Short Report on AUV Activities at TÜBİTAK Ulusal Metroloji Enstitüsü

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Organization

TÜBİTAK Ulusal Metroloji Enstitüsü (UME) is the national metrology institute and the highest technical authority in Turkey for the field of metrology. The work of UME is committed to excellence in measurement and testing for the benefit of industries and consumers alike. TÜBİTAK UME operates as national reference laboratory in metrology under the auspices of The Scientific and Technological Research Council of Turkey (TÜBİTAK) placed under the Ministry of Science, Industry and Technology. It meets the requirements for calibration and testing laboratories as defined in the ISO/IEC 17025 employing a staff of 268 people (November 2015). It is a fundamental task of TÜBİTAK UME to realize and maintain the standards of the units in compliance with the International System of Units (SI) and to disseminate them, above all within the framework of legal and industrial metrology as well as persuading its scientific and technological development in order to anticipate new measurement and testing requirements in the areas of energy, safety, health, quality and environmental protection. TÜBİTAK UME provides government authorities and key economic players with the technical assistance they require to draft new regulations and standards at national level.

Acoustics Laboratory is one of the 26 laboratories operational in the institute. Until 2014 the laboratory had four different working area, acoustics, ultrasonics, vibration and gravimetry. However, Medical Metrology Laboratory was established at the end of 2014 and responsibility for activities in ultrasound was transferred to Medical Metrology Laboratory. Acoustics Laboratory mainly performs primary and secondary calibration of devices used for acoustical and vibration measurements, e.g. microphones, sound level calibrators, accelerometers, calibration exciters etc. In addition, laboratory provides testing services such as sound power, sound intensity and sound absorption measurements. Acoustical tests (mainly sound power measurements) are performed in full compliance with relevant international standards and are accredited by Turkish Accreditation Agency (TÜRKAK), signatory of ILAC MRA.

National standards

Being responsible for realization, maintenance and dissemination of units TÜBİTAK UME has following calibration and measurement set-ups in the AUV field:

- Pressure reciprocity calibration of laboratory standard microphones from 10 Hz to 25 kHz
- Measurement of ultrasound power between 10 mW and 150 W
- Primary calibration of accelerometers with sinusoidal excitation in the range from 10 Hz to 10 kHz in both, magnitude and phase of the complex sensitivity

In addition, TÜBİTAK UME has various calibration set-ups. Some of them are listed below:

- Calibration of sound level meters
- Calibration of sound calibrators and pistonphones
- Calibration and testing of mechanical couplers
- Calibration of vibration measuring chains
- Testing of acoustic couplers and ear simulators
- Calibration of impedance heads

and capability for verification of free-field and diffuse field environments.

Work on the establishment of capabilities for secondary shock calibrations is currently in progress.

Infrastructure

The laboratory is well equipped by various commercially available system and devices. However, there are few system designed and constructed at TÜBİTAK UME, e.g. laser pistonphone, various reference sound sources, ultrasonic power transducers. TÜBİTAK UME has special acoustical facilities, Full Anechoic Room with 50 Hz cut-off frequency and Reverberation Room with 100 Hz cut-off frequency. These facilities used both for calibration/testing and research purposes.

Staff

In spite of the fact that activity of Acoustics Laboratory and Medical Metrology Laboratory covers many subject fields there were permanent shortcoming with staff. From 4 to 5 people were working in the AUV field for a long time. This brought limitation to scope of activities with careful investigation of priorities. However the situation was improved significantly and new staff was hired both for Acoustics Laboratory and Medical Metrology Laboratory. Currently overall number of people working in two laboratories is 10, and four of them are chief researchers. Furthermore three out of 10 people have PhD degree. Work experience of the senior staff in the field of acoustical metrology is more than 20 years.

Calibration/ Testing Services

Calibration and measurement capabilities of TÜBİTAK UME in AUV field as published on the BIPM KCDB includes 25 entries with the following breakdown in the subject fields: 16 in sound in air, single entry in ultrasound, and 8 entries in the field of mechanical vibration. No

changes in CMCs were made during reporting period. However TÜBİTAK UME is planning to revise CMC entries significantly on the base of results of CCAUV.V-K2, CCAUV.U-K3 and EURAMET.AUV.A-K5 comparisons in the nearest future.

On the average TÜBİTAK UME annually performs about 300 calibrations in AUV field for customers. The great majority of these calibrations are calibrations of microphones, sound calibrators, sound level meters, accelerometers and vibration measuring devices. As four accredited calibration laboratories became operational in Turkey during past five years, slight decrease in the number of calibrations performed by TÜBİTAK UME for customers occurred. These laboratories are accredited mainly for calibration of sound level meters, sound calibrators, accelerometers and noise dose meters.

Comparisons

BIPM Key Comparisons Database (KCDB) has records on 10 key comparisons participated by TÜBİTAK UME in AUV field. 3 other bilateral comparisons conducted with PTB at the earliest stage of the establishment of Acoustics Laboratory are not registered at the BIPM KCDB, but their results are public available (e.g. Final Report of the EUROMET Project No: 736).

There were two official comparisons with TÜBİTAK UME involvement in the period from 2013 to 2015. They are following:

EURAMET.AUV.A-K5, Comparison of laboratory standard microphone calibrations
TÜBİTAK UME performed calibrations of microphones in the frequency range from 10 Hz to 10 kHz in February 2014 and reported results to pilot laboratory. Draft A of the comparison is under preparation.

COOMET.AUV.V-K1, Comparison of accelerometer calibrations
Although measurements within the comparison were completed in 2008, no consensus was reached on the comparison report. This was mainly due to disagreement between participants on the linking of the results to the results of CCAUV.V-K1 comparison. Pilot laboratory, VNIIM (Russia) produced the revised version of Draft B, which was distributed to participants for approval in October 2015. However there are few issues still to be corrected in the report and TÜBİTAK UME among of two participants has objections to the revised report.

TÜBİTAK UME also participated in two other comparisons. They are out of scope of the CIPM MRA and were performed as a task within the framework of joint research projects (JRP) under European Metrology Research Programme (EMRP).

It is worth to mention that TÜBİTAK UME will be piloting comparison on calibration of sound level meters in accordance with IEC 61672-3 standard. This comparison is an initiative

of European Accreditation Cooperation (EA) and will involve accredited laboratories all over the Europe. It is planned to start comparison in the first quarter on 2016.

Research and Other Projects

Since the establishment of basic calibration capabilities at the very beginning up to the recent years, TÜBİTAK UME has placed a growing emphasis on research activities that cross into areas that are outside its traditional remit as a national metrology institute. In AUV field TÜBİTAK has completed successfully or is currently active in the projects, which brief summary outlined below:

Metrology for a universal ear simulator and the perception of non-audible sound (Ears)

TÜBİTAK UME was involved in the tasks of characterization of novel universal ear simulator, which has the potential to significantly improve the calibration of audiological devices for better diagnosis and screening results mainly for newborns and children. The institute together with other partners performed measurements of transfer impedance of the universal ear simulator prototype. In addition, investigation of dependence of universal ear simulator on environmental conditions like static pressure and temperature were carried out. Furthermore, TÜBİTAK UME made clinical trials of universal ear simulator prototypes.

Dosimetry for Ultrasound Therapy (DUTy)

The aim of the joint research project was to develop the metrological infrastructure (definitions, validated measurement and modeling methods) which would underpin the specification of dose for therapeutic ultrasound applications allowing appropriate treatment planning and risk assessment. TÜBİTAK UME's activity was focused on the development of laboratory standards for thermal and non-thermal therapeutic dose parameters. TÜBİTAK UME worked on quantitative assessment of thermal and mechanical effects of therapeutic ultrasound by sonicating a joint-mimicking phantom, made of muscle-equivalent material.

Realisation, dissemination and application of the unit watt in airborne sound (SIB56 SoundPwr)

The project, which is currently in progress, has the primary goal to establish traceability for the measurand sound power to SI units. Starting point is a primary standard for the unit Watt in airborne sound. TÜBİTAK UME among other four partners developed a primary standard for airborne sound power in the frequency range between 100 Hz and 20 kHz based on a vibrating solid body. Sound power of the source was determined on the base of velocity values measured by laser vibrometer and by conventional methods. Results for both methods are in agreement in the order of 0.5 dB for the broad frequency range with exceptions at low frequencies below 125 Hz.

Development of Metrology Infrastructure at SASO (Saudi Arabia)

TÜBİTAK UME is involved in the joint project with Standardization Organization of Kingdom of Saudi Arabia (SASO) with the aim of establishment metrological infrastructure

at the National Measurement and Calibration Center (NMCC). In the AUV field this activity mainly involves the following calibration systems:

- System for reciprocity calibration of microphones
- System for comparison calibration of microphones
- System for calibration of sound level meters and sound calibrators
- System for calibration of audiometers
- System for primary and secondary calibration of vibration pick-ups, calibration exciters and vibration measuring chains.

Publications

The list of publications of TÜBİTAK UME in AUV field in the period from 2013 to 2015 is given below:

1. G.Durando, C.Guglielmone, J.Haller, O.Georg, A.Shaw, E.Martin, B.Karaböce, **Towards Comparison of Ultrasound Dose Measurements - Current Capabilities and Open Challenges,** Physics Procedia 70 (2015), pp.1114-1118
2. B.Karaböce, H.O.Durmuş, **Visual Investigation of Heating Effect in Liver and Lung Induced by a HIFU Transducer,** Physics Procedia 70 (2015), pp.1225-1228
3. B.Karaböce, A.Şahin, A.T.İnce, Y.Skarlatos, **Characterization of Pressure Fields of Focused Transducers at TÜBTAK UME,** Physics Procedia 70 (2015), pp.1241-1245
4. E.Bilgiç, E.Sadıkoğlu, C.Kırbaş, **The Measurement and Evaluation of Vibration: Exposure to Hand-arm and Whole-body Vibration**, In Proceedings of 11th National Acoustical Congress, İstanbul Technical University, 19-20 October 2015, İstanbul, Turkey (in Turkish)
5. B.Karaböce, E.Bilgiç, E.Sadıkoğlu, C.Kırbaş, H.O.Durmuş, **Characterization of New Design Ear Simulator To Be Used in Newborn Hearing Tests**, In Proceedings of 11th National Acoustical Congress, İstanbul Technical University, 19-20 October 2015, İstanbul, Turkey (in Turkish)
6. B.Karaböce, H.O.Durmuş, **System Established at TÜBİTAK UME for Hearing Aids Test and Measurement Results**, In Proceedings of 11th National Acoustical Congress, İstanbul Technical University, 19-20 October 2015, İstanbul, Turkey (in Turkish)
7. C.Kırbaş, E.Bilgiç, E.Sadıkoğlu, **The Effect of Near Field on the Determination of Sound Power Level**, In Proceedings of 11th National Acoustical Congress, İstanbul Technical University, 19-20 October 2015, İstanbul, Turkey (in Turkish)
8. E.Bilgiç, C.Kırbaş, E.Sadıkoğlu, H.Mutaf, **Influence of Measurement Surface and Number of Microphones on Determination of Sound Power Level of Noise Sources**, In Proceedings of 11th National Acoustical Congress, İstanbul Technical University, 19-20 October 2015, İstanbul, Turkey (in Turkish)

9. C.Kırbaş, E.Bilgiç, E.Sadıkoğlu, **Research on a Realization of the Unit "Watt" in Airborne Acouscis**, In Proceedings of 11th National Acoustical Congress, Istanbul Technical University, 19-20 October 2015, İstanbul, Turkey (in Turkish)
10. B.Karaböce, H.O.Durmuş, **Investigation of Thermal Effect In Vitro Liver and Lung Induced by a HIFU Transducer,** In Proceedings of National Congress of Medical Technologies (TIPTEKNO'15), pp.519-522,15-18 October 2015, Bodrum, Turkey (In Turkish)
11. E.Bilgiç, Y.Durgut, **Effect of Waveform Model on Sensitivity Values of Transducers Used in Dynamic Mechanical Measurements**, Acta Physica Polonica A, vol:128(2), pp.267-270, August 2015
12. B.Karaböce, **Focused Ultrasound Temperature Effect in Tissue-mimicking Material and Sheep Liver,** In Proceedings of IEEE International Symposium on Medical Measurements and Application (MEMEA), 7-9 May 2015, Torino, Italy
13. E.Bilgiç, Y.Durgut, **Effect of Waveform Model on Sensitivity Values of Transducers Used in Dynamic Mechanical Measurements**, In Proceedings of International Conference on Computational and Experimental Science and Engineering, 25-29 October 2014, Antalya, Turkey
14. B.Karaböce, Y.Gülmez, E.Bilgiç, E.Sadıkoğlu, A.T.İnce, Y. Skarlatos, **Comparison of the Input Electrical Power Measurement Methods for HIFU Transducers**, IEEE Xplore, vol. 978-1-4799-2921, pp.1-6, April 2014
15. E.Sadıkoğlu, E.Bilgiç, C.Kırbaş, B. Karaböce, **National Interlaboratory Comparison on Calibration of Sound Calibrators**, In Proceedings of 10th National Acoustical Congress, pp.304-309, Yıldız Technical University, 16-17 December 2013, İstanbul, Turkey (in Turkish)
16. B.Karaböce, C.Kırbaş, F.Akdaş, E.Bilgiç, E.Sadıkoğlu, **Characterization of "Silent" Cabin Used for Audiometric Measurements**, pp.315-322, In Proceedings of 10th National Acoustical Congress, pp.315-322, Yıldız Technical University, 16-17 December 2013, İstanbul, Turkey (in Turkish)
17. E.Bilgiç, E.Turhan, **Calibration Methods for Charge Type Conditioning Amplifiers and Results of Calibrations Performed at TÜBİTAK UME**, In Proceedings of 10th National Acoustical Congress, pp.323-331, Yıldız Technical University, 16-17 December 2013, İstanbul, Turkey (in Turkish)
18. E.Bilgiç, E.Sadıkoğlu, C.Kırbaş, B. Karaböce, **National Interlaboratory Comparison on Calibration of Vibration Exciter**, In Proceedings of 10th National Acoustical Congress, pp.342-348, Yıldız Technical University, 16-17 December 2013, İstanbul, Turkey (in Turkish)
19. E.Bilgiç, E.Sadıkoğlu, C.Kırbaş, B.Karaböce, **Effect of Sound Level Meter's Response Out of Tolerances to Noise Measurement Results,** In Proceedings of 10th National Acoustical Congress, pp.388-395, Yıldız Technical University, 16-17 December 2013, İstanbul, Turkey (in Turkish)

20. C.Kırbaş, E.Bilgiç, E.Sadıkoğlu, B.Karaböce, **Interlaboratory Comparison on Sound Power Measurements**, In Proceedings of 10th National Acoustical Congress, Yıldız Technical University, pp.396-405, 16-17 December 2013, İstanbul, Turkey (in Turkish)
21. B.Karaböce, E.Bilgiç, E.Sadıkoğlu, **HIFU Technique for Cancer Therapy**, In Proceedings of National Congress of Medical Technologies (TIPTEKNO'13), 31 October – 2 November 2013, Antalya, Turkey (in Turkish)
22. E.Bilgiç, M.Aksulu, **Relationship Between Rail Parameters and Noise in the Rail Transport Systems**, In Proceedings of 8th National Metrology Congress, pp.288-301, 26-28 September 2013, Gebze – Kocaeli, Turkey (In Turkish)
23. C.Kırbaş, E.Bilgiç, E.Sadıkoğlu, **Diffuse Field Comparison Calibration of Microphones,** In Proceedings of 8th National Metrology Congress, pp.276-287, 26-28 September 2013, Gebze – Kocaeli, Turkey (In Turkish)
24. E.Bilgiç, E.Sadıkoğlu, **Parameters Affecting Measurements of Noise Exposure**, In Proceedings of 8th National Metrology Congress, pp.302-309, 26-28 September 2013, Gebze – Kocaeli, Turkey (In Turkish)