Groups (GAWG) and EURAMET TC-MC and has participated in the following international comparison study:

- EURAMET.QM-S5 (EURAMET Project 1166) - Carbon Dioxide in Nitrogen

INORGANIC CHEMISTRY LABORATORY

One of the objectives of the TÜBİTAK UME Inorganic Chemistry Laboratory involves method development and method validation including the preparation of their uncertainty budgets in order to ensure their reliability and acceptability in the field of chemical metrology. In this respect, the Inorganic Chemistry Laboratory conducts and participates in research projects which aim to develop measurement methods for lower detection limits of measurements for challenging parameters, which are becoming more important not only in Turkey but also in the international arena.

Inorganic Chemistry Laboratory supports the measurement activities of public and industrial institutions to ensure the reliability of their measurements in the area of inorganic chemistry. The laboratory has been implementing projects funded by the EU Instrument for Pre-Accession Assistance (IPA), one of which involves technical assistance and knowledge transfer for the production of CRMs. The second complementary project involves the supply of necessary equipment and infrastructure for CRM production.

The laboratory has been involved actively in collaborative projects within the European Metrology Research Program (EMRP). The laboratory has been participating in international comparison studies since 2005 and has demonstrated a high degree of success with its results in recent comparisons, in particular. With the support of these comparison results, the Inorganic Chemistry Laboratory published the first CMC entries of the Chemical Metrology Group of TÜBİTAK UME in 2010.

The Inorganic Chemistry Laboratory was established in 2003. Available equipment and systems in the laboratory include the following:

- HR-ICP-MS
- ICP-MS
- Laser Ablation System
- Microwave Digestion System
- Ion Chromatography

Ion Chromatography

Microwave Digestion Systems

Examples of Laboratory Projects

- FP7 EMRP iMERA-Plus Project, 2008-2011: “Traceable Measurements for Biospecies and Ion Activity in Clinical Chemistry”
- EU-IPA Project, 2009-2012: “Europe and Metrology in Turkey (EMIT)”
- EU-IPA Project, 2010-2015: “Supply of Chemical Metrology Equipment to TÜBİTAK UME”
- FP7 EMRP Environment Project, 2011-2014:“Traceable Measurements for Monitoring Critical Pollutants Under the European Water Framework Directive”
- FP7 EMRP Health Project, 2012-2015: “Metrology for Metalloproteins”

The laboratory actively participates in the activities of the CCQM Inorganic Analysis Working Groups (IOWG) and EURAMET TCMC and has participated in the following international comparison studies:

- CCQM-P46 : Preparation of Calibration Solutions
- CCQM-P62 : Trace Elements in High Purity Nickel
- CCQM-K42 : Composition of Aluminum Alloy
- CCQM-P64 : Trace Elements in Soybean Powder
- CCQM-P72 : Toxic Metals in Food (Metals in Food (Tin, lead and cadmium in Tomato Paste)
- CCQM-K43.1/P96 : Arsenic, Hg, Se and Methylmercury in Marine Fish (Swordfish)
- CCQM-K45 : Toxic Metals in Food: Tin in Tomato Paste

- EURAMET 763 : Mono Elemental Calibration Solutions (Zn, Pb, Ca and Cu)
- CCQM-K49/P85 : Analysis of Essential and Toxic Elements in Bovine Liver
- CCQM-K56/P64.1 : Trace Elements in Whole Fat Soybean Powder
- CCQM-P97 : Cadmium and Lead in Herb
- CCQM-P111 : Seawater Salinity
- CCQM-P86.1 : Total Se and Se Speciation Analysis of Se-rich Wheat Flour
- CCQM-K75/P118 : Determination of Toxic Metals in Algae
- IPA 2008 PT3 : Waste Water
- CCQM-P96.1 : Measurement of AsB Solution and AsB Content in Marine Fish
- SIM-QM-S2 : Trace Elements in Drinking Water
- CCQM-K89/P126 : Trace and Essential Elements in Herba Ecliptae
- CCQM-K30.1 : Analysis of Pb in Wine
- CCQM-P12.2 : Analysis of Pb, Fe, Cu and Cd in Wine
- CCQM-K87/P124 : Mono-Elemental Calibration Solutions (Pb, Cr, Co)
- EURAMET 1185 : Determination of Selenomethionine in Human Serum
- CCQM-K100 : Copper in Ethanol
- CCQM-K97 : Measurement of Arsenobetaine Standard Solution and Arsenobetaine Content in Fish Tissue (Tunafish)

ORGANIC CHEMISTRY LABORATORY

The Organic Chemistry Laboratory carries out activities with the aim of ensuring the quality and nationwide traceability of measurements in the area of organic chemistry. To this end, the laboratory conducts method development and method validation studies, and determines uncertainty values for new measurement methods. The laboratory works at the international level with respect to the metrological hierarchy to provide traceability and international comparability of chemical measurement results.

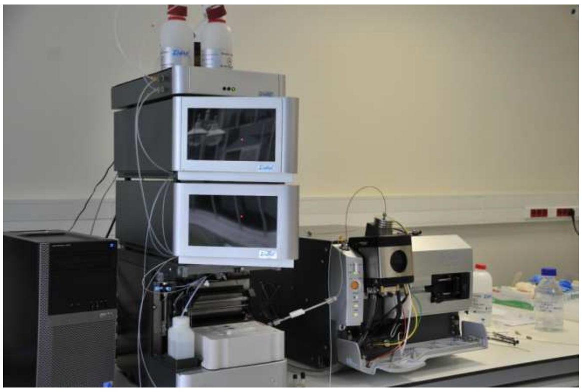
Bruker Microtof Q LC-MS/MS

Thermo TSQ Quantum GC-MSMS

Since 2006, the Organic Chemistry Laboratory has been cooperating with the Energy Market Regulatory Authority to produce, distribute and control the national fuel marker, added to all types of fuel distributed in Turkey.

At the international level, the Organic Chemistry Laboratory represents Turkey in its field of expertise. In this scope, EMRP project partnerships, EURAMET TC-MC and CIPM CCQM representations are carried out. Participation in international comparison studies and publication of CMC tables in the Key Comparison Database demonstrate our metrological capability in the international arena.

The Organic Chemistry Laboratory was established in 2003. Available equipment and systems in the laboratory include the following:



Tandem Gold LC-MS/MS

- Liquid Chromatography (LC-MS, LC-MS/MS)
  - Ion Trap
  - Triple Quadropole
  - TOF
- Gas Chromatography (GC-MS, GC-MS/MS,TD-GC/MS)
  - Triple Quadropole
  - Quadropole
  - Ion Trap

- Isotope Ratio Instruments
  - EA-IRMS
  - GC-IRMS
  - LC-IRMS
  - TC-EA-IRMS

- Liquid Chromatography Instruments
  - HPLC-UV/PDA
  - Preparative HPLC

- Gas Chromatography Instruments

- FID/ECD

- Spectrometers
  - UV-Vis-NIR Spectrometer
  - Floresans Spectrometer
  - Fourier Transform Infrared Spectrometer
  - Raman Spectrometer
  - Nuclear Magnetic Resonance (600 MHz)

- Qualitative Analysis
  - pH Meter
  - Polarimeter
  - Melting point Determination Apparatus
  - Viscometer
  - Immersion Cooler (-90 ºC, -50 ºC)
  - Automatic SPE
  - Mills

Examples of Laboratory Projects

- EPDK Project, 2012-2013 “Development and Application of National Fuel Marker”
- Industrial Project, 2005-2007: “Development of Test Kits for Biochemical Tests With GC, LC/MS and ICP/MS”
- FP7 EMRP iMERA-Plus Project, 2008-2011: “Traceable Measurements for Biospecies and Ion Activity in Clinical Chemistry”
- TÜBİTAK 1001 Project, 2010-2012: “PBDEs and PBBs in Plastics”
- FP7 EMRP Environment Project, 2009-2012 “Traceable Measurements for Monitoring Critical Pollutants Under the European Water Framework Directive”
- FP7 EMRP Environment Project, 2010-2013 “Metrology for Biofuels”

The laboratory actively participates in the activities of the CCQM Organic Analysis Working Groups (OAWG) and EURAMET TC-MC and has participated in the following international comparison studies:

- CCQM-K55.b : Purity Assessment of High Purity Organic Materials: Aldrin
- CCQM-P75 : $\delta^{13}C$ and $\delta^{15}N$ in Methionine
- CCQM-P91 : Pyrethroids in Apple Juice Concentrate
- CCQM-K81 : Chloramphenicol as Residue in Pig Muscle
- CCQM-P117a : Purity Assessment of High Purity Organic Materials: (17β-Estradiol)
- CCQM-P129 : Water and Ethanol in Bioethanol Fuel
- CCQM-K95 : Mid-polarity Analytes in Food Matrix: Mid-Polarity Pesticides in Tea
- CCQM-K55.c : Purity Assessment of High Purity Organic Materials: L-valine

PHOTONICS and ELECTRONICS SENSORS LABORATORY

The research and development activities of the Photonics and Electronic Sensors Laboratory (PESL), housed within the TÜBİTAK UME Chemistry Group, cover a wide spectrum of subjects such as photovoltaics, OLED lighting and displays, transparent conductive oxide coatings and nano-structured materials for photonics applications.

The area of photovoltaics takes up an important share of the research and development studies conducted under PESL. Those studies focus on technology development for a-Si:H/c-Si heterojunction with intrinsic thin layer (HIT) solar cells, copper indium gallium diselenide (CIGS) solar cells, organic photovoltaics (OPV) and dye sensitized solar cells (DSSC). PESL collaborates with other laboratories at TÜBİTAK UME to develop the metrological infrastructure for outdoor and indoor measurements of novel solar cell technologies that are directly traceable to SI units.

Glove-Box Systems for the Development of OLED and OPV

PESL develops Organic Light Emitting Diodes (OLED) and White OLEDs (WOLED) for lighting applications. In order to improve the performance and stability of organic electronic devices, PESL conducts research on the design and development of a variety of new encapsulation materials and techniques. PESL works in cooperation with the research institutes of TÜBİTAK Marmara Research Center as well as universities in Turkey and abroad towards the development of new materials for OLEDs and OPVs.

Deposition Systems in Clean-Room Area

Examples of Laboratory Projects

- Organic Electronics: Building OLED Technology Infrastructure
- Fabrication of a-Si:H/c-Si Heterojunction Solar Cells and Investigation of Their Interface Defects
- Use of New Donor-Acceptor Copolymers in Organic Solar Cell Applications

REFERENCE MATERIALS LABORATORY

The TÜBİTAK UME Reference Materials Laboratory was established in 2012. The main objective of the Reference Materials Laboratory is to produce and certify reference materials for the purpose of ensuring the quality of chemical measurements in Turkey.

Certified Reference Materials (CRM) are essential for measurements in the fields of environment, health and food safety.

The laboratory also provides proficiency tests to accredited laboratories and industry on several chemical measurements twice a year.

Training in "General Metrology" and "Uncertainty Calculations in Chemical Measurement" are offered twice a year and TrainMIC workshop is offered once a year for industry.

Available equipment and systems in the laboratory:

- Particle Size Analyzer
- V-mixer
- 3D-Mixer

Chloramphenicol (CAP) Primary Calibrant Certified Reference Material

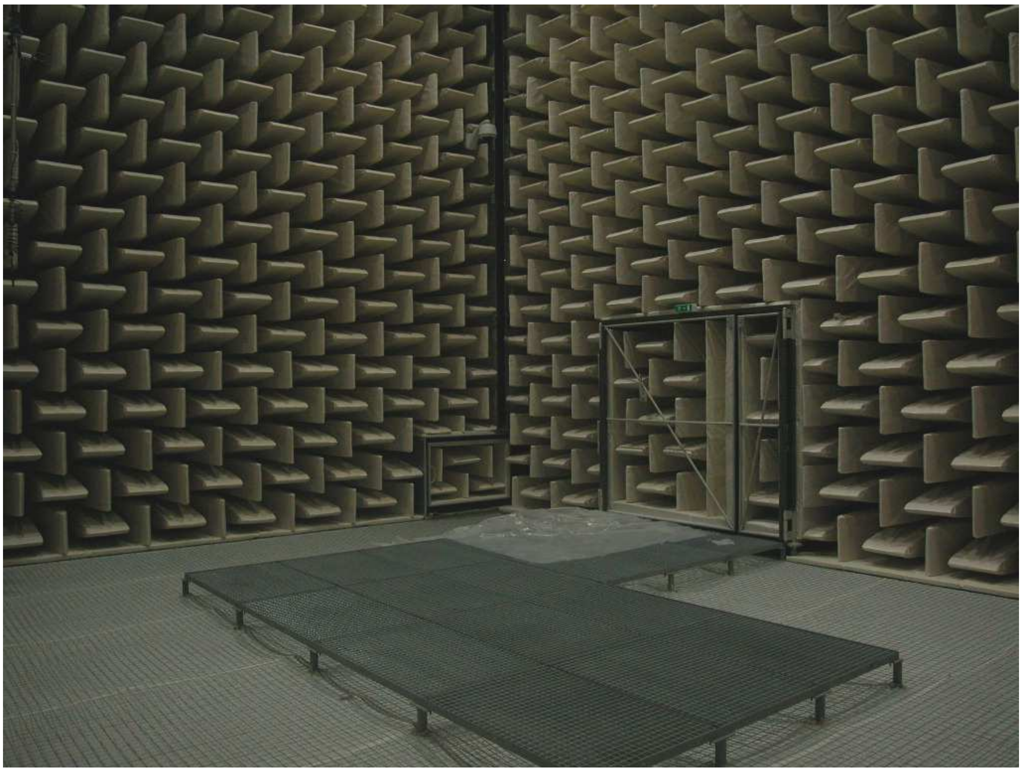
Examples to the Laboratory Projects

- CRM 1201, 2012-2013: Production of Spring Water Certified Reference Material
- CRM 1202, 2013-2015: Trace Metals in Hazelnut Certified Reference Material Production and Certification
- CRM 1301, 2012-2015: Chloramphenicol (CAP) Primary Calibrant Certified Reference Material Production and Certification
- CRM 1302, 2012-2015: Production and Certification of Dried Fig Certified Reference Material
- CRM 1308, 2012-2016: Production and Certification of 25-OH Vitamin D2/D3 in Lyophilized Serum

MECHANICAL GROUP LABORATORIES

ACOUSTICS LABORATORIES

The main objective of TÜBİTAK UME Acoustics Laboratories is the realization, maintenance and improvement of the standards for the measurement quantities of sound pressure in air, rectilinear acceleration, and ultrasonic power. The integration and equivalence of realized national standards within the international metrology system is assured through participation in international comparisons. Traceability and measurement coherence for secondary level laboratories within the country are provided by means of a wide range of calibration, measurement and test services. One of the other objectives is to generate research projects that address the needs of the country and the demands of the stakeholders in the related areas. To this end, Acoustics Laboratory takes part as a project partner in research projects undertaken within the European Metrology Research Program. These types of collaborative projects contribute to the laboratory's international cooperation network and experience. The Acoustics Laboratories consists of the three divisions, namely: the Acoustic, the Ultrasonic and the Vibration Laboratory. The services provided by the laboratories and work areas can be summarized as follows:



Determination of Sound Power Level of the Industrial Products in Full Anechoic Room

ACOUSTICS LABORATORY

Establishment and improvement of the standard for the unit of sound pressure at the primary level is the main activity. Calibration of devices used in acoustical measurements at the primary and secondary levels, characterization of special acoustical rooms, in room measurements of the sound absorption coefficient of materials and reverberation time are the other activities of the acoustic laboratory.

The standard for the unit of sound pressure is established in the frequency range from 10 Hz to 25 kHz in accordance with the IEC 61094-2 standard. The degree of equivalence between the realized standard and the national standards of other countries is determined through participation in international comparisons. The uncertainty of the national standard is at a level comparable to the uncertainty levels of the standards of leading national metrology institutes. The unit is disseminated to the secondary level by means of the calibration of various devices and transducers such as condenser microphones, sound calibrators, etc. The Acoustics Laboratory, with its infrastructure consisting of a full anechoic room with 50 Hz cut-off frequency and reverberation room, and its measurement capabilities, performs a wide range of highly accurate measurements and is a provider of acoustics metrology expertise within the country and abroad. The laboratory contributes to R&D projects in the country and within the European Metrology Research Programme (EMRP).

Measurement of the Sound Absorption Coefficient of Material in Reverberation Room

ULTRASONIC LABORATORY

Maintenance of the primary standard for ultrasound power in diagnostic and therapeutic medical applications is the fundamental activity of the laboratory. Other activities involve the characterization of transducers used in ultrasonic and sound velocity measurements in materials. Subjects studied by the laboratory are as follows:

- Determination of the output power of the ultrasonic diagnostic and treatment devices,
- Field characterization of transducers.

National standard of ultrasonic power unit at the primary level is established by means of radiation force balance in accordance with the IEC 61161 standard. The national standard covers a frequency range of 1 MHz to 15 MHz and a power range of 10 mW to 15 W.

Additionally, measurement capability up to 150 W is also provided for output power measurements of high intensity focused ultrasonic transducers, which are widely used in medicine, by the established radiation force balance in the laboratory. The laboratory has recently been focused on a project that investigates the use of ultrasonic in health treatments.

VIBRATION LABORATORY

The establishment and improvement of the primary standard for the unit of rectilinear acceleration is the main activity in the vibration field. The primary and secondary level calibration of devices used in vibration measurement is the other significant activity of the Vibration Laboratory.

The national standard for the linear acceleration unit is established based on laser interferometry in accordance with the ISO 16063-11 standard.

Absolute calibration of the reference standard accelerometers is performed in the frequency range from 10 Hz to 10 kHz. The unit is disseminated to secondary level by means of a comparison calibration against the reference standard accelerometer calibrated at primary level. There are plans to extend the working range of the standard for linear acceleration unit to the lower frequency range.

Examples of Laboratory Projects

- Investigation on Earth's Crustal Vertical Movement Based on Gravity and GPS Measurements in Marmara Region
- i-MERA Plus Joint Research Project, "External Beam Cancer Therapy"
- Investigation and Evaluation of Room Acoustics Parameters in the Scope of the Indoor Space in which Turkish Makam (System of Melody Type) Music is Performed.
- FP7 EMRP Project, "Metrology for Universal Ear Simulator and Perception of Non-audible Sound"
- FP7 EMRP Joint Research Project, "Metrology for Therapeutic Ultrasound"

DIMENSIONAL LABORATORIES

The Dimensional Laboratories are primarily concerned with maintenance of the primary standard for the unit of length and disseminating traceability for dimensional measurements. The metre, one of the fundamental SI units, was redefined in 1983 as “the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second”. This definition has been realized in the TÜBİTAK UME Wavelength Laboratory with reference stabilized lasers. Having achieved traceability at the primary level by using these lasers, the Dimensional Laboratories transfer the unit “metre” to accredited laboratories and industry.

The Dimensional Laboratories consist of six divisions, namely: Gauge Blocks and Interferometric Length Measurements, Angle Measurements, Surface Texture and Nanometrology, Geometrical Standards and Form Measurements, 3-Dimensional Measurements (Coordinate Metrology) and the Topographic and Industrial Measurements Laboratory. The services provided by the laboratories and work areas can be summarized as follows:

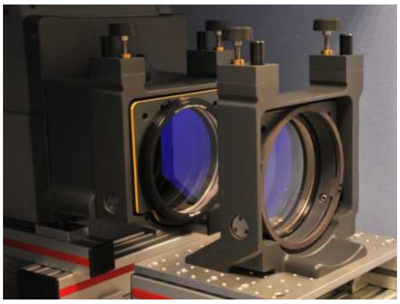
GAUGE BLOCKS and INTERFEROMETRIC LENGTH MEASUREMENTS LABORATORY

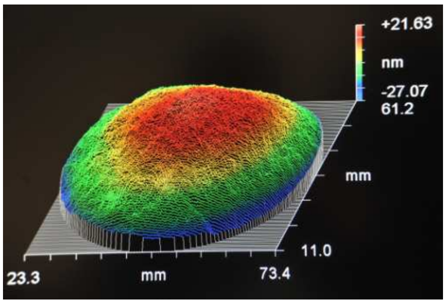
The length of artifacts can be directly compared with internationally recommended wavelength standards using interferometry.


Gauge Block Interferometer


1m Gauge Block Comparator

The highest accuracy grade gauge blocks are calibrated at TÜBİTAK UME using interferometry. Gauge blocks up to 300 mm are calibrated by an automatic gauge block interferometer which compares the length of the gauge block against the very accurately known wavelength of two frequency-stabilized He-Ne lasers. Gauge blocks from 100 mm up to 1000 mm are calibrated by a High Accuracy Long Gauge Block Comparator or a TÜBİTAK UME made Köster Interferometer located in the Wavelength Laboratory. Mechanical comparators are also available for calibration of gauge blocks of lower accuracy grades. Flatness measurement of optical surfaces (such as optical flats, mirrors, or platens) and calibration of corner cubes are performed using a Zygo Verifire Flatness Interferometer. Parts with diameters up to 150 mm can be accommodated.


Zygo - Flatness Interferometer



Results of Flatness Measurement

ANGLE MEASUREMENTS LABORATORY

The SI unit of the plane angle is the radian (rad) which is defined as the angle subtended at the centre of a circle by an arc, the length of which is equal to the radius. In industry, the unit “degree (°)” is used for angle measurement. It is obtained by the 360th division of the full circle, which is in fact a 2π rad angle.

The national standard for angle measurements at TÜBİTAK UME is realised utilising a precise air bearing rotary table equipped with a Heidenhein ERP 880 encoder (0.001” resolution). A high resolution (0.005”) autocollimator (Elcomat HR) is used in conjunction with the precise table for calibration of high accuracy angle standards (such as polygons and angular tables) through the application of self-calibrating methods. Additionally, Moore indexing tables, autocollimators, polygons, angle gauge blocks and levels are available for various angle measurements.

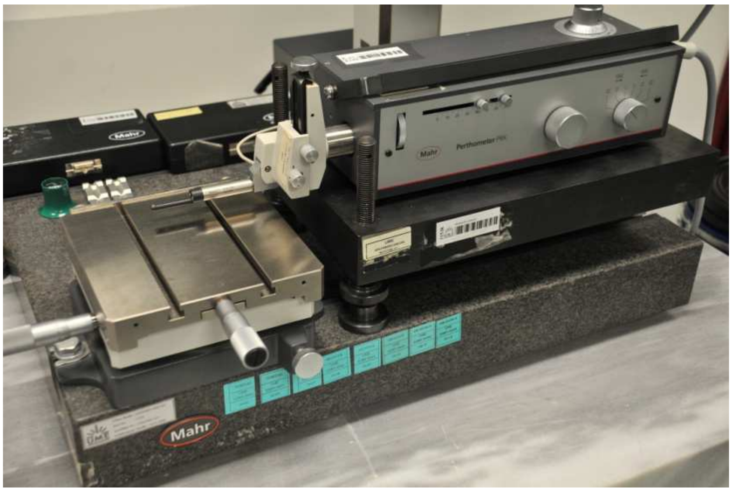
An angle can also be obtained by trigonometric calculation of length measurements. Using a sine-bar or similar type of instrument, small angles can be generated to calibrate spirit levels and electronic levels. TÜBİTAK UME has made various sine bars for calibration of such instruments. Sine bars can be used for realisation of the SI Unit angle with an uncertainty of 0.01” (50 nanoradian) and the calibration of autocollimators and levels.

SURFACE TEXTURE AND NANOMETROLOGY LABORATORY

Surface texture affects the mechanical and physical properties of parts significantly. Required surface texture on parts can be obtained by choosing and monitoring the manufacturing process. This way, the required physical properties of parts such as friction, wear, fit, seal, fatigue, adhesion of coatings, electrical and thermal contact, and even optical properties such as glass transparency, etc., can be adjusted through manufacturing design.

Measurements of surface roughness are made using stylus equipment (Mahr Perthometer Concept) at TÜBİTAK UME with which all surface-roughness parameters can be determined (R_a, R_q, R_y, R_z, etc.). Geometry, roughness and depth standards are calibrated with high accuracy in accordance with ISO 4287. The contact stylus instrument is traceable to the unit metre through our reference standards.

Nanosensors are calibrated using a plane mirror and differential interferometers. New work in this area is underway for mask and line scale measurements. We are constructing a system for precise mask and line scale measurements. The system contains a nanoscale 2D positioning system and a digital microscope with magnification up to 150X.



Surface Roughness Measurements

GEOMETRICAL STANDARDS AND FORM MEASUREMENTS LABORATORY

The form features of parts are highly important for fittings. They are also important for high accuracy dimensional artefacts as dimensional accuracy also depends on the form of parts. In simple terms, the form error can be described as the deviation of the shape of the manufactured part from the relevant ideal geometric shape.

Straightness and squareness measurements are performed with a CMM (co-ordinate measuring machine) using the reversal technique. Measurement values obtained from the CMM are transferred to a processing software developed by TÜBİTAK UME. The error of the CMM is separated and the straightness or squareness (or both) errors of the artefact are determined.

The flatness of surface plates up to a number of square meters in size is measured by electronic levels and software developed specifically for this purpose.

Roundness and cylindiricity measurements are performed using Mahr MMQ40 and MFU 800 form measuring instruments. The error-separation method is applied for high accuracy measurements.

Gauges are calibrated on a Mahr 828 CiM length-measuring machine modified at TÜBİTAK UME. The machine, fitted with a remote control mechanism and temperature control case, is used for high-accuracy grade calibrations of setting ring and plug gauges. The use of alternative purpose measuring heads also allows measurement of thread and gap gauges. Diameters from 2 mm to 300 mm (external diameters, down to 0.1mm) can be measured using a gauge-block substitution technique. The achievable uncertainty, depending on the gauge, can be less than 0.2 µm.

3-DIMENSION MEASUREMENTS (CO-ORDINATE METROLOGY) LABORATORY

Coordinate measuring machines (CMM) are becoming more important in industrial production owing to their various applications, in particular, for measurement of form and distance at the same time (geometric dimensioning and tolerancing). The activities of TÜBİTAK UME in the field of coordinate metrology include the calibration of gauges and artefacts (particularly cylindrical gauges, taper gauges, thread gauges, taper thread gauges, gear standards and special-purpose gauges), the verification of workpieces and the investigation of calibration procedures.

3-Dimension Measurements

5 m Line Scale and Steel Ruler Measurement System

TOPOGRAPHIC AND INDUSTRIAL MEASUREMENTS LABORATORY

A laboratory-built 5 m bench is used for calibration of tapes and rules. A large range of optical tooling equipment such as precise optical levels, teodolites, telescopes and total stations are used depending on the industrial demands and applications. Optical measurements and levelling can be performed on site.

Examples of Laboratory Projects

- SEA-EU-NET EU 7th Framework Programme Project, “Facilitating the Bi-Regional *EU*-ASEAN Science and Technology Dialogue”
- TÜBİTAK 1001 Project, “3D Geometrical Characterizations of Cylindirical Artifacts with Nanometrical Precision”
- Development of a Short Distance EDM (Electronic Distance Meter) Calibration System on 5 m Bench
- Development of a Reference Straightness and Squareness Measurement System
- Development of a Laser Diffractometer System for the Calibration of Pitch Standards
- Development of a Measurement System for the Non-nominal Short Gauge Block

FLUID FLOW LABORATORIES

The Fluid Flow Laboratories consist of three divisions, namely: the Water Flow, Gas Flow and Air Speed Laboratories. The services provided by the laboratories and work areas can be summarized as follows:

WATER FLOW LABORATORY

The TÜBİTAK UME Water Flow Laboratory has been built to cover the full range of industrial needs for water flow rate measurements in Turkey.

The capacity of the measurement lines and primary reference systems allows coverage of a flow rate range from 0.01 m^3/h to 2000 m^3/h with an uncertainty of less than 0.06 % (k=2).

Water Flow Rate Measurements Laboratory

There is a 300 m^3 soft water reservoir inside the laboratory. There are several stainless steel pumps with frequency converters to control flow rate. The maximum flow capacities of the pumps are in the range of 20 m^3/h to 1000 m^3/h. The pumps are constructed either to feed the calibration lines either directly or through the constant pressure head tanks. The head tanks, located at the top of the tower, have capacities of 50, 15 and 5 m^3. The height of the tower is 35 m from the laboratory floor level.

For temperature controlled measurements (e.g. for hot water meters), there are two water feeding pumps and tanks with water temperature controllers, operating independently from the water reservoir that supplies hot and cold water to the measuring line.

There are 17 test lines in the range of DN-250 to DN-5, which consist of stainless steel pipes, remote controlled valves, various reference flow meters (e.g. Coriolis, magnetic and ultra-sonic) and instruments to measure water temperature and pressure. At the TÜBİTAK UME Water Flow Laboratory gravimetric systems are used as the primary reference system. There are four of these systems that were designed and built in Turkey. Their maximum weight capacities are 10 kg, 1 ton, 5 tons and 30 tons. All are operated at flying start and stop mode.

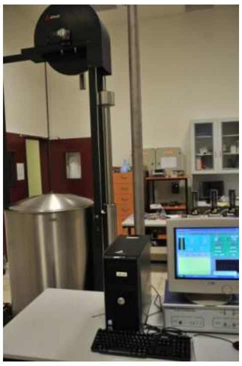
All instruments in the Water Flow Laboratory are controlled by a PLC system and measurements are performed by computer. The following types of measurements can be performed in the laboratory:

- Testing and calibration for water flow meters
- Cold and hot water meter testing
- Valves, armatures and pump tests

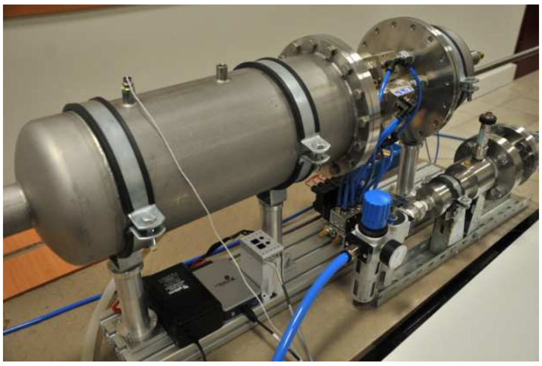
GAS FLOW LABORATORY

At UME gas flow laboratory, there are several reference flow meters which are covering the volumetric flow range of from 1 ccm to 20 000 m^3/h. Test and calibration of various gas flow meter devices can be performed by using air as medium in the laboratory.

The primary reference of the UME gas flow laboratory is the Bell-Prover device. This device is covering an atmospheric air flow rate range of 0.2 m^3/h to 85 m^3/h with an uncertainty of 0.05 %. Bell Prover is traceable against UME dimensional, pressure, time-frequency and temperature laboratories. All reference standards in the gas flow laboratory are calibrated by Bell Prover.



Bell-Prover System



Sonic Nozzle Bank Gas Flow Rate Calibration and Testing Device

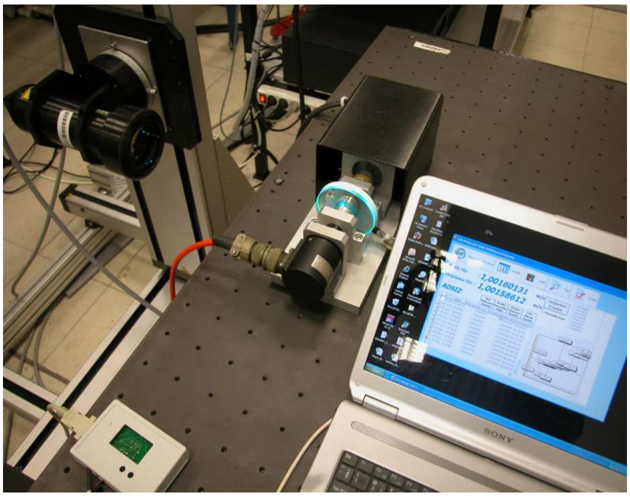
For low gas flow rates, there are wet gas meters and dry piton meters used as reference devices. Wet gas meters covers a flow rate range of 2 l/h to 18 000 l/h with 0.2% uncertainty and dry piston meters used for 1 ccm to 50 LPM range with 0.2% uncertainty. At UME gas flow laboratories, new measurement devices were also developed. Sonic nozzle bank is the newest development. Sonic nozzle bank can provide continuous flow rate up to 120 m^3/h with an uncertainty of 0.25%. The whole system can be controlled by a computer and UME can develop such systems according to customer's specifications and needs especially for natural gas distributor companies and gas meter manufacturers. There are also several reference turbine meters at different sizes for various flow rate ranges of air flow at atmospheric pressure. With those reference turbine meters and the pipe test rigs UME gas flow laboratory provides calibration and testing services for the following ranges;

- 10 m^3/h - 6600 m^3/h with an uncertainty range 0.11% and 0.43% depending on the flowrate
- Up to 19500 m^3/h the uncertainty is between 0.45% and 0.78% depending on the flowrate.

AIR SPEED LABORATORY

Presently UME air speed laboratory is providing test and calibration services of the various anemometers and air speed measuring devices for the speed range of 0.5 m/s to 40 m/s with a 250 mm square duct channel.

A two dimensional laser doppler anemometry (LDA) is used as the main reference measurement system in the air speed laboratory. To be able to make the LDA a primary reference system, a spinning disk device was designed and developed. Spinning disk device is simply a turning wheel at constant known speeds.



The Spinning Disk Device and the LDA During a Calibration Measurement

Calibration of the LDA is performed by measuring the speed at outer surface of the wheel. Since the surface speed of the wheel is defined by angular speed and wheel diameter the LDA system becomes traceable against UME dimensional and time-frequency laboratories.

In air speed laboratory, for most of the calibrations and tests the pitot tube device is used as reference.

A new wind tunnel which was designed by our laboratory staff and produced by a local company is available for calibration and testing of air speed anemometers since February 2013. With the new tunnel, we will provide more stable speeds at much less uncertainties.

Examples of Laboratory Projects

- Modernization of IGDAS Natural Gas Meters Calibration System
- FP7 EMRP Project, “METEOMET- Metrology for Meteorology”
- Design and Development of Sonic Nozzle Bank Gas Meters Calibration and Test System
- Development of Micro-PIV System
- Metrology for Drug Delivery
- Design and Development of A Spinning Disk Device to Achieve Internal LDA Traceability

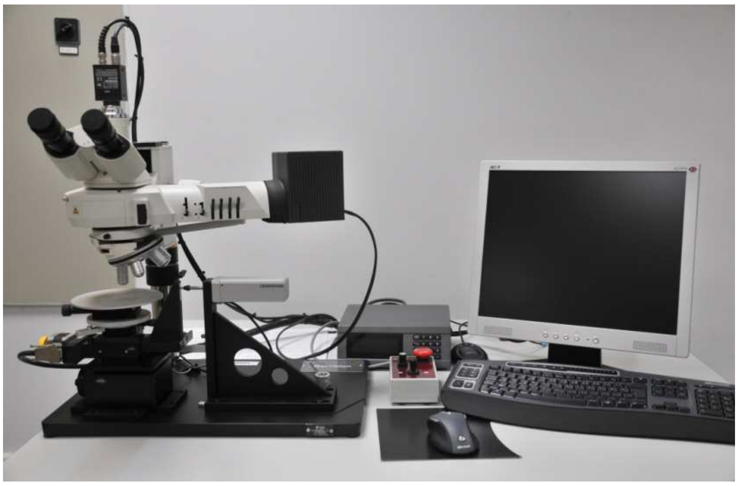
FORCE LABORATORIES

Force Laboratories consist of three divisions, namely, the Force, Hardness and Torque Laboratories. The services provided by the laboratories and their work areas can be summarized as follows:

FORCE LABORATORY

Standard forces are obtained fundamentally based on the static force measurement principle and Newton's 2nd law (F=m.g). Systems which can generate force by using this principle, called Force Standard Machines (FSM) are used for calibration of force measuring devices (i.e. proving rings, dynamometers, load cells, force transducers). A force measuring device essentially consists of a component that is elastically deformed when a load or force is applied to it and a system that reads this deformation mechanically or electrically.

The primary area of activity of the TÜBİTAK UME Force Laboratory is the establishment national force standards and the dissemination of measurement traceability to industry. In this scope, force measuring devices are calibrated in the range between 0.5 N to 3 MN with a dead weight FSM up to 110 kN, with a lever amplification machine up to 1.1 MN and with built-up force standard machines up to 3 MN.



Brinell-Vickers Indentation Measurement System

110 kN and 1,1 MN Capacities Force Standard Machines

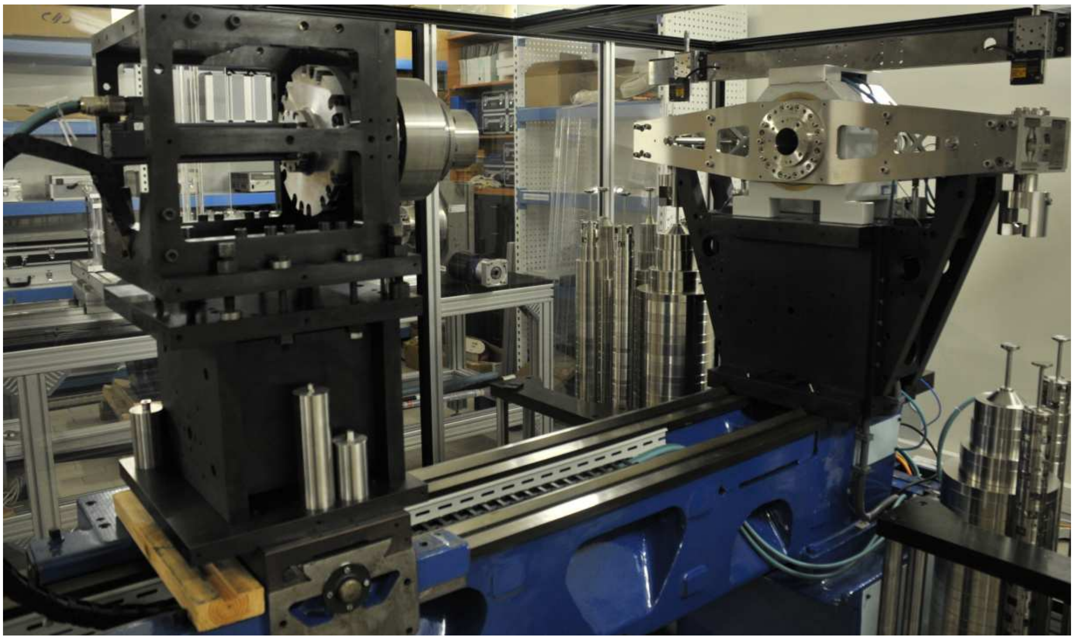
HARDNESS LABORATORY

In all fields of engineering, it is important to have knowledge of material properties at the time of design for a correct and suitable design. One of the most commonly referenced material properties is hardness. The area of study of the TÜBİTAK UME Hardness Laboratory is the establishment of national hardness standards and their transfer of the hardness unit to industry. In this scope, hardness reference blocks used for the calibration of hardness testing machines are calibrated by the TÜBİTAK UME Hardness Laboratory. The transfer of hardness scales constituted at UME is done through the calibration of hardness reference blocks. Hardness measurements in Turkey are ensured by reference equipment established for Rockwell, Brinell and Vickers hardness scales, the most commonly used hardness scales in our country and in the world.

Besides blocks, the calibration of hardness diamond indenters and testing machines; the design, mounting and automation of primary hardness standard machines; training and consultancy for companies in the field of hardness metrology and providing assessment services are also carried out by UME Hardness Laboratory.

TORQUE LABORATORY

The aim of the torque laboratory is the realization and maintenance of primary torque standards and the establishment of the national torque scale to transfer to industries. The primary level torque standard of our country was established with the 1000 N.m TÜBİTAK UME dead weight torque standard machine, by which torque measuring devices are calibrated by the TÜBİTAK UME Torque Laboratory.



1000 Nm Capacity Torque Standard Machine

Examples of Laboratory Projects

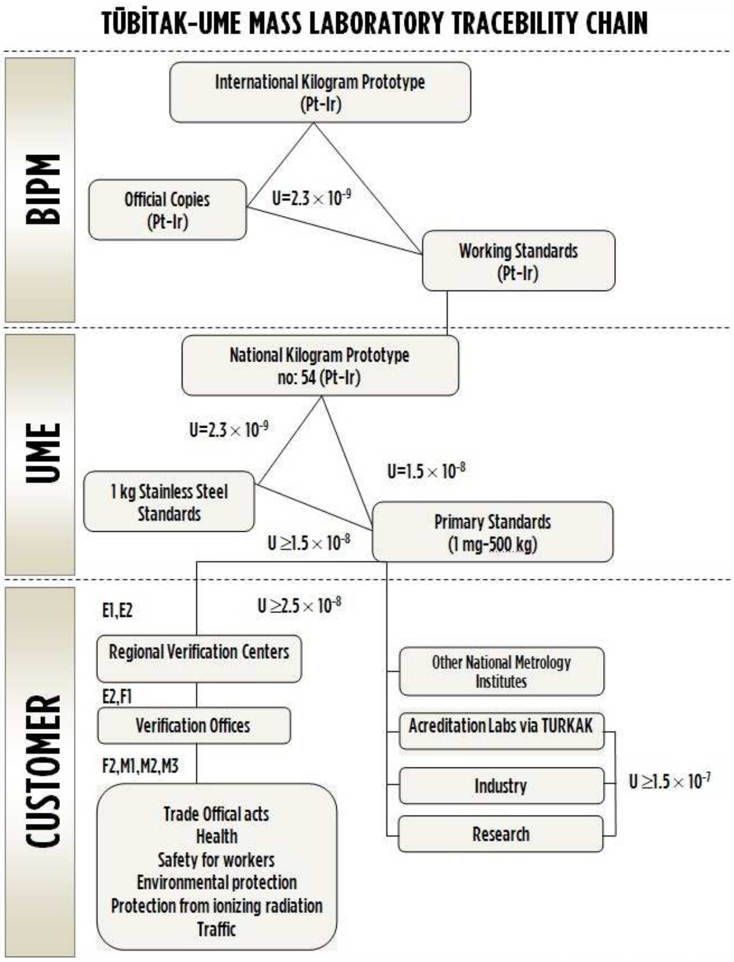
- Establishment of 600 N Force Standard Machine
- Establishment of Rockwell Hardness Standard Machine
- Establishment of Brinell-Vickers Hardness Standard Machine
- Establishment of 1000 N.m Torque Standard Machine
- KAMAG 1007 Project,“Establishment of 1000 N.m Torque Calibration Machine in TSE”
- Establishment of Force Laboratories Quality and Equipment infrastructure
- KAMAG 1007 Project, “Design, Development and Establishment of Force Reference Systems for Calibration of Force Measuring Devices”
- KAMAG 1007 Project, “Design, Development and Establishment of Hardness Reference Systems for Calibration of Hardness Reference Blocks”

MASS LABORATORIES

Mass Laboratory consists of three divisions: Mass, Volume-Density and Viscosity Laboratories. The working areas of the laboratories can be summarized as follows:

MASS LABORATORY

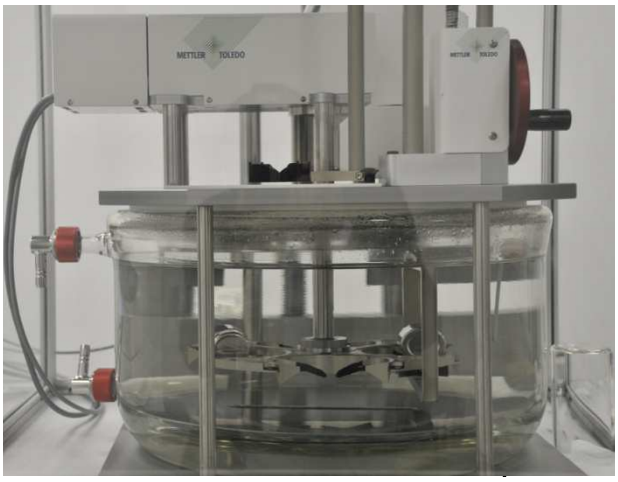
The Mass unit, which is one of the seven base SI units, is kilogram. The definition of the kilogram is based on the decision taken at the 3rd General Conference on Weights and Measures (Conférence Générale des Poids et Mesures, CGPM) that states, "Mass unit is kilogram and the unit of mass is equal to the mass of the international prototype of the kilogram." The traceability of primary level mass measurements is based on the national kilogram prototype number 54 belonging to Turkey. E0-class mass standards, which have high metrological characteristics and a mass comparator with a resolution of 0,1 µg and a maximum capacity of 1 kg is used for the realization of the unit of mass at primary level. In Mass Laboratory, the primary level 1 kg mass standard is determined with an 30 µg uncertainty. Traceable measurements are provided in in legal and industrial metrology and for mass related physical quantities such as density, pressure and force measurements using the primary level reference mass standards. The Mass Laboratory also conducts scientific research, such as the determination of air density experimentally in air, vacuum and inert gas environments and the determination of the effects of storage conditions on mass standards held in different environments (vacuum, inert gas and air).



Traceability Chain of the Unit of Mass, the Kilogram

VOLUME - DENSITY LABORATORY

The unit of volume is not an SI unit, but it is acceptable for use in International Systems of Units. Initially, the litre was defined as the volume of 1 kg of water. (3rd CGPM, 1901), then as the equivalent of 1 decimetre cube (12th CGPM, 1964). It was decided that the sign for litre would be "l" or "L" (16th CGPM, 1979). The traceability of volume measurements is provided in the range between 1 g to 50 kg reference mass by using the hydrostatic weighing method based on the Archimedes principle. Traceability of volume measurements is disseminated by the Volume - Density Laboratory using the primary level standards based on the gravimetric measurement method using single-channel piston operated pipettes-burettes between 5 µL and 10000 µL, glassware volumetric instruments between 0.1 mL and 5000 mL, and metal volume vessels in between 2 L - 200 L.



Measurement System

Density is a derived unit the in international system of units SI, defined as the ratio of a substance's mass to its volume; kg/m^3 is used as the SI unit for density. Traceability is provided using primary level laboratory standards based on the Cuckow method in the range of 650 kg/m^3 - 2000 kg/m^3 hydrometer scale.

VISCOSITY LABORATORY

Viscosity is defined as the resistance of fluids against flow. This physical property can be under two headings: dynamic viscosity and kinematic viscosity. Fluids, in terms of their viscosity, are either Newtonian or Non-Newtonian fluids.

The Viscosity Laboratory provides traceability to values that correspond to the kinematic and dynamic viscosity values of twice distilled water at normal atmospheric pressure (0.101325 MPa) with a density at 20 °C of ρ_W = 0.99820 g/cm^3. The internationally accepted viscosity values of water are published in ISO/TR 3666:1998. Reference Ubbelohde viscometers are used to transfer traceability to secondary level laboratories.

Rotational Viscometer
Measurement Setup

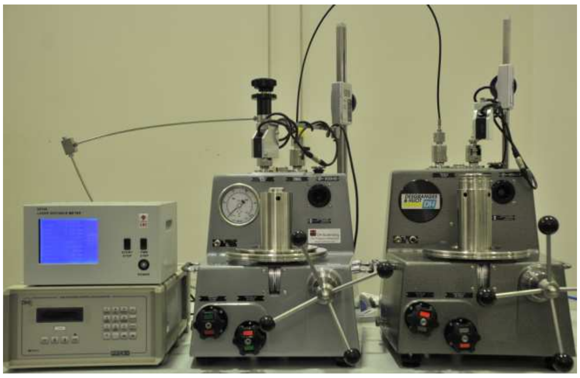
Using the primary level standards established in the laboratory, traceability is transferred to dynamic and kinematic viscosity measurements of Newtonian liquids in the range between 0.5 mm²/s and 100 000 mm²/s. In addition, traceability is provided for rotational viscometers the range of 0.001 mm²/s² to 100 mm²/s².

Examples of Laboratory Projects

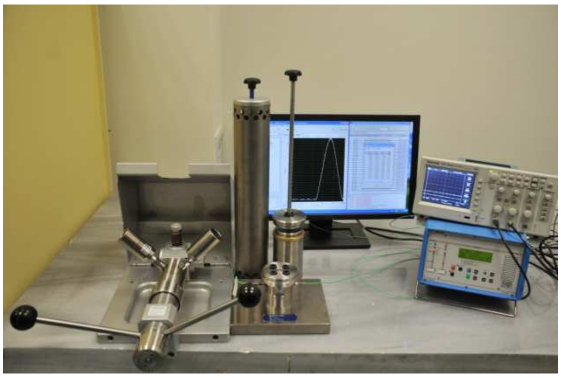
- FP7 EMRP Project, “SIB05 NEW KILO Developing a Practical Means of Disseminating the New Kilogram”
- Developing of Mass Standards below a Milligram
- Manufacture of E_1 and E_2 Mass Standards
- Experimental Air Density Determination by Weighing in Air and Under Vacuum/Helium
- Investigation of Storage Conditions Kept Mass Standards Under the Difference Conditions (Vacuum, Inert Gas and Air)
- Investigation on the Influences of Sorption and Cleaning and on the Long Term Stability of Mass Standards
- Determination of Methods of the Transition From Vacuum to Air Mass Standards Held in Different Environments
- Manufacture of 5 Ton Scales Runs Electromagnetic Force Compensation Method
- Automation of Hydrometer Measurement System
- Automation of the Measuring System to Determine the Volume and Density of the Reference Masses
- Realization of Primary Level Viscosity Reference Standards and Laboratory Working Standards
- Determination of the Duration of the Calibration Standard Newtonian Fluids
- Design of Flow Periods of Automatic Measuring Apparatus of Ubbelohde Viscosimeters

PRESSURE LABORATORIES

The Pressure Laboratories maintain capabilities for the measurement of 12 quantities for which Calibration and Measurement Capability (CMC) declarations have been published in the BIPM Key Comparison Database (KCDB). The Pressure Laboratories is divided into two units: the Pressure and the Vacuum Laboratories. The services provided by the laboratories and work areas can be summarized as follows:



Hydraulic Pressure Measurements



Dynamic Pressure Transducer Measurements

PRESSURE LABORATORY

Pneumatic, hydraulic, gauge and absolute pressure measurements are performed in the Pressure Laboratory. Measurements of pneumatic pressure are conducted in the range of 20 Pa to 100 MPa, and for hydraulic pressure, between $8 x 10^5$ Pa to 500 MPa.

The Pressure Laboratory provides consultancy services on pressure metrology, calibration methods, measurement techniques and uncertainty calculations. Also, it advises public and private establishments on the necessary technical requirements for laboratory construction and accreditation.

VACUUM LABORATORY

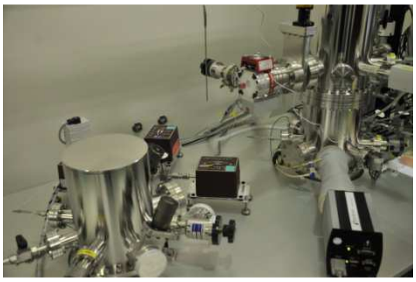
The main activities of the Vacuum Laboratory are conducted in four working areas: maintenance of the MSSE1 (Multi-Stage Static Expansion System) as the National Vacuum Standard, the secondary level vacuum calibration system, leak measurements and partial pressure measurements using a Quadrupole Mass Spectrometer.

All secondary-level vacuum gauge calibrations are performed on the secondary-level standard, the VGMS (Vacuum Gauge Metrology System), with a working pressure range of 10^{-4} Pa to 1.3 x 10^5 Pa and relative uncertainty of 8.3 x 10^{-2} - 7.9 x 10^{-3}. The traceability of the reference standards are provided through the primary level system.

The pressure range of the primary system is between 9 x 10^{-4} Pa and 10^3 Pa, and the relative uncertainty is 2.1 x 10^{-3} - 7.5 x 10^{-4}. The Primary Standard Static System has participated in an international intercomparison (EUROMET 442 A/B project).

As a partner in two joint research projects under the European Metrology Research Program, the laboratory has began working in areas such as leak standard measurements, stability measurements of leak detectors and quadrupole mass spectrometer, and the investigation of the effects of various parameters on the sensitivity of the spectrometer.

These measurements are being performed on the Dynamic Vacuum System established in 2012. Using this system, performance tests of vacuum pumps are planned in the future.



Dynamic Reference Vacuum System

Secondary Level Vacuum Gauge Calibration System (VGMS)

Primary Vacuum Standard "Multi-Stage Static Expansion System" (MSSE1)

Examples of Laboratory Projects

- FP7 EMRP Project, "IND12 Vacuum Metrology for Production Environments"
- FP7 EMRP Project, "IND09 Traceable Dynamic Measurements of Mechanical Quantities"

PHYSICS GROUP LABORATORIES

ELECTROMAGNETIC LABORATORIES

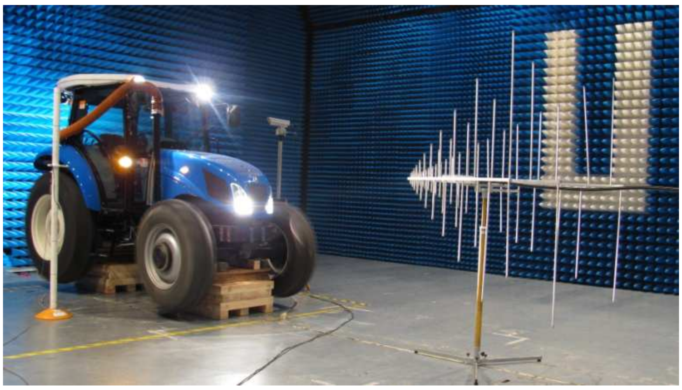
Electromagnetic Laboratories consists of the three divisions, namely: EMC 1 (Equipment Level EMI/EMC), EMC 2 (System Level EMI/EMC) and RF and Microwave Laboratory. The services provided by the laboratories and work areas can be summarized as follows:

EMC 1 LABORATORY (EQUIPMENT LEVEL EMI/EMC)

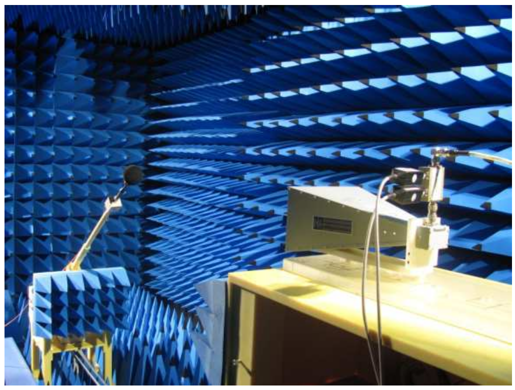
Electromagnetic Compatibility (EMC) is the branch of electrical sciences which studies the unintentional generation, propagation and reception of electromagnetic energy with reference to the unwanted effects (Electromagnetic interference, or EMI) that such energy may induce. EMC aims to ensure that equipment items or systems will not interfere with or prevent each other's correct operation through spurious emission and absorption of EMI. EMC is sometimes referred to as EMI Control, and in practice EMC and EMI are frequently referred to as a combined term "EMC/EMI".

EMC tests are commonly performed in full anechoic chambers, semi anechoic chambers, open area test sites and screened chambers in accordance with military or civil EMC standards. Full/semi anechoic chambers are special chambers whose internal metallic walls are covered by electromagnetic absorbers.

They are also screened from ambient electromagnetic interference. Unlike anechoic chambers, screened chambers do not include absorbers on their internal metallic walls but they are isolated from ambient electromagnetic interference.



EMC Test



Sample Calibration Setup

TÜBİTAK UME EMC Laboratory has the largest semi anechoic chamber in Turkey. In addition, it has one full anechoic chamber, four screened chambers, one open area test site, one GTEM cell and several TEM cells for civil and military EMC tests and also for EMC calibrations in the frequency range from 5 Hz to 40 GHz.

TÜBİTAK UME EMC Laboratory's working areas are as follows;

- The EMC test services have been accredited by the Turkish Accreditation Agency (TURKAK).
    - EMC tests for military products (MIL-STD 461E/F)
    - EMC tests for commercial products (EN/IEC/CISPR standards)
    - EMC tests for vehicle and electrical/electronic subassembly (Relevant European directives such as 2005/83/EC, 75/322/EEC and ISO standards)

- Calibrations for EMC Tests
    - Antenna Calibrations (ANSI C63.5 and SAE-ARP 958)
    - Electrical / Magnetic Field Calibrations (IEEE 1309)
    - Loop Antenna Calibrations (IEEE291 and SAE-ARP 958)
    - Rod Antenna Calibrations (ANSI C63.5 and SAE-ARP958)
    - Absorbing Clamp Calibrations (CISPR16-1-3)
    - Current Clamp Calibrations (CISPR 16-1- 2 and ISO 11452-4)
    - Active / Passive Probe Calibrations (CISPR16-1-2)

EMC 2 LABORATORY (SYSTEM LEVEL EMI/EMC)

Sample Project

Electromagnetic interference and compatibility studies were started at EMC /TEMPEST Test Center (ETTM) of TÜBİTAK UEKAE (National Research Institute of Electronics and Cryptology) as part of a project sponsored by the Turkish Armed Forces in 1995. The first studies were started with TEMPEST.

Many firsts were achieved within the framework of these studies. For example, the first electromagnetic shielded anechoic test room was built for the Turkish Armed Forces in 1999. Especially since 1999, in-depth studies were conducted at the platform level of electromagnetic compatibility.

Training and consulting activities were undertaken for implementation of the MIL-STD-464 document. One of the basic elements of platform level from an antenna-antenna electromagnetic interference was studied and an academic study was conducted to measure infrared device (IRCM) against electromagnetic emissions impact of antenna systems on helicopters. In this study, the resulting experience from the GAF RF-4E aircraft modernization project was used in the determination of aircraft antenna placement and interference analysis.

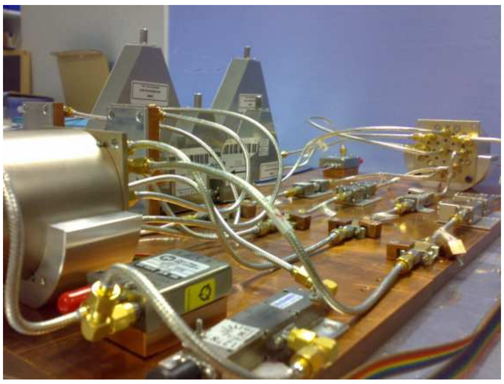
In 2005, a large scale project, MİLGEM, was signed and work began on all the activities of electromagnetic compatibility of the platform. On the scale model HF antennas measurements were developed an antenna measurement infrastructure with entirely national facilities within the scope of this project.

Also a planar near-field antenna measurement system for the radar antennas, as well as high gain directional antennas, was developed in 2009. The framework of the Eureka-Eurostars programme in European Union, joined as a NET-EMC project member. It is a software tool to perform analysis of electromagnetic interference on the platforms. Also has worked for standardization meetings in the affiliate panel (AEP) of NATO air-electric and electromagnetic factors by electromagnetic interference. Nowadays, TÜBİTAK UEKAE EMC Laboratory joined to TÜBİTAK UME Electromagnetic Radiation Laboratory as an EMC2. EMC2 has many large-scale projects and continues to provide EMI/EMC and antenna placement test and analysis services.

RF and MICROWAVE LABORATORY

The RF and Microwave laboratory has been equipped to measure power and s-parameters. A microcalorimeter system is used for primary level power measurements as a national standard on coaxial and waveguide. The Coaxial microcalorimeter has a frequency range of 100 kHz to 18 GHz and the waveguide microcalorimeter has a frequency range of 18 GHz to 26.5 GHz.

Measurements of the reflection and transmission coefficient of devices are performed by a vector network analyzer. The measurements of Type N, 3.5 mm and 2.4 mm connectors are achieved at frequencies of 18 GHz, 26.5 GHz and 50 GHz, respectively. Besides these activities, the laboratory has a project to establish a microwave noise calibration system to measure microwave noise sources.



Total Power Radiometer

A full band total power radiometer up to 26.5 GHz frequency was established and tested. The first results were satisfactory. The laboratory is also a partner in the EMRP Joint Research Project, “Implemantation of the new Kelvin”.

Examples of Laboratory Projects

- FP7 EMRP Project, "Traceable Measurement of Field Strength and SAR for the Physical Agents Directive"
- Doppler Speed Measurement Radar Calibrator System
- Antenna Measurement System for 2D/3D Pattern and Factor Measurements
- Peace Eagle Ground Support Center Antenna Placement and EMI/EMC Activities Project (Project Partners; BOING, HAVELSAN, TuAirF, SSM)
- MİLGEM EMI/EMC Activities Project" (Project Partners; HAVELSAN, ASELSAN, TuNavyF, SSM)
- Turkish Coast Guard Search and Rescue Ship EMI/EMC Testing Services Project (Project Partners; RMK Marine shipyard, ASELSAN, TuNavyF, SSM)
- LCT Ship EMI/EMC Testing and Analysis Services Project (Project Partners; ADİK Shipyard, ASELSAN, TuNavyF, SSM)
- TÜBİTAK SAGE Air-to-Ground Munitions Systems EMI/EMC Testing and Analysis Services Project" (Project Partners; TÜBİTAK SAGE, TuAirF, SSM)
- AZMIM EMI/EMC Test Activities Project" (Project Partners; FNSS, TuArmyF, SSM)
- MOSHIP and KURYED EMI/EMC Testing and Analysis Services Project (Project Partners; İstanbul Shipyard, ASELSAN, TuNavyF, SSM)

HIGH VOLTAGE LABORATORY

The TÜBİTAK UME High Voltage Laboratory has the capability to perform all AC, DC and Impulse high voltage measurement system calibrations in the laboratory or on-site. Taking account of the needs of the country and the industry, special test and measurement system design and construction, determination of appropriate measurement methods, design and construction of standards used for traceability transfer are also carried out by the laboratory.

400 kV AC High Voltage System

1000 kV Impulse High Voltage System

With the existing infrastructure, the TÜBİTAK UME High Voltage Laboratory provides the following services: DC high voltage measurement system calibrations up to 400 kV, AC high voltage measurement system calibrations up to 400 kV, lightning impulse high voltage measurement system calibrations up to 1000 kV, switching impulse high voltage measurement system calibrations up to 850 kV, partial discharge (PD) detector calibrations, partial discharge (PD) calibrator calibrations, partial discharge (PD) measurements of electromechanical devices under high voltage, high voltage capacitance standard calibrations, high voltage capacitance measurement device calibrations, capacitance measurements of electromechanical devices under high voltage. The laboratory can also perform high voltage tests of electromechanical devices in accordance with the applicable national and international standards.

The TÜBİTAK UME High Voltage Laboratory also designs and constructs DC high voltage dividers, AC high voltage dividers, lightning and switching impulse high voltage dividers, lightning and switching impulse calibrators, lightning and switching impulse measurement and analysis systems, AC and DC high voltage special voltmeters.

Examples of Laboratory Projects

- Internal Project “Design and Construction of 100 kV DC Reference High Voltage Divider”
- Internal Project “Design and Construction of 100 kV AC Standard Capacitor / High Voltage Divider (SF6 Gas Insulated)”
- TÜBİTAK 1001 Project, “Design and Construction of 500 kV Reference and 1000 kV Transfer Lightning Impulse High Voltage Divider”
- Industrial Project, “Design and Construction of 200 kV Lightning and Switching Impulse High Voltage Divider”
- Industrial Project, “Design and Construction of Lightning and Switching Impulse Measurement and Analysis System”
- TÜBİTAK 1001 Project, “Design and Construction of AC/DC Reference High-Voltage Probe and Peak Voltmeter”
- FP7 EMRP Project, “HVDC Metrology for High Voltage Direct Current”

IMPEDANCE LABORATORIES

DC and low frequency impedance measurements have been carried out in Impedance Laboratories. Impedance Laboratories consists of the two divisions, namely: DC Resistance and Capacitance Laboratory. The services provided by the laboratories and work areas can be summarized as follows:

DC RESISTANCE LABORATORY

Current Comparator Bridge made by TÜBİTAK UME

Traceability of DC resistance measurements is provided by Quantum Hall Resistance Standard established in UME, traceability of AC resistance measurements is provided by calculable AC resistors. Inductance measurements are performed at primary level using Maxwell-Wien Inductance Measurement Bridge while capacitance standards are calibrated by BIPM.

DC resistance measurements can be performed between 100 μΩ and 1 TΩ. DC resistance measurements between 1 GΩ and 100 TΩ are performed using UME made Wheatstone Bridge, while the measurements up to 1 GΩ are performed using commercially available measurement bridges. Low current measurements down to 2 pA can also be performed using high value resistors. Studies about to extend the scope of the low current measurements below 2 pA are also carried out.

Quantum Hall DC Resistance Standard

CAPACITANCE LABORATORY

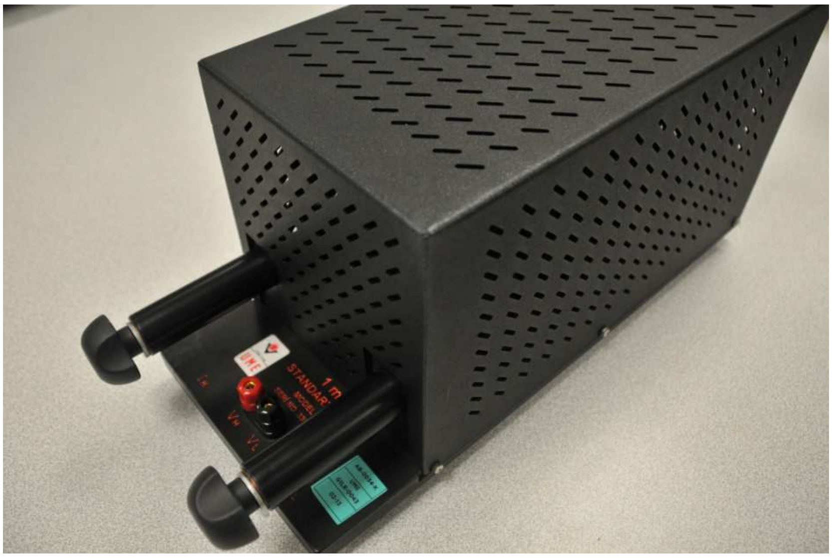
The traceability of AC resistance measurements is obtained by means of calculable AC resistors whose DC values are traceable to the Quantum Hall Resistance Standard. AC resistance measurements are usually used for calibrations of RLC meters. These measurements are carried out between 10 Ω and 2 MΩ at TÜBİTAK UME.

Traceability of capacitance measurements are obtained via Fused-Silica capacitors that are calibrated by BIPM. Two commercial bridge, AH2500A and AH2700A are used for the capacitance calibrations up to 1 µF. Capacitance calibrations between 1 µF and 1 mF are performed using UME made capacitance measurement bridge. Capacitance measurement frequency is up to 30 MHz for Agilent 16380 type capacitors.

Traceability of inductance measurements are obtained from capacitance and AC resistance units using Maxwell-Wien Bridge established at the laboratory. While inductance measurement range is 100 µH - 10 H, inductance measurements of the order of nH can be performed thanks to the latest works in the laboratory.

AC voltage ratio measurements are generally used for inductive voltage dividers and strain gauge indicators/calibrators.Traceability of the AC voltage ratio measurements are provided by UME-made primary level inductive voltage divider calibration system.

In addition to calibration services, device and standard manufacturing service is also provided in Impedance Laboratories. Within this context, devices and standards such as DC resistance standards, current shunts, capacitance standards and inductive voltage dividers can be manufactured in the laboratory.



TÜBİTAK UME Made 400 μΩ Current Shunt

Examples of Laboratory Projects

- Design and Construction of DC Resistance Comparison Bridge With the Measurement Accuracy of 1 ppm for Use in the Calibration of Temperature Sensors
- Establishment of a Measurement System Based on Microwave Cavity Principle for a European Union Project of Characterization of Energy Gases
- Establishment of a Charge Amplifier Calibration System to Be Used for Acoustic Measurements
- Design a Photodetector Amplifier to Be Used for Optical Measurements
- Development of a Calibration System for Strain Gauge Indicators and Calibrators
- Design and Manufacturing Oil Baths With the Stability of 1 mK/K
- Investigation of Electrical Features of Electromechanic and Electromagnetic Horns
- Realization of Sub-pA Measurements
- Performing Sub-nH Measurements
- Capacitance Measurements up to 30 MHz

MAGNETISM LABORATORY

The basic activities of the Magnetism Laboratory are the calibration of magnetic field measurement devices and characterization of magnetic materials. The laboratory establishes national standards in these areas, maintains their operational condition and transfers the traceability to secondary labs.

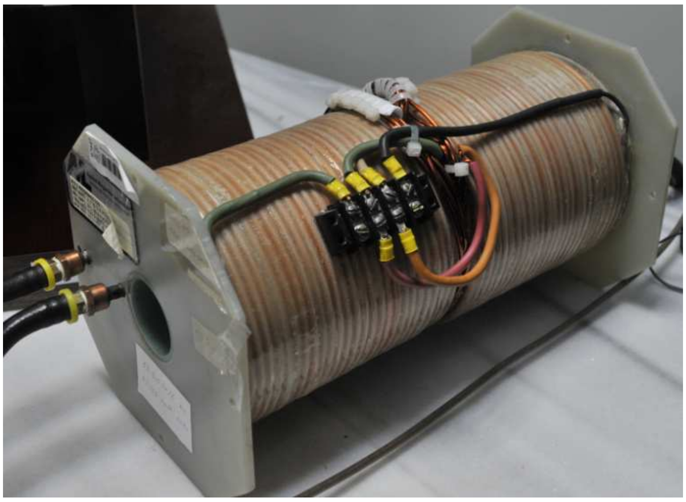
Magnetic field measurements with our primary standard, NMR Teslameter, are performed in the range of of 0.35 T - 3.4 T with an expanded uncertainty of 7 ppm.

Calibration of magnetic field measurement devices in the range of 0 mT - 10 mT is performed in a Helmholtz coil and in the range of 10 mT - 180 mT using a spilt-field coil. To generate DC magnetic fields and perform calibrations up to 2 T, an electromagnet is used. Calibration services are offered with an uncertainty of 0.3% for 0 mT - 10 mT DC and 0 mT - 5 mT AC ranges, 0.35% - 0.5% for the 10 mT - 180 mT DC range and 0.2% for the 180 mT - 2000 mT DC range.

Measurements of magnetic flux are performed in the range of 10^{-6}-1 Wb with an uncertainty of 0.09%.

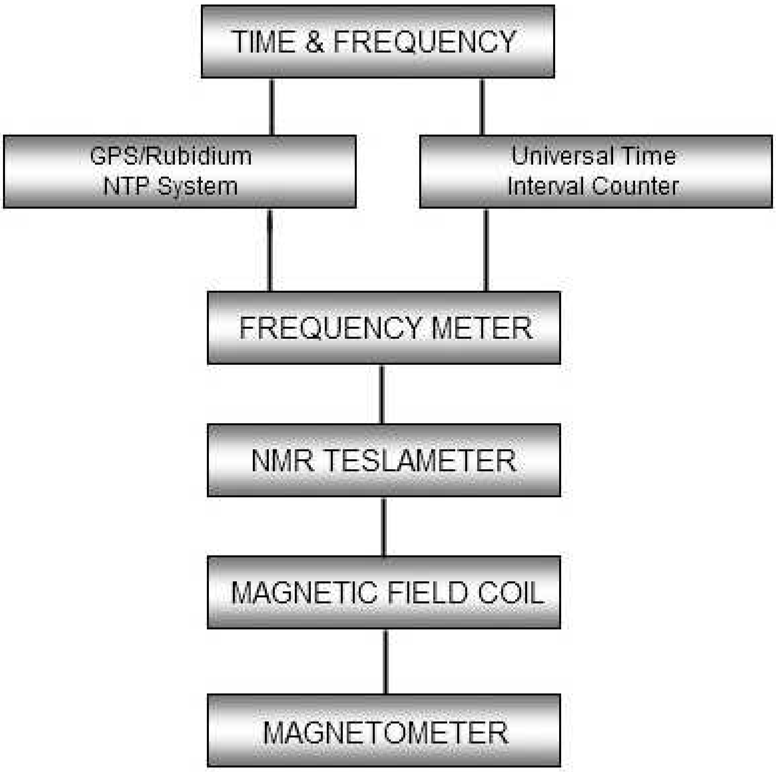
Calibration of magnetic field coils in the range of coil constants of 30 µT/A - 50 mT/A is performed with an uncertainty of 0.2% for DC magnetic field in the range of 0 T - 1 T and 0.26% for AC magnetic field in the range of 0 mT - 5 mT.

Characterization of magnetic materials is done using a VSM (Vibrating Sample Magnetometer) and SQUID (Superconducting Quantum Interference Magnetometer) magnetometers. Basic parameters of magnetic materials, such as magnetic permeability (µ), saturation magnetization (M_S), coercive field (H_C), remanent magnetization (M_r) are determined using these devices. VSM and SQUID magnetometers are calibrated using materials like nickel and palladium whose specific magnetization is known and is traceable to international primary standards, which is confirmed by certificates. The SQUID magnetometer can perform measurements with an uncertainty of 0.1% at temperatures between 1.9 K and 400 K for magnetic fields in the range of 0 T - 5 T and magnetic moments in the range of 0.000125 emu - 1.25 emu.



Split Field Coil

Hall Probe Gaussmeter

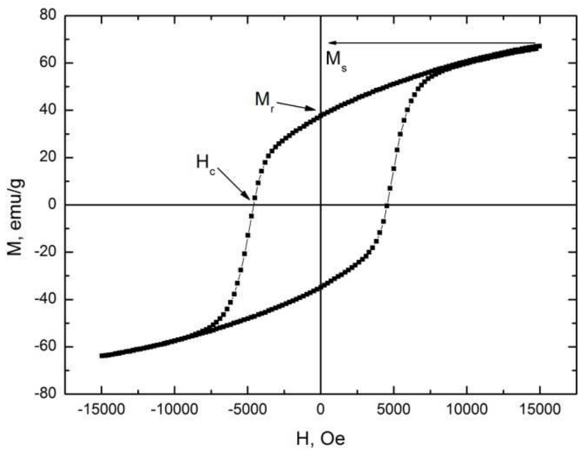


Traceability Chain of Magnetometer Calibrations

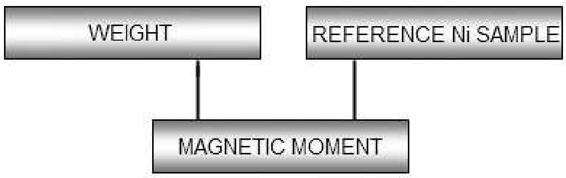
Helmholtz Coil

Compass Gaussmeter

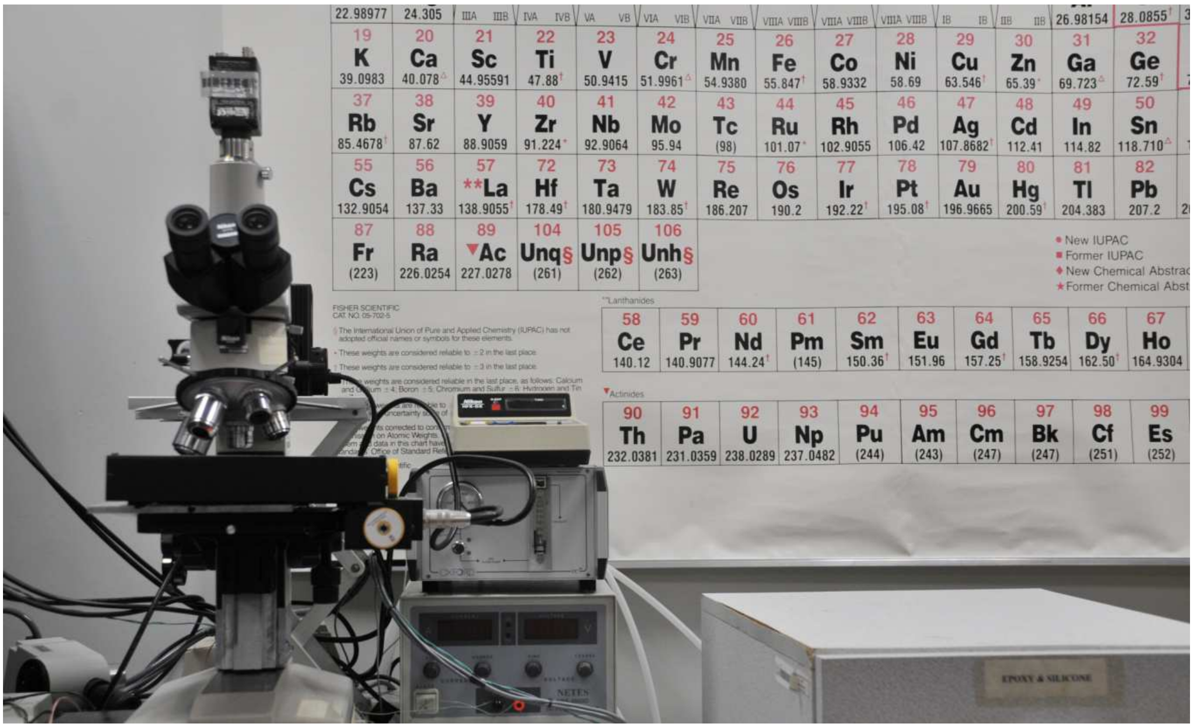
Additionally, the Magnetism Laboratory is equipped with a Magnetooptic Visualization System for direct observation of magnetic field spatial distribution on the surface of magnetic materials. The principle of operation of this system is based on the Faraday effect, i.e. the rotation of the polarization direction of polarized light passing through a magnetic field. To achieve Faraday rotation, special transparent magnetic Yttrium Iron Garnet films with the in-plane direction of magnetization are used. Measurements of local magnetic field are performed in the range of 0.1 mT - 100 mT with a spatial resolution of 1 μm and uncertainty of 4%.



Typical M-H Hysterisis Curve of a Ferromagnetic Material



Traceability Chain of Magnetization Measurements



Magneto-optical (MO) Imaging System

Examples of Laboratory Projects

- FP7 EMRP Project, “NanoSpin - Nanomagnetism and Spintronics”
- FP7 EMRP Project, “MetMags - Metrology for Advanced Industrial Magnetics”
- Development of Fluxgate Magnetometer With a Superconducting Sensor for Measurement of Low Magnetic Fields in the Nanotesla Range
- Development of Magnetic Materials for Microwave Absorption

OPTICS LABORATORIES

The Optics Laboratories consists of four units; Detector Radiometry, Photometry, Spectrophotometry and Fiber Optic laboratories.In addition to scientific metrology research activities, within the scope of a government funded project granted in 2012, the Optics Laboratories have started work to establish facilities to test solar panels used to transform solar energy, a significant renewable energy resource, into the electrical energy.

The aim is to establish a performance test center for silicon and thin film photovoltaic panels that meets the requirements of IEC 61646 and IEC 61215.

The research and development activites performed by the Optics Laboratories can be summarized as follows:

Cryogenic radiometer based-absolute specral CW optical power measurement system

DETECTOR RADIOMETRY LABORATORY

In Optic Laboratories the measurements of optical energy (J) at 1064 nm, spectral optical power (W), spectral responsivity (A/W), and irradiance (W/m^2 . nm) at 250 nm - 2500 nm are carried out.The traceability of optical energy measurements is provided by energy meters calibrated abroad by a metrology institute with higher level standards.

The traceability of the remaining radiometric measurements is obtained from the Cryogenic Radiometer, the primary absolute optical power measurement equipment, available in the Detector Radiometry Laboratory.

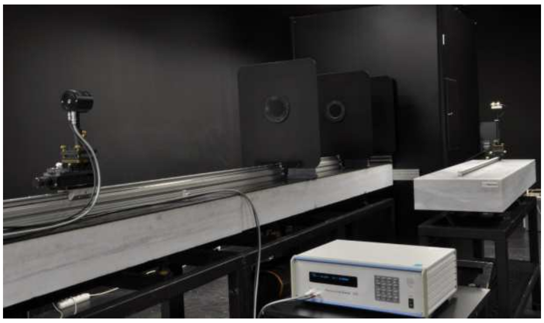
Optical energy measurements of pulsed lasers is performed in the range of 10 mJ - 150 mJ at 1064 nm for beam diameters varying from 6 mm to 8 mm. Spectral continuous wave optical power is measured between 10 µW - 1 W at both He-Ne, Ar+ ve Nd:YAG discreet wavelentghs and monochromatic radiation wavelengths in the spectral range of 250 nm - 2500 nm.

In these measurements Si, Ge, InGaAs, and pyroelectric radiometers are used as transfer and working standards. Thanks to these standards, the spectral responsivity calibrations of the semiconductor and the thermal detectors, sensitive to the same spectral range, are done in the range of $1x10^{-4}$ A/W - 1,5 A/W.

The spectral irradiance measurements are performed in the irradiance scale of $1x10^{-4}$ W/m^2 – 1.4 W/m^2 in the same spectral range as the spectral continuous wave (CW) optical power of 250 nm - 2500 nm.

PHOTOMETRY LABORATORY

In Photometry Laboratory, the luminous intensity unit Candela (cd), which is one of the seven fundamental SI units, and other photometric units; total luminous flux (lm), illuminance (lx), luminance (cd/m^2), luminous exposure (lx.s), luminous intensity coefficient (cd/lx) and retro reflection coefficient ($cd/(lx{\cdot}m^2)$), which are derived from the candela, are realized and measured.



Luminous intensity and illuminance measurement configuration

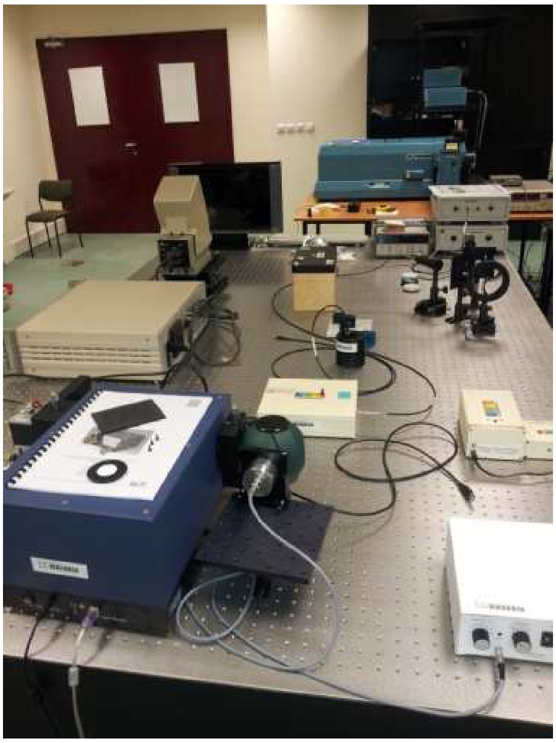
Total luminous flux measurement setup

The traceability of total luminous flux (lm) is maintained from the reference luminous flux lamps calibrated abroad, wheras the traceability of the rest of photometric units is maintained with the cryogenic radiometer .

Luminous intensity (cd), illminance (lx), luminous exposure (lx.s) and luminance (cd/m^2) calibrations are performed in the range of 1 cd - 10000 cd, 0.1 lux - 5000 lx, 0.01 lx.s - 5000 lx.s, and 1 $cd/\ m^2$ - 10000 cd/m^2, respectively, with photometers and photometric measurement equipments.

Total luminous flux measurements are carried out in the range of 5 (lm) - 5000 (lm) by using an integrating sphere, relative to the calibrated total luminous flux lamp. Luminous intensity coefficient and retroreflection coefficient measurements of retro-reflective materials are performed in $2x10^{-4}$ cd/lx - 10000 cd/lx by using the retroreflection measurement setup constructed by the Optic Laboratories.

SPECTROPHOTOMETRY LABORATORY



Color measurement setup of reflective, transmittive and emissive surfaces.

In the Spectrophotometry Laboratory, spectral transmittance, reflectance and absorption properties of solid and liquid materials, calibration of spectrophotometer instruments, measurement of color temparature of light sources, color parameters of solid and liquid materials, calibration of color measurement instruments, and gloss measurements are are the main areas of activity.

Spectral regular and diffuse reflectance/ transmittance properties of samples are determined using a monochromator based setup in the range of 0.1 - 1.0 reflectance units and of 0.001 - 1.0 transmittance units for the spectral range of 250 nm - 2500 nm.

The wavelength verification and absorption calibration of spectrophotometer instruments are performed using reference liquid and solid filters in the spectral range of 240 nm - 900 nm and 0.0 Abs - 3.0 Abs, respectively.

The color temperature values of light sources are measured between 2000 K - 9000 K using a spectroradiometer.

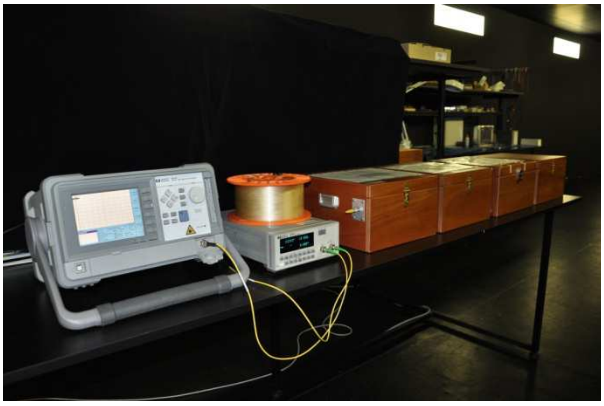
Standard measurement conditions (d:8°, d:0° and 0°:45°) and two standardized observer fields of view (2° ve 10°) are used in calculation and determination of CIE color parameters (XYZ, Yxy ve L*a*b*).

Gloss measurements are carried out at standardized angles of 20°, 60° and 85°. Spectral reflectance, color, and gloss measurements are traceable to a foreign national metrology institute wheras the rest of spectrophotometric measurements are based on the traceability chain of the TÜBİTAK UME radiometric scale.

FIBER OPTICS LABORATORY

In the Fiber Optics Laboratory, fiber optic power (W), attenuation (dB), spectral attenuation of fiber cable (dB/km) and distance (m) measurements are performed for single mode optical fibers.

Fiber optic power and attenuation (fiber optic attenuator) measurements for single mode optical fibers are performed the 10 µW - 380 µW at 1310 nm and 1550 nm and 0.00 dB - 15.00 dB ranges, respectively. These measurements are made with fiber optic sphere radiometer, InGaAs detectors, fiber optic power meters and attenuator instruments, traceable to the TÜBİTAK UME radiometric scale.



Color mesurement setup of reflective, transmittive and emissive surfaces.

Furthermore, spectral attenuation scale calibration of single mode Optical Time Domain Reflectometers (OTDRs) are carried out over the specral range of 1285 nm - 1327 nm ve 1530 nm - 1570 nm by means of Fiber Optic Attenuation Standards, characterized according to IEC60793-1-40. The distance scales of single mode Optical Time Domain Reflectometers (OTDRs) are calibrated using a Recirculating Delay Line artefact, which generates 10 recirculating transitions and was characterized in the TÜBİTAK UME Optic Laboratories.

The OTDR and fiber optic power related calibrations are performed according to IEC 61746 and IEC 61351, respectively.

Examples of Laboratory Projects

- TÜBİTAK 1001 Project, “Design of Multifunctional Color Analysis Instrument”
- TÜBİTAK 1001 Project, “Investigation of Magnetooptic Faraday Effect on the Sensing Coil of Interferometric Fiber Optic Gyroscope”
- DPT Project, “Establishment of Photovoltaic Performance Test Facility”
- Design of Gonioreflectometer Measurement System
- Design of Retroreflection Measurement System
- Design of Fiber Bragg Grating (FBG) Based Sensor System to Be Used in Real Time Strain Measurements

POWER AND ENERGY LABORATORY

The Power and Energy Laboratory is responsible for the establishment and maintenance of the national standards for AC Power and Energy and AC voltage and current ratio measurements, the dissemination of traceability to secondary level laboratories by means of calibration and ensuring international recognition of the measurements by means of international laboratory comparisons. The laboratory also engages in contract-based R&D activities in line with customer demands.

Relying on its accumulated experience, knowledge and infrastructure, the laboratory conducts activities such as scientific and industrial R&D projects, design of measurement device/standards, improvement of measurement methods and systems, calibration, training, consultancy and publication.

AC Power Measurement Standard

AC Current and AC Voltage Ratio Measurements

The Power and Energy Laboratory provides calibrations for a wide range of measuring equipment such as power and energy measurement devices, electricity meters, instrument voltage and current transformers. AC power and energy measurements are realized in the voltage range of 30 V - 500 V, in the current range of 0.01 A - 120 A and in the frequency values of 50 Hz and 60 Hz. AC power measurements are performed with uncertainties of 22 µW/VA (22 ppm) and 200 µW/VA (200 ppm) within the power frequencies. AC current ratio measurements are realized in the current range of 5/5 A - 5000/5 A. AC voltage ratio measurements are realized in the voltage range of 3 kV - 36 kV. Ratio and phase displacement measurements are performed with an uncertainty of 50 ppm. The unit of AC power is realized through a digital sampling wattmeter used as the AC power measurement standard.

Using the AC power measurement standard, the accuracy of the AC power measurements is transferred to power meters of the laboratory and then to customers' devices by means of calibration. The traceability for AC current ratio measurements are provided at the primary level using a reference current comparator and a current transformer bridge, while for AC voltage ratio measurements at the secondary level, a voltage transformer and a voltage transformer bridge are used. In accordance with the needs of the national metrology system, the laboratory conducts R&D activities.

Examples of Laboratory Projects

- Industrial Project, “Calibration Automation for Power & Energy Meters”
- Industrial Project, “Development of a Reference Current Transformer and Standard Current Transformer Burden Sets”
- Industrial Project, “Development of a Transfer Standard for High Current Test Laboratories”
- Industrial Project, “Development of Compensated Isolation Current Transformers for Closed-Link Electricity Meters”
- FP7 EMRP Project, “ENG04 Smart Grids - Metrology for Smart Electrical Grids”
- EURAMET TC EM Project, No 1168 “Using Agilent 3458 Multimeter for Precision Sampling in Calibration Laboratory”
- TÜBİTAK 1001 Project, “Investigation of Magnetic and Capacitive Error Components of Current Transformers Together With Burden Effects and Development of Compensation Methods”
- Industrial Project “Development of Electronic Current Transformers: LPCTs and RCs’’

The reliability of the measurements performed in the laboratory is demonstrated through participation in various international comparisons. The laboratory has participated in a total of five intercomparisons, in three of which it acted as the pilot laboratory. Detailed information can be found in the BIPM Key Comparison Database (http://kcdb.bipm.org).

TEMPERATURE LABORATORIES

The Temperature Laboratories consist of three divisions: Contact Thermometry, Radiation Thermometry and Humidity Laboratories. The services provided by the laboratories and work areas can be summarized as follows:

CONTACT THERMOMETRY LABORATORY

The Contact Thermometry realizes the temperature unit Kelvin (K) which is one of the seven basic SI units. The laboratory is responsible for realizing the ITS-90 scale implemented on platinum resistance thermometers at the primary level in the temperature range between 13.8033 K (-259.35 °C) and 1234.93 K (961.78 °C).

Fixed-point temperatures defined in ITS-90 are given below:

- Triple point temperature of Argon (-189.3442 °C),
- Triple point temperature of Mercury (-38.8344 °C),
- Triple point temperature of Water (0.010 °C),
- Melting point temperature of Gallium (29.7646 °C),
- Freezing point temperature of Indium (156.5985 °C) ,
- Freezing point temperature of Tin (231.928 °C),
- Freezing point temperature of Zinc (419.527 °C),
- Freezing point temperature of Aluminium (660.323 °C),
- Freezing point temperature of Silver (961.780 °C)

Triple
Point of Water Cell

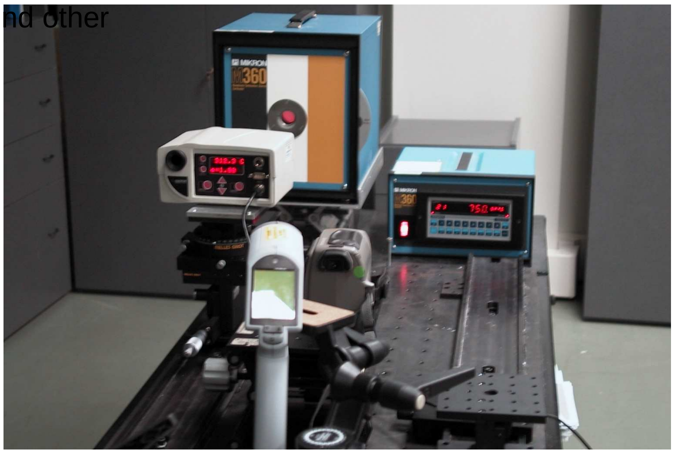
Filling Stage During Construction of Mercury Fixed Point

Fixed point cells, used to obtain specific temperature values, are fabricated and maintained in the laboratory. In order to respond to needs in defense and other industries, all kinds of temperature measurements and calibrations are carried out at a primary level. The laboratory constitutes and maintains the defined primary and secondary standards of temperature in ITS-90 and disseminates the scale to secondary laboratories.

RADIATION THERMOMETRY LABORATORY

The Radiation Thermometry Laboratory realizes the part of the ITS-90 scale above the freezing point of silver (1234.93 K; 961.78 ℃), wh ich is defined by Planck's Radiation Law. The ITS-90 Radiation Thermometry Scale is established using one of silver, gold, or copper fixed-point blackbody cells. Additionally, low temperature measurements are performed using indium, tin, zinc and aluminum fixed-point blackbody cells. In order to improve the measurement uncertainty at high temperatures, eutectic fixed-point blackbody cells are constructed and measured for R&D purposes.

Radiation thermometry methods allow remote and fast temperature measurements and are therefore used in iron-steel, textile, plastics, glass, paper, cement and food industries where measurement devices' contact with the target could be harmful or the target object is hard to reach, also in military and industrial thermal cameras and night-vision systems. Although, radiation thermometry is defined in ITS-90 for high temperatures, in practice, it is commonly used for temperatures as low as -50 ℃, in food, me dical, construction, and other industries.



Set-up for Calibration of a Radiation Thermometer

Radiation Thermometer TSP-2 in Front of the Blackbody Source

HUMIDITY LABORATORY

The Humidity Laboratory provides measurement traceability through primary level calibrations of thermometers, pressure transmitters and flow meters. Relative humidity and temperature measurements can be performed at ambient temperatures in the range from -10 ℃ to 70 ℃ for relative humidity measurements between 11 % rh and 95 % rh. Dew-point measurements can be performed at ambient temperatures between -10 ℃ and 70 ℃ for dew-point measurements between -60 ℃ FP and 60 ℃ DP. The reference humidity generator provides its traceability from the measurements of pressure and temperature. Furthermore, the accuracy of the reference humidity generator and reference dew-point meters are mutually monitored. The reference humidity generator and dew-point meters have been used in international comparisons.

There are continuing R&D studies for the measurement of moisture and fabrication of relative humidity sensors in the laboratory. The installation of a primary level, two-temperature humidity generator system, which will serve the range of -80 ℃ to 10 ℃ frost/dew-point temperature values, is also one of the ongoing projects of Humidity Laboratory.

Humidity Calibration Set-up

Examples of Laboratory Projects

- Construction of Radiation Thermometer
- Development of A Calibration Method for Thermocouples Via Radiation Thermometer
- FP7 EMRP Project, “NOTED - Novel Techniques for Traceable Temperature Dissemination”
- FP7 EMRP InK Project, “Implementing the New Kelvin”
- FP7 EMRP Project, “Characterization of Energy Gases”
- FP7 EMRP HiTeMS Project, “High Temperature Metrology for Industrial Applications”
- Construction of Primer Level Reference Fixed Points As Stated in ITS-90
- Construction of Platinum Based Reference Thermocouples
- Construction of Two-Temperature Humidity Generator System and Its Characterization
- Construction of High Temperature Metal-Carbon Eutectic Fixed Point Cells
- Fabrication and Characterization of Porous Thin-Film Relative Humidity Sensor

TIME - FREQUENCY AND WAVELENGTH LABORATORIES

The second (s), one of the seven SI units, can be measured with an accuracy of 10^{-14} - 10^{-15}, which makes it the most accurately measurable unit. For this reason, time and frequency measurements are used in order to increase the accuracies of other units. Nowadays, technologically advanced countries establish their own time and frequency systems and support studies to improve time and frequency standards. With improving technology, the need for highly accurate time and frequency data and measurements in avionics, space and defence systems has increased. The improvement of frequency stabilised lasers is very important and useful for the development of the optical clock and for length measurements with nanometer uncertainty and displacement measurements with picometer uncertainty.

The Time - Frequency and Wavelength Laboratories consist of two divisions: The Time - Frequency Laboratory and the Wavelength Laboratory.

The services provided by the laboratories and their work areas can be summarized as follows:

TIME - FREQUENCY LABORATORY

Time Scale Generation and Traceability

In the Time - Frequency Laboratory of TÜBİTAK UME, time keeping and dissemination systems were developed using five commercially available Cs clocks and two GPS receivers. This laboratory has been contributing to the calculation of International Atomic Time (TAI), realized by the BIPM, since 1994. The UTC (UME) time scale is generated with an uncertainty better than $2x10^{-14}$. A 10 MHz and 1PPS signal is used as the reference for calibration services, the time dissemination system and the femtosecond COMB for laser frequency measurements.

Time Keeping and Dissemination System

Time Dissemination

The Time Dissemination System was developed for the distribution of generated time from Cs atomic clock via local area networks (LANs), wide area networks (WANs), and internet/intranet by using a network time protocol (NTP) at stratum - 1 level. Through this system, time dissemination is realized with an uncertainty better than 5 ms for LAN and better than 50 ms for WAN.

WAVELENGTH LABORATORY

Frequency Stabilized Lasers

In the Wavelength Laboratory, lasers of different wavelengths have been developed and stabilized to the Rb and Cs atoms, I_2 and CH_4 molecules with a stability of $1x10^{-11}$ - $1x10^{-14}$. The parameters influencing the frequency of the He-Ne/I_2 and He-Ne/CH_4 gas lasers, Nd-YAG/I_2 solid state laser and the ECDL/Rb,Cs semi-conductor lasers have been investigated and analyzed. The absolute frequency of the He-Ne/I_2 (633 nm) stabilized on the f line of the iodine molecules has been measured and compared both with the BIPM (473 612 353 602.0 ± 1.1 kHz) and the UME (473 612 353 600.6 ± 1.1 kHz) Ti:Sa Comb systems.

The absolute frequency (88 376 181 000 253 ± 23 Hz) of the He-Ne/CH_4 laser (3390 nm) has been measured by the PTB frequency chain system. Developed ECDL lasers have been locked to the Cs (852 nm) and Rb (780 nm) D_2 atomic lines and to the 2-photon S-D lines of Rb atoms (778 nm).

High-Resolution Laser Spectroscopy

Using the frequency tunable lasers, selective reflection on the D_2 lines of Cs atoms, wave mixing, laser pressure on the resonances, optical pumping on the Zeeman levels, coherent population trapping effects have been investigated. Free space microwave-atom-laser interaction and radio-optical coherent resonances has been the subject of study. Research into the polarization and Faraday effects on the S-D 2-photon transitions of Rb atoms has been carried out. Another research topic has been the influence of light intensity and gas pressure on the absorption resonances of the I_2 and CH_4 molecules.

Absolute Frequency Measurements of Stabilised Lasers with Femtosecond COMB

Absolute frequency measurements of frequency stabilised He-Ne/I_2, Nd-YAG/I_2 and ECDL/Rb,Cs lasers were performed with a femtosecond Ti:Sa COMB (530 nm - 1100 nm) that is externally triggered by the 10 MHz signal of the Cs atomic clock. In the laboratory, a Yb fiber based femtosecond COMB working in the 600 nm - 1600 nm range and generating 33 fs pulses has been developed. The repetition and offset frequency of the developed Yb COMB system has been locked to the 10 MHz signal of Cs atomic clock.

Yb Fiber Based Femtosecond Frequency Comb and Supercontinuum Spectrum Generation in Photonic Crystal Fiber

Length Measurement with the Laser Interferometer

The Köster Interferometer is a system which can measure the length of gauge blocks with a resolution of 10^{-9} meter. In this system, laser beams from three different stabilized lasers are transferred via fiber cables into the interferometer where the gauge block is placed. The interference fringes observed through the CCD camera are analyzed and the lengths of the gauge blocks are obtained. Gauge blocks with lengths between 125 mm - 1000 mm are calibrated using this system. A 1 meter gauge block can be measured with an uncertainty of 200 nm.

Sub-nanometer Displacement Measurements

TÜBİTAK UME, together with five other national metrology instiutes (NMIs) under the coordinatorship of INRIM (Italy), collaborated in the NANOTRACE joint research project funded by the European Metrology Research Programme (EMRP). The aim of the project was to develop the next generation of optical interferometers having a target uncertainty of 10 ppm. TÜBİTAK UME designed and developed temperature and vacuum controlled interferometers within this project. Differential Fabry - Perot Interferometers have also been developed and have been compared with the NPL x-ray interferometer, generating traceable reference displacements.

The differential Fabry-Perot interferometer system makes use of frequency stabilized tunable External Cavity Diode Lasers (ECDLs) and beat frequency measurement techniques. The half and one fringe displacements of the x-ray interferometer have been measured with an accuracy of less than 5 pm with the system developed.

Experimental Set-up for Sub-nanometer Displacement Measurements

Examples of Laboratory Projects

- Development and Realization Time and Frequency Measurement and Calibration System for SASO, Kingdom of Saudi Arabia
- FP7 EMRP Project, “Traceability of Sub-nm Length Measurements”
- Development of Short Mastar Gauge Block Interferometer
- Development and Realization of Two-Photon Transition Stabilized Laser System
- Development and Realization Time Dissemination and Distribution System
- Development of Cs Atomic Clock Stabilized Yb Fiber Optical Frequency COMB
- Development of Doppler Radar Calibrator
- FP7 EMRP Project, “NANOTRACE - New Traceability Routes for Nanometrology”
- Development of Long Mastar Gauge Block Koster Interferometer
- Development of Wavelength Standards and Its Application for Length Measurements
- Development of Time and Frequency System Based on Cs Atomic Clock and GPS Receiver and Realization of International Traceability
- FP7 EMRP Project, “Compact Microwave Clocks for Industrial Applications”

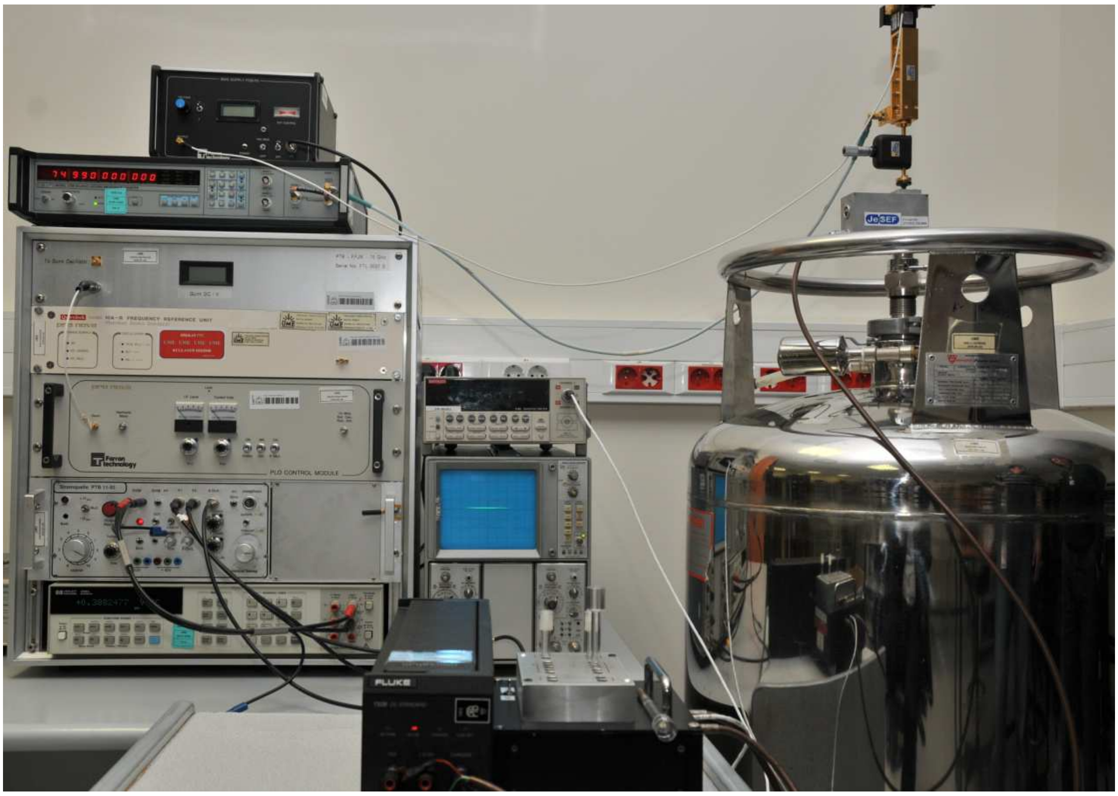
VOLTAGE LABORATORY

The Voltage Laboratory is responsible for the establishment and maintenance of the national standards for voltage measurements, the dissemination of traceability to secondary level laboratories by means of calibration and ensuring international recognition of the measurements by means of international laboratory comparisons.

The laboratory also conducts activities such as R&D projects, calibration, training, consultancy, development of measurement methods and systems and design of measurement standards.

The Voltage Laboratory has measurement capabilities in the areas of DC and AC voltage, DC and AC current. Measurement ranges are 0 V - 1000 V for DC voltage, 2 mV - 1000 V at frequencies of 10 Hz - 1 MHz for AC voltage, 0.1 V - 50 V at 1 MHz - 100 MHz for RF voltage, 1 µA - 1000 A for DC current and 100 µA - 20 A at 10 Hz-100 kHz for AC current.

The realization of the unit of voltage is based on the AC Josephson effect. The Josephson DC Voltage Standard is used to maintain the TÜBİTAK UME group of zener diode based-DC voltage standards. Using these standards, the accuracy of the Josephson voltage is transferred to the working standards of the laboratory and then to customer devices by means of calibration.



UME Josephson Voltage Standard

Traceability for DC current measurements is established using DC voltage and resistance standards which are traceable to the Josephson and Quantum Hall standards respectively.

AC measurement traceability is provided by comparison to the DC standards using thermal converters. Thermal converters are used in the combination with suitable serial and parallel connected resistors to form standards for AC voltage and current.

TÜBİTAK UME
Made Thermal Converter

The reliability of measurements performed in the laboratory is demonstrated through participation in various international comparisons. Details about the laboratory comparisons and calibration and measurement capabilities (CMCs) can be found in BIPM KCDB database (http://kcdb.bipm.org).

Laboratory facilities including calibration services are operated in accordance with TÜBİTAK UME's Quality Management System which complies with ISO/IEC 17025 "General requirements for the competence of testing and calibration laboratories". Voltage Laboratory has been accredited by Turkish Accreditation Agency (TÜRKAK) according to ISO/IEC 17025. The accreditation scope of the laboratory covers a wide range of calibration services. (Accreditation No: AB-0034-K)

Examples of Laboratory Projects

- "Extending AC Current Measurement Capabilities Up to 100 A (10 Hz - 100 kHz)"
- "Establishing of the System for Measurement of AC Voltage in the Range of 1 mV - 100 mV at 1 - 100 MHz Frequency Band"

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TRUE MEASUREMENT EXCELLENCE

NATIONAL METROLOGY INSTITUTE
P.O.BOX 54, 41470 GEBZE KOCAELI / TURKEY
T +90 (262) 679 50 00 F +90 (262) 679 50 01
www.ume.tubitak.gov.tr