

Short Report on Activities in the Field of Acoustical Metrology at UME

Activities related to the establishment of metrological infrastructure in acoustical field at National Metrology Institute of Turkey, UME began in the early 90s. Currently, UME has an advanced infrastructure for acoustical measurements, providing traceability to Turkish industry.

Since acoustical metrology covers four measurement fields: sound in air, ultrasound, underwater acoustics and vibration, the current status of national standards and calibration/measurements capabilities are described in this document in separate sections.

1. Sound in Air

The national standard of sound pressure is realized through the calibration of laboratory standard microphones by the pressure reciprocity technique in full accordance with the requirements of the International Standard, IEC 61094-2. At present, UME's capability for reciprocity calibration covers the frequency ranges of 10 Hz - 10 kHz and 10 Hz - 31.5 kHz for LS1P and LS2P microphones, respectively. Reciprocity calibration of microphones is performed using the Brüel & Kjaer Type 9699 Reciprocity Calibration System. The overall uncertainty of microphone reciprocity calibrations lies in the ranges of 0.04 dB - 0.10 dB and 0.04 dB - 0.20 dB for LS1P and LS2P microphones, respectively. Work on the upgrade of the reciprocity calibration system is in progress. The aim is to use a real time FFT/PCB analyzer instead of discrete system based on a digital multimeter. The upgraded system will allow performing phase calibration of laboratory standard microphones in the whole frequency range with better filtering.

UME developed laser pistonphones for the calibration of microphones at low frequencies. Two types of laser pistonphones are available. One of them is based on the conventional Michelson interferometer, another on a self-mixing interferometer with diode laser. Both laser pistonphones were designed and constructed at UME. Performance of the laser pistonphones were validated through the comparison of calibration results of LS1P microphones by laser pistonphone and reciprocity method in the overlapping frequency range.

In order to prove its calibration capabilities and to establish a degree of equivalence between its realized standard and the national standards of other countries, UME has participated in many key comparisons since 1996. Most important among them are CCAUV.A-K3, CCAUV.A-K2, EUROMET.AUV.A-K1 and COOMET.AUV.A-K1.

The dissemination of the unit is maintained through the calibration of working standard microphones (WS1P and WS2P), which are used for calibrations of sound calibrators by insert voltage technique. UME's capability includes calibrations of a very wide range of devices used for acoustical measurements. Currently, UME has 16 entries for calibration and measurement capabilities (CMC) published in the BIPM Key Comparison Data Base (KCDB), which covers 6 calibration services in the field of airborne acoustics.

UME has very special facilities for acoustical measurements, e.g. Full Anechoic and Reverberation Rooms. The Full Anechoic Room with a cut-off frequency of 50 Hz, and the Reverberation Room with an overall volume of 260 m³, were planned to serve various purposes. But at the present stage they are used intensively for measurements of sound power and sound absorption in accordance with relevant ISO Standards. The demand from Turkish industry for such measurements is high enough. These measurement services are accredited by the Turkish Accreditation Agency (TÜRKAK).

There is a single accredited calibration laboratory offering services in acoustics in Turkey, and a few accredited laboratories involved in the measurements of environmental noise are available, the number of calibrations and measurements performed by UME is relatively large. But it is expected that in the near future secondary level laboratories will be established and this will lead to a decrease in the annual number of calibrations performed at UME.

In order to support development of national quality infrastructure UME organizes interlaboratory comparisons and proficiency testing programs for accredited and non-accredited laboratories. Interlaboratory comparison for environmental noise measurements was conducted in 2009, and preparatory work for new comparison on calibration of sound level calibrators is in progress.

2. Ultrasound

UME has established the national standard for ultrasonic power measurements based on radiation force balance in accordance with the requirements of the IEC 61161 Standard. The Standard covers a frequency range of 1 MHz to 10 MHz, and a power scale of 100 mW to 30 W. Two systems are available for calibration purposes. An absorbing target is used in one of them, while in the second set-up a reflecting target is used. The overall uncertainty of calibrations lies in the interval of 5% to 7 % depending on the frequency of calibration. The degree of equivalence of the realized standard with the standards of other countries has been established through a bilateral comparison with the German Metrology Institute (PTB). This comparison was registered as EUROMET project 736 and piloted by UME. UME plans to participate in the future CIPM key comparison for ultrasonic power measurements, CCAUV.U-K3. UME completed measurements within comparison according to the schedule. UME currently has a single CMC entry related to ultrasonic power measurements.

Dissemination of the ultrasonic power unit standard to the secondary level of metrological hierarchy, namely to the customer devices level, occurs in two ways. Ultrasonic power transducers calibrated by radiation force balance method are used as reference standards for the calibration of ultrasonic wattmeters. Nowadays, demand for the calibration of ultrasonic transducers or ultrasonic power meters is very low in Turkey. As a consequence, no accredited laboratories for ultrasonic power measurements are available in Turkey.

UME is one of the partners within the joint research project "External Beam Cancer Therapy" under European Metrology Research Programme (EMRP). The institute is involved in the work-package related to the characterization of HITU transducers. The modified radiation force balance with absorbing target was developed and ultrasonic power measurements up to 150 W were performed. The new system was validated based on the comparison within the project. In addition, UME investigated various methods for measurements of electrical power applied to HITU transducers. Results of conducted research work were reported in International Conference on Advance Metrology for Ultrasound in Medicine (AMUM) in 2010.

3. Vibration

The national standard of the linear acceleration unit in the frequency range between 10 Hz - 10000 Hz has been realized at UME with an expanded uncertainty of 0.4 % - 1.0% in accordance with the requirements of the ISO 16063-11 Standard. Realization of the standard is based on the homodyne Michelson interferometer using the fringe counting and the "minimum point" signal processing technique. The performance of the primary calibration system and the long-term stability of the reference accelerometers were controlled and proven through year-by-year calibration and participation in international comparisons. Main comparisons in which UME participated are a regional key comparisons, EUROMET.AUV.V-K1 and COOMET.AUV.V-K1.

The major improvement in the field of vibration over past two years was the construction of the new set-up for calibration of vibration transducers based on sine approximation method. Currently UME has capability for both magnitude and phase calibration of accelerometers. The validation of the set-up will be done based on the results of CCAUV.V-K2 comparison.

Dissemination of the linear acceleration unit to the secondary level has been secured by means of comparison calibration of vibration pick-ups. UME has 6 CMC entries published in the BIPM KCDB in the vibration field, which covers 4 calibration services. However, UME also has the capacity for on-site vibration measurements. This service is accredited by TÜRKAK.

Currently UME organizes interlaboratory comparison on the national scale on measurement of mechanical vibration for the evaluation of human exposure to vibration. Comparison is about to start at the end of the year.

4. Underwater Acoustics

There was no significant activity in the field of underwater acoustics in Turkey until 2006. A very limited capability for calibration of hydrophones in air by using a calibrated pistonphone is available at UME. As a part of the capacity building program in the field of underwater acoustics, the set-up for calibration of hydrophones and other electroacoustical transducers at low frequencies recently has been established at UME. The calibration system is similar to the laser pistonphone and it is based on a laser interferometer for the measurement of piston displacement, which induces sound pressure in a small water vessel. The calibration system is operational in the frequency range from 10 Hz to 250 Hz and the estimated uncertainty of calibration is at the level 0.5 dB.

Advance infrastructure for the calibration of hydrophones was developed recently in Marmara Research Center in Gebze-Kocaeli, Turkey. But the institute is not a designated institute under CIPM MRA.

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