**Technical Capacity Building Program**

**at**

**TUBITAK UME**



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# Training List at TUBITAK UME

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| --- | --- | --- | --- | --- |
| **Code Name** | **Subject** | **Description of Training** | **Duration** | **Date** |
| **1-UME- M** | **Mass** | Legal metrology | 6 weeks (30 Days) | September 2020 |
| Quality |
| Mass Metrology |
| **2-UME-P** | **Pressure** | Legal metrology | 6 weeks (30 Days) | September 2020 |
| Quality |
| Pressure Metrology |
| **3-UME- FTH** | **Force ,Torque, Hardness Metrology** | Legal metrology | 6 weeks (30 Days) | September 2020 |
| Quality |
| Force ,Torque, Hardness Metrology |
| **4-UME- VDV** | **Volume, Density, Viscosity Metrology** | Legal metrology | 6 weeks (30 Days) | September 2020 |
| Quality |
| Volume, Density, Viscosity Metrology |
| **5-UME-F** | **Flow Metrology** | Legal metrology | 6 weeks (30 Days) | September 2020 |
| Quality |
| Flow Metrology |
| **6-UME-D** | **Dimensional Metrology** | Legal metrology | 6 weeks (30 Days) | September 2020 |
| Quality |
| Dimensional Metrology |
| **7-UME-T** | **Temperature Metrology** | Legal metrology | 6 weeks (30 Days) | September 2020 |
| Quality |
| Temperature Metrology |
| **8-UME-PE** | **Power & Energy Metrology** | Legal metrology | 6 weeks (30 Days) | September 2020 |
| Quality |
| Power & Energy Metrology |
| **9-UME- V** | **Voltage Metrology** | Legal metrology | 6 weeks (30 Days) | September 2020 |
| Quality |
| Voltage Metrology |
| **10-UME-I** | **Impedance Metrology** | Legal metrology | 6 weeks (30 Days) | September 2020 |
| Quality |
| Impedance Metrology |

# Training Program of Mass Metrology

| **Mass Laboratory**  **30 days at TUBITAK UME** |
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| **Legal Metrolog**y : **5 days**  **Orientation Program**: TUBITAK UME presntation and lab visits **: 2 days** |
| **Quality (General Metrology, Fundamentals of Measurement, Introduction and Implementation of ISO/IEC 17025: 2017 Standard) : 3 days**  **General Metrology, Fundamentals of Measurement, Calibration and Validation**   * Metrology as a science of measurements. Brief history of metrology International System of Units (SI). SI Brochure * International Metrological Infrastructure. Metre Convention. Mutual Recognition Arrangement (CIPM MRA) * General terms and concepts in metrology. International Vocabulary in Metrology (VIM) * National Quality Infrastructure. Role of National Metrology Institute in National Quality Infrastructure   **Introduction to Evaluation of Measurement Uncertainty**   * Basic terms and definitions used in evaluation of Measurement uncertainty * Basic method for evaluation of measurement uncertainty: GUM approach * Type A evaluation of measurement uncertainty * Type B evaluation of measurement uncertainty * Statistical distributions used in uncertainty estimation * Calculation of combined and expanded uncertainty * Reporting calibration/measurement results   **Introduction and Implementation of ISO/IEC 17025: 2017 Standard**   * General information about the ISO/IEC standard, history of its development * Overview of the structure of the standard * Normative references and bibliography * General and structural requirements * Resource requirements * Process requirements * Management requirements (Option A and Option B) * Metrological traceability * Risk based thinking |

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| **Mass laboartory : 20 days**   * Secondary level mass measurements, dissemination of unit of mass, determination of mass value and conventional mass value and uncertainty calculations * Performance tests of mass comparators to be used for mass determination * Volume/Density determination of mass standards by hydrostatic weighing method * Verification of weights / weight sets * Verification of non-automatic weighing instruments * Verification of automatic weighing instruments * Calibration of non-automatic weighing instruments * Calibration of automatic weighing instruments |

# Training Program of Pressure Metrology

| **Pressure Metrology**  **30 days at TUBITAK UME** |
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| **Legal Metrology : 5 days**  **Orientation Program: TUBITAK UME presntation and lab visits : 2 days** |
| **Quality (General Metrology, Fundamentals of Measurement, Introduction and Implementation of ISO/IEC 17025: 2017 Standard) : 3 days**  **General Metrology, Fundamentals of Measurement, Calibration and Validation**   * Metrology as a science of measurements. Brief history of metrology International System of Units (SI). SI Brochure * International Metrological Infrastructure. Metre Convention. Mutual Recognition Arrangement (CIPM MRA) * General terms and concepts in metrology. International Vocabulary in Metrology (VIM) * National Quality Infrastructure. Role of National Metrology Institute in National Quality Infrastructure   **Introduction to Evaluation of Measurement Uncertainty**   * Basic terms and definitions used in evaluation of Measurement uncertainty * Basic method for evaluation of measurement uncertainty: GUM approach * Type A evaluation of measurement uncertainty * Type B evaluation of measurement uncertainty * Statistical distributions used in uncertainty estimation * Calculation of combined and expanded uncertainty * Reporting calibration/measurement results   **Introduction and Implementation of ISO/IEC 17025: 2017 Standard**   * General information about the ISO/IEC standard, history of its development * Overview of the structure of the standard * Normative references and bibliography * General and structural requirements * Resource requirements * Process requirements * Management requirements (Option A and Option B) * Metrological traceability * Risk based thinking |

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| **Pressure laboartory : 20 days**  **General Concepts of Pressure Metrology**   * What is pressure * Terms and definitions * Absolute pressure, barometric pressure, gauge pressure, differential pressure   **Calibrations of Analog and Digital Guges**   * Calibration of Analogue and Digital Manometers * Basics of analogue and digital manometers, types, working principles, classification, things to do prior to calibration * International standards of “guidelines on the calibration of electromechanical manometers” * Calibration procedure of analogue and digital manometer, calibration of analogue and digital manometers and uncertainty calculations * Practical applications and examples on analogue and digital manometers * Preparing for calibration, cleaning, setup&installation, calibration data recording form, preparing an excel calculation template * Full calibration of a analogue manometer * Calculating mesurement uncertainty, reporting results, preparing a calibration certificate   **Calibrations of Pressure Transducers**  Calibration of Pressure Transducers&Transmitters   * Preparing for calibration, cleaning, setup&installation, calibration data recording form, preparing an excel calculation template * Full calibration of a analogue manometer * Calculating mesurement uncertainty, reporting results, preparing a calibration certificate   **Pressure Balance Metrology**  Introduction to pressure balance metrology   * Costruction of pressure balance * Pneumatic, hydraulic, gauge and absolute measurements on pressure balances * Calculating the pressure for a measurement for pressure balances * Doing practical measurements with pressure balances * Uncertainty calculations on pressure balances   **Interlaboratory Comparisons**   * Types of comparisons * Organization and participation for comparisons * Preparing comparison technical protocols * Performing measurements * Preparing measurement report |

# Training Program of Force-Hardness-Torque Metrology

| **Force-Hardness-Torque Metrology**  **30 days at TUBITAK UME** |
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| **Legal Metrology : 5 days**  **Orientation Program: TUBITAK UME presntation and lab visits : 7 days** |
| **Quality (General Metrology, Fundamentals of Measurement, Introduction and Implementation of ISO/IEC 17025: 2017 Standard) : 3 days**  **General Metrology, Fundamentals of Measurement, Calibration and Validation**   * Metrology as a science of measurements. Brief history of metrology International System of Units (SI). SI Brochure * International Metrological Infrastructure. Metre Convention. Mutual Recognition Arrangement (CIPM MRA) * General terms and concepts in metrology. International Vocabulary in Metrology (VIM) * National Quality Infrastructure. Role of National Metrology Institute in National Quality Infrastructure   **Introduction to Evaluation of Measurement Uncertainty**   * Basic terms and definitions used in evaluation of Measurement uncertainty * Basic method for evaluation of measurement uncertainty: GUM approach * Type A evaluation of measurement uncertainty * Type B evaluation of measurement uncertainty * Statistical distributions used in uncertainty estimation * Calculation of combined and expanded uncertainty * Reporting calibration/measurement results   **Introduction and Implementation of ISO/IEC 17025: 2017 Standard**   * General information about the ISO/IEC standard, history of its development * Overview of the structure of the standard * Normative references and bibliography * General and structural requirements * Resource requirements * Process requirements * Management requirements (Option A and Option B) * Metrological traceability * Risk based thinking |

| **Program of Training Force Metrology : 5 days**   * General information about application fields of force proving instruments * Types of force proving instruments * force standard machines * Knowledge of load (force) measuring devices * Verification necessities and period of force proving instruments * Verification method and procedure of force proving instruments * Application about verification methods of force proving instruments * Evaluation of measurement results taken during verification process. * Calculation of measurement uncertainty * Classification of force proving instruments * General information about application fields of material testing machine * Types of material testing machines in industry * Knowledge of load (force) measuring devices * Importance of material testing machine verification * Verification necessities and period of material testing machine * Verification method and procedure of force measuring instrument of material testing machines * Application about verification methods of material testing machines for force measuring devices * Evaluation of measurement results taken during verification process. * Calculation of measurement uncertainty of material testing machines * Classification of material testing machines force system |
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| **Program of Training Torque Metrology : 5 days**  **General information about Torque and Torque Metrology**   * Calibration requirments acc. to the ISO 6789-1: 2017 * Calibration sequence acc. to the ISO 6789-1: 2017 * Calculation of deviation acc. to the ISO 6789-1: 2017 * Theoretical knowledge about uncertainty budget of torque hand tools calibration acc. to the ISO 6789-2:2017 * Preperation of Excel calculation form for torque hand tools, type I, Class A, B, C * Preperation of Excel calculation form for torque hand tools, type II, Class A,B, C, D, E * preparation of certificate of torque hand tools   Application I:   * Calibration practise for indicating torque hand tools * Calibration of torque wrench (Type I - Class B or C) * Calculation of calibration results, * Certification of calibration,   Application II:   * Calibration practise for setting torque hand tools * Calibration of torque wrench (Type - II Class A) * Calculation of calibration results, * Certification of calibration, |
| --- |
| **Program of Training Hardness Metrology : 5 days**   * General information about application fields of hardness instruments * Calibration of Rockwell, * Calibration of Brinell, * Calibration of Vickers, * Hardness Reference Blocks and Uncertainty Calculations * Calculation of measurement uncertainty * General information about application fields of hardness instruments * Calibration of Force Application Systems, * Calibration of Indentation Measurment Systems, * Calibration of Indirect Calibration by Hardness Reference Blocks of Hardness Testing Machines (Rockwell, Brinell, Vickers)   Calculation of measurement uncertainty |

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# Training Services at TÜBİTAK UME in Volume, Density and Viscosity Laboratory

| ume_yeni_2  **Training Program**  **20 days at TUBITAK UME** | |
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| **Days / Hours** | **Activities** |
| **Day 1** | **Welcome and Short Introduction**   * Visiting three laboratory areas * Information about the facilities of each laboratory areas |
| **Day 2 - 8** | **Volume Metrology**   * Introduction and terminology of Volume Metrology according to volumetric instruments (ISO 4787 and EURAMET cg-19) * Theoretical knowledge about volumetric instruments calibration * Theoretical knowledge about uncertainty budget of volumetric instruments calibration * Practice of volumetric instruments * Assessment of input quantities and calculation of uncertainty parameters of volumetric instruments. (ISO 4787 and EURAMET cg-19) * Introduction and terminology of Volume Metrology according to Piston-Operated Pipettes (ISO 8655-1) * Theoretical knowledge about Piston-Operated Pipettes calibration (ISO 8655-2 and 6) * Theoretical knowledge about uncertainty budget of Piston-Operated Pipettes calibration (ISO 8655 and ISO 20461) * Practice of Piston-Operated Pipettes * Assessment of input quantities and calculation of uncertainty parameters of Piston-Operated Pipettes (ISO 8655 and ISO 20461) * Discussion of training results |
| **Day 9 - 16** | **Density Metrology**   * Introduction to hydrometer calibration (ISO 649) * Theoretical knowledge about hydrometer calibration * Requirements for hydrometer calibration * Introduction of hydrometer calibration setup * Theoretical knowledge about uncertainty budget of hydrometer calibration * Practice of hydrometer calibration * Uncertainty evaluation in hydrometer calibration * Example of the calculation * Self practice of trainees and calculation of input values with uncertainties * Discussion of training results |
| **Day 16 - 20** | **Viscosity Metrology**   * Viscosity metrology general description and concepts * Theoretical knowledge about uncertainty budget of viscosity calibration * Viscosity Metrology according to Kinematic Viscosity measurement (ASTM D 445 and DIN 51 562-1-4) * Practice of determination of Kinematic Viscosity using Ubbelohde Viscometer calibration * Viscosity Metrology according to Capillary Viscometer calibration (ASTM D 446 and DIN 51 562-1-4) * Practice of calibration Capillary Ubbelohde Viscometer * Discussion of training results |

# Training Program of Flow Metrology

| **Flow Metrology**  **Fluid Mechanics Laboratory**  **30 days at TUBITAK UME** |
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| **Legal Metrology : 5 days**  **Orientation Program: TUBITAK UME presntation and lab visits : 2 days** |
| **Quality (General Metrology, Fundamentals of Measurement, Introduction and Implementation of ISO/IEC 17025: 2017 Standard) : 3 days**  **General Metrology, Fundamentals of Measurement, Calibration and Validation**   * Metrology as a science of measurements. Brief history of metrology International System of Units (SI). SI Brochure * International Metrological Infrastructure. Metre Convention. Mutual Recognition Arrangement (CIPM MRA) * General terms and concepts in metrology. International Vocabulary in Metrology (VIM) * National Quality Infrastructure. Role of National Metrology Institute in National Quality Infrastructure   **Introduction to Evaluation of Measurement Uncertainty**   * Basic terms and definitions used in evaluation of Measurement uncertainty * Basic method for evaluation of measurement uncertainty: GUM approach * Type A evaluation of measurement uncertainty * Type B evaluation of measurement uncertainty * Statistical distributions used in uncertainty estimation * Calculation of combined and expanded uncertainty * Reporting calibration/measurement results   **Introduction and Implementation of ISO/IEC 17025: 2017 Standard**   * General information about the ISO/IEC standard, history of its development * Overview of the structure of the standard * Normative references and bibliography * General and structural requirements * Resource requirements * Process requirements * Management requirements (Option A and Option B) * Metrological traceability * Risk based thinking |
| **Training Program in Fluid Mechanics Laboratory : 20 days**  **Welcome and Short Introduction**   * Visiting laboratory areas * Information about the facilities of each laboratory areas * Fundamentals of fluid mechanics   **Gas Flow Measurements**   * General information * Laboratory Work and Practices * Uncertainty calculations   **Water Flow Measurements**   * General information * Laboratory Work and Practices * Uncertainty calculations   **Air Velocity Measurements**   * General information * Laboratory Work and Practices * Uncertainty calculations   **CFD analysis with ANSYS**   * A sample for water flow in a pipe * A sample for air flow in a pipe   **Laboratory Work and Practices**   * Water Flow Measurements * Air Velocity Measurements * Gas Flow Measurements   **Comparisons**   * Preparation of the protocol * How to take measurements * How to make uncertainity calculations * Preparation of the comparision report |

# Training Program of Dimensional Metrology

| **Dimensional Laboratory**  **30 days at TUBITAK UME** |
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| **Legal Metrology : 5 days**  **Orientation Program: TUBITAK UME presntation and lab visits : 2 days** |
| **Quality (General Metrology, Fundamentals of Measurement, Introduction and Implementation of ISO/IEC 17025: 2017 Standard) : 3 days**  **General Metrology, Fundamentals of Measurement, Calibration and Validation**   * Metrology as a science of measurements. Brief history of metrology International System of Units (SI). SI Brochure * International Metrological Infrastructure. Metre Convention. Mutual Recognition Arrangement (CIPM MRA) * General terms and concepts in metrology. International Vocabulary in Metrology (VIM) * National Quality Infrastructure. Role of National Metrology Institute in National Quality Infrastructure   **Introduction to Evaluation of Measurement Uncertainty**   * Basic terms and definitions used in evaluation of Measurement uncertainty * Basic method for evaluation of measurement uncertainty: GUM approach * Type A evaluation of measurement uncertainty * Type B evaluation of measurement uncertainty * Statistical distributions used in uncertainty estimation * Calculation of combined and expanded uncertainty * Reporting calibration/measurement results   **Introduction and Implementation of ISO/IEC 17025: 2017 Standard**   * General information about the ISO/IEC standard, history of its development * Overview of the structure of the standard * Normative references and bibliography * General and structural requirements * Resource requirements * Process requirements * Management requirements (Option A and Option B) * Metrological traceability * Risk based thinking |

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| **Program of Training Dimensional Laboratory : 20 days**  **Special Training program for Basic Dimensional Devices (Micrometers, Dial Gauges, Height Gauges, Vernier Calipers)**   * Use of basic dimensional devices, * Calibration methods, * Uncertainty parameters and calculations   **Short Gauge Blocks And Their Calibration**   * Short gauge blocks calibration and uncertainty calculation, gauge blocks definitions, technical specifications, materials, production and classifications   **Short Gauge Block Comparators And Their Calibration**   * Training of short gauge block comparators calibration (Acc.to EURAMET/cg-02/v.02)   **Special Training program for measurement tapes and scales**   * General terms and definitions * Calibration of tapes and scales * Uncertainty parameters and calculations   **Special Training program for Surface Roughness Measurements and Uncertainty Calculations**   * Surface roughness measurements and uncertainty calculations, surface texture and their types, roughness measurements techniques   P**arallel Ring-Plug Gauges Calibration and Uncertainty Calculation**   * Parallel ring-plug gauges calibration and uncertainty calculation, calibration of reference ring-plug gauges with form measurements and without form measurements, calibration of Go-NoGo ring-plug gauges   P**arallel Thread Ring-Plug Gauges Calibration and Uncertainty Calculation**   * Parallel Thread Ring-Plug Gauges Calibration and Uncertainty Calculation   **Form Measurements and Uncertainty Calculations**   * Form measurements and uncertainty calculations, form deviations and method of determination of form deviations, calibration of form measurement device |

# Training Program of Temperature Metrology

| **Temperature Laboratory**  **30 days at TUBITAK UME** |
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| **Legal Metrology : 5 days**  **Orientation Program: TUBITAK UME presntation and lab visits : 2 days** |
| **Quality (General Metrology, Fundamentals of Measurement, Introduction and Implementation of ISO/IEC 17025: 2017 Standard) : 3 days**  **General Metrology, Fundamentals of Measurement, Calibration and Validation**   * Metrology as a science of measurements. Brief history of metrology International System of Units (SI). SI Brochure * International Metrological Infrastructure. Metre Convention. Mutual Recognition Arrangement (CIPM MRA) * General terms and concepts in metrology. International Vocabulary in Metrology (VIM) * National Quality Infrastructure. Role of National Metrology Institute in National Quality Infrastructure   **Introduction to Evaluation of Measurement Uncertainty**   * Basic terms and definitions used in evaluation of Measurement uncertainty * Basic method for evaluation of measurement uncertainty: GUM approach * Type A evaluation of measurement uncertainty * Type B evaluation of measurement uncertainty * Statistical distributions used in uncertainty estimation * Calculation of combined and expanded uncertainty * Reporting calibration/measurement results   **Introduction and Implementation of ISO/IEC 17025: 2017 Standard**   * General information about the ISO/IEC standard, history of its development * Overview of the structure of the standard * Normative references and bibliography * General and structural requirements * Resource requirements * Process requirements * Management requirements (Option A and Option B) * Metrological traceability * Risk based thinking |

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| **Program of Training Temperature Laboratory : 20 days**  **Primary Level Contact Temperature Metrology**  **Calibration of Standard platinum Resistance Thermometers**   * Terms and definitions related to temperature * Theoretical background for temperature measurements, Basics of Thermodynamics, Phase Transitions, Temperature- Resistance Relationship * International Temperature Scale (ITS-90) * Basic elements of Primary Level Temperature Calibration (Fixed Points, SPRTS, Bridges, etc) * Practical work – Measurements with ITS-90 fixed point cells, Inducing freezing plateau, Evaluation of the plateau * Applying hydrostatic head and self-heating corrections * Calculation of W value * Uncertainty Evaluation |
| **Secondary Level Contact Temperature Metrology**  **Calibration of Industrial Thermometers**   * Theoretical background for temperature measurements with industrial PRTs, Digital Thermometers, Thermistors, Interpolation Equations * Laboratory Practice : Calibration of Industrial PRT and Digital Thermometer by comparison method * Uncertainty Evaluation |
| **Calibration of Temperature-controlled Enclosures and Dry-Block Calibrators**   * Definition of the thermometers used for temperature measurements for temperature-controlled volumes, The related standards EURAMET/cg.20 guide, EURAMET/cg.13 guide TS EN 600068-3-5, in accordance with TS EN 600068-3-11, * Laboratory practice with characterization of temperature-controlled volume and dry-block calibrator * Uncertainty evaluation |
| **Calibration of Radiation Thermometers by Comparison Method**   * Theoretical background on ITS-90 Radiation Temperature Scale & Planck’s Radiation Law, Industrial Radiation Thermometers and Blackbody Sources and Emissivity * Laboratory Practice : Calibration of IR calibrator and radiation thermometer by comparison method * Uncertainty evaluation |
| **Calibration of Thermo-Hygrometers**   * Definitions and equations related with relative humidity, working principles of various hygrometers, humidity generators, humidity measuring techniques, Theoretical background of Two-pressure humidity generator in terms of Relative Humidity * Laboratory Practice : Hygrometer relative humidity calibration in the Two-pressure humidity generator * Uncertainty Evaluation   **Calibration of Dew-point temperature meters**   * Definitions and equations related with dew-point temperature, working principles of dew-point meters, dew-point temperature measuring techniques, uncertainty evaluation of dew-point meters, Theoretical background of Two-pressure humidity generator in terms of Dew-Point temperature * Laboratory Practice : Dew-point meter calibration in the Two-pressure humidity generator * Uncertainty Evaluation |

# Training Program of Power and Energy Metrology

| **Power and Energy Laboratory**  **30 days at TUBITAK UME** |
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| **Legal Metrology : 5 days**  **Orientation Program: TUBITAK UME presntation and lab visits : 2 days** |
| **Quality (General Metrology, Fundamentals of Measurement, Introduction and Implementation of ISO/IEC 17025: 2017 Standard) : 3 days**  **General Metrology, Fundamentals of Measurement, Calibration and Validation**   * Metrology as a science of measurements. Brief history of metrology International System of Units (SI). SI Brochure * International Metrological Infrastructure. Metre Convention. Mutual Recognition Arrangement (CIPM MRA) * General terms and concepts in metrology. International Vocabulary in Metrology (VIM) * National Quality Infrastructure. Role of National Metrology Institute in National Quality Infrastructure   **Introduction to Evaluation of Measurement Uncertainty**   * Basic terms and definitions used in evaluation of Measurement uncertainty * Basic method for evaluation of measurement uncertainty: GUM approach * Type A evaluation of measurement uncertainty * Type B evaluation of measurement uncertainty * Statistical distributions used in uncertainty estimation * Calculation of combined and expanded uncertainty * Reporting calibration/measurement results   **Introduction and Implementation of ISO/IEC 17025: 2017 Standard**   * General information about the ISO/IEC standard, history of its development * Overview of the structure of the standard * Normative references and bibliography * General and structural requirements * Resource requirements * Process requirements * Management requirements (Option A and Option B) * Metrological traceability * Risk based thinking |

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| **Program of Training Power and Energy Laboratory : 20 days**  **Welcome and Short Introduction**   * Visiting two laboratory areas * Information about the facilities of each laboratory areas   **General Concepts Relating to AC Power Measurements**   * AC Power Measurements in general * Precision Active, Reactive and Apparent Power Measurements * Uncertainty calculations   **Laboratory Work and Practices**   * Practices on AC Power Mesaurements * Precision Active, Reactive and Apparent Power Measurements * Using Digital Sampling Method for AC Power Measurements * Error sources in Measurements * Prediction, Definition, Calculation and Compensation of Errors   **General Concepts Relating to Energy Measurements**   * Energy measurements in general * Minimum Requirements for Energy Meter Measurements   **Laboratory Work and Practices**   * Electricity meter tests and calibrations * Need for Isolation Current Transformers in Meter Testings * Uncertainty calculations   **AC Power & Energy Tracebility, CMCs, Comparisons**   * Preliminary Works on AC Power Comparisons and CMCs * Comparison Methods and Traceability in AC Power Measurements * Recent Research Areas in AC Power Measurements   **General Concepts Relating to Instrument Current & Voltage Transformers**   * Current & Voltage Transformers in general * Current & Voltage Transformer Tests and Calibrations * Uncertainty calculations |
| **Laboratory Work and Practices**   * Practices on Current & Voltage Transformer Measurements * Error Sources of Current & Voltage Transformers * Compensation Methods * Electronically-compensation Methods   **Laboratory Work and Practices**   * Current Transformer Test Set and Bridge Calibrations * Current Transformer Burden Measurements * Voltage Transformer Test Set and Bridge Calibrations * Voltage Transformer Burden Measurements   **Instrument Transformers Tracebility, CMCs, Comparisons**   * Preliminary Works on Current & Voltage Transformers (High Current and High Voltage Ratios) Comparisons and CMCs * Comparison Methods and Traceability in High Current Ratio Measurements * Comparison Methods and Traceability in High Voltage Ratio Measurements * Recent Research Areas in AC High Voltage and High Current Measurements including New Transducers and Sensors |

# Training Program of Voltage Metrology

| **Voltage Laboratory**  **30 days at TUBITAK UME** |
| --- |
| **Legal Metrology : 5 days**  **Orientation Program: TUBITAK UME presntation and lab visits : 2 days** |
| **Quality (General Metrology, Fundamentals of Measurement, Introduction and Implementation of ISO/IEC 17025: 2017 Standard) : 3 days**  **General Metrology, Fundamentals of Measurement, Calibration and Validation**   * Metrology as a science of measurements. Brief history of metrology International System of Units (SI). SI Brochure * International Metrological Infrastructure. Metre Convention. Mutual Recognition Arrangement (CIPM MRA) * General terms and concepts in metrology. International Vocabulary in Metrology (VIM) * National Quality Infrastructure. Role of National Metrology Institute in National Quality Infrastructure   **Introduction to Evaluation of Measurement Uncertainty**   * Basic terms and definitions used in evaluation of Measurement uncertainty * Basic method for evaluation of measurement uncertainty: GUM approach * Type A evaluation of measurement uncertainty * Type B evaluation of measurement uncertainty * Statistical distributions used in uncertainty estimation * Calculation of combined and expanded uncertainty * Reporting calibration/measurement results   **Introduction and Implementation of ISO/IEC 17025: 2017 Standard**   * General information about the ISO/IEC standard, history of its development * Overview of the structure of the standard * Normative references and bibliography * General and structural requirements * Resource requirements * Process requirements * Management requirements (Option A and Option B) * Metrological traceability * Risk based thinking |

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| **Training Program Voltage Laboratory : 20 days**  **DC Voltage Measurements**   * Introduction to Voltage Metrology * DC Electronic Standards * Josephson Standards * Calibration of the DC standards using Josephson Standard * Calibration of the DC standard by Reference group * Uncertainty calculations   **DC Ratio Measurements**   * Voltage Dividers * Calibration of a Voltage Divider * Calibration of the DC voltage source by using divider * Uncertainty calculations   **DC Current Measurements**   * Calibration of the DC Current source by using Reference Shunt * Uncertainty calculations   **AC-DC Transfer Measurements**   * Basic Concepts of AC-DC transfer * Thermal Converters * Calibration of the thermal converters by comparison * Calibration of the AC-DC shunts * Calibration of the AC Voltage sources and meters by using thermal converters * Calibration of the AC Current sources and meters by using thermal converters and ac-dc current shunts * Uncertainty calculations   **High Precision (8.5 Digit) Multimeter Calibration**   * Calibration of the multimeter by Reference Calibrator * Uncertainty calculations |

# Training Program of Impedance Metrology

| **Impedance Laboratory**  **30 days at TUBITAK UME** |
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| **Legal Metrology : 5 days**  **Orientation Program: TUBITAK UME presntation and lab visits : 2 days** |
| **Quality (General Metrology, Fundamentals of Measurement, Introduction and Implementation of ISO/IEC 17025: 2017 Standard) : 3 days**  **General Metrology, Fundamentals of Measurement, Calibration and Validation**   * Metrology as a science of measurements. Brief history of metrology International System of Units (SI). SI Brochure * International Metrological Infrastructure. Metre Convention. Mutual Recognition Arrangement (CIPM MRA) * General terms and concepts in metrology. International Vocabulary in Metrology (VIM) * National Quality Infrastructure. Role of National Metrology Institute in National Quality Infrastructure   **Introduction to Evaluation of Measurement Uncertainty**   * Basic terms and definitions used in evaluation of Measurement uncertainty * Basic method for evaluation of measurement uncertainty: GUM approach * Type A evaluation of measurement uncertainty * Type B evaluation of measurement uncertainty * Statistical distributions used in uncertainty estimation * Calculation of combined and expanded uncertainty * Reporting calibration/measurement results   **Introduction and Implementation of ISO/IEC 17025: 2017 Standard**   * General information about the ISO/IEC standard, history of its development * Overview of the structure of the standard * Normative references and bibliography * General and structural requirements * Resource requirements * Process requirements * Management requirements (Option A and Option B) * Metrological traceability * Risk based thinking |

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| **Training Program in Impedance Laboratory : 20 days**  **General Concepts Relating to Impedance Measurements**   * Introduction to impedance metrology * Definitions * Impedance units * Calibrations in the scope of impedance   **DC Resistance Measurement Methods and Standards**   * 2 wire measurements * 4 wire measurements * Low value resistance measurements * High value resistance measurements   **Calibration of DC resistors and current shunts**   * Standard resistor types * History of standards * Calibration methods for standard resistors * Calibration methods for current shunts   **Calibration of DC Resistance Meters**   * Types of ohmmeters * Calibration of ohmmeters * Microohmmeters, megaohmmeters   **Calibration of High Value Resistors and Resistance Meters**   * High value resistance measurements * High value resistors * High resistance meters * Calibration of high value resistance and meters   **Uncertainty Calculations and Reporting the Measurement Results**   * Introduction to uncertainty analysis in DC resistance measurements * Uncertainty Analysis and Model Functions * Examples and reporting the measurement results |