

Joint Report of Activities from DFM and BKSVDPLA

Joint Report of Activities, September 2017

1. Introduction

The Danish Primary Laboratory of Acoustics (DPLA) is an entity co-operated by Brüel & Kjær S&V A/S (BKSVDPLA) and Danish Fundamental Metrology Ltd. (DFM). DPLA has been nominated as Danish Primary Laboratory in the field of Acoustics in gases and solids by the Danish Safety Technology Authority (Sikkerhedsstyrelsen). In order to comply with the structure required to participate in EURAMET, DPLA is represented by DFM as the Danish National Metrology Institute, and BKSVDPLA as Designated Institute.

Further cooperation on research in acoustic metrology is maintained independently between DFM and BKSVDPLA and the Acoustic Technology group of the Institute of Electrical Engineering, Technical University of Denmark.

DFM and BKSVDPLA are members of Daniamet. This is an umbrella organization that covers and coordinates multiple aspects of the decentralised Danish metrological infrastructure such as: fundamental metrology, legal metrology, and the network of primary and reference laboratories.

Responsibilities

It is the responsibility of DPLA to maintain and disseminate the basic units in the field of Acoustics in gasses and solids and through research in the field to develop and improve methods for primary as well as secondary calibration. This responsibility is partially undertaken by offering services of microphone and accelerometer calibration at primary and secondary level. DFM's services are accredited by DANAK (accreditation 255), and BKSVDPLA's (accreditation 277); the technical assessment of the laboratories is carried out by experts of other National Metrology Institutes. Secondary calibrations by comparison methods, performance testing and verification of acoustical measuring instruments are also performed by other accredited calibration laboratories in Denmark.

2. Activities in 2016-2017

Calibration activities

DFM and BKSVDPLA conduct their calibration services independently.

The number of certificates issued by BKSVDPLA in 2016 amounts to 97 for primary reciprocity calibration of microphones, and 194 for primary calibration of accelerometers. The accelerometer calibration activity has increased significantly in the first half of 2017 and 107 certificates has been issued.

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For DFM the number of services has increased from around 20 certificates for primary and secondary calibration of microphones in 2014-15 to around 35 in 2016. The number is expected to grow slightly in 2017.

In addition to the calibrations for customers many internal microphone calibrations are carried out in order to maintain the unit of sound pressure and for research and development activities. For this purpose, DPLA holds a combined number of 19 B&K Type 4160 and 30 B&K Type 4180 microphones, which generally are calibrated each year. BKSVDPLA holds five reference accelerometers (2 back-to-back, two single ended and one low frequency), that are maintained and used as transfer standards. The accelerometers are used for daily checks and recalibrated every year. One of these is sent for international comparison every year.

Research activities

The major research activities on Acoustics in air are related to calibration of microphones by improving the calibration methods, extending the frequency range and the dynamic range of calibrations.

The activities on Acceleration have mainly been focused on refining the ISO16063-11 method 3 using off the shelf FFT analysers and extending the frequency range. Furthermore, an effort has been made to include calibration at DC using the earth's gravitation.

Microphone calibration at DFM

Low-frequency calibration

Calibration of LS1 and LS2 microphones to frequencies down to 2 Hz has become an established service of DFM. Efforts on testing the calibration of working standard microphones type WS2 have yielded stable and repeatable results, though with an increased uncertainty without major changes to measurement and calculation procedures. This means that some WS2 microphones can also be primary calibrated using the reciprocity technique. Though the measurement systems and procedures are well established, the calculation procedures described in the relevant IEC standard are still ambiguous. DFM supports the research of new, improved methods by researching alternative calibration methods that can be used for validating the low-frequency calculation procedures. These methods include the use of electrostatic actuators, optical measurements of the velocity of the membrane of the diaphragm, and use of acousto-optical methods to reconstruct the sound field within a cavity.

Additionally, the transfer of the accuracy of the primary calibration by secondary methods is investigated and implemented.

High-Frequency calibration

Further development of the system for free-field calibration of working standard microphones up to 150 kHz, including the investigation of alter-

native methods for the realisation of the acoustic pascal has been carried out. These methods are based on the estimation of the sound pressure at a point from measurements of the acousto-optic effect and assumptions of wave propagation. These results may be also useful for free-field comparison calibration.

Additionally, research has also been focused on the determination of the environmental coefficients of the free-field sensitivity of working standard microphones type 3 (WS3) which may be an important source of uncertainty for the calibration of this type of microphones. This research will extend to cover Laboratory Standard microphones.

Microphone calibration at BKSVDPLA

Very low frequency calibration

Research continues with the aim of establishing well documented and reliable references at frequencies below 1 Hz. Focus is on extending the frequency range of pressure sensitivity reciprocity calibrations and sustaining the results with other, independent methods. The aim is to refine the method so as to establish a calibration service for very low frequency references. The work is in continuation of the effort to resolve the ambiguities in the international standard governing these measurements (IEC 61094-2). The activity has been reduced in 2016, due to participation in EURAMET research activities, see below. The work is, however, close to a conclusion.

Vibration transducer calibration at BKSVDPLA

Extended frequency range for vibration transducer calibration

ISO16063-11 method 3 has been implemented using quadrature output laser interferometers to cover low frequency vibration transducer calibration down to 0.1 Hz and high frequency calibration up to 100 kHz but limited by the mechanical properties of the exciters and transducers. These systems have now been accredited in the range 0.1 Hz to 10 kHz.

Calibration at DC using Earth's gravity per ISO16063-16 has also been implemented and accredited.

Focus has for the last year been on getting the systems to operate smoothly and precisely.

International cooperation

The two partners of DPLA are active players in the global cooperation in CCAUV and in the regional cooperation within EURAMET. A member of DFM held the Chair of EURAMET's TCAUV until May 2013 and a member of BKSVDPLA is now Convenor of TCAUV's Sub-Committee for Sound in Air since 2017.

Staff members of DFM and BKSVDPLA are active members of IEC TC29 and ISO 108/SC3 in which they act as specialists and project leaders for specific standards. A member of BKSVDPLA staff was chairman of ISO 108/SC3 until the end of 2016 where the decision was made to place the activities directly under TC108.

BKSVDPLA has participated in the Key Comparison CCAUV.A-K5, dealing with calibration of LS1 microphones in both Modulus and Phase at frequencies down to 2 Hz.

DFM has participated in the Regional Supplementary Comparison AFRI-METS.AUV.A-S1 concerned with pressure calibration of LS2 microphones. Additionally, DFM is participating in the regional supplementary comparison EURAMET.AUV.A-S2 concerned with free-field secondary calibration of WS microphones.

BKSVDPLA has participated in Pilot Study APMP.AUV.A-P2 (calibration of multifrequency calibrator). The final Draft A report has recently been sent to APMP TC-AUV for review.

BKSVDPLA has also participated in the Key Comparison CCAUV.V-K2 (10 Hz to 10 kHz) in EURAMET.AUV.V-S1 (0 Hz to 200 Hz) and in CCAUV.V-K3 (Magnitude and phase of sensitivity 0.1 to 40 Hz) and have provided items for the CCAUV.V-K5 Magnitude and phase of sensitivity 10 Hz to 20 kHz started in 2017. BKSVDPLA has agreed to be co-piloting this comparison.

International research collaboration

DFM and BKSVDPLA participate actively in European research projects, particularly under EURAMET's European Metrology Programme for Innovation and Research (EMPIR).

The two partners of DPLA participate in the project 15HLT03 "Metrology for modern hearing assessment and protecting public health from emerging noise sources," which is concerned with "two aspects of hearing assessment and conservation; the further development of the next generation of ear simulators that will provide measurement traceability for hearing tests on adults, children and neonates, and improvement in our understanding of human response to infrasound and ultrasound, including novel assessment methods for potential health risks." BKSVDPLA activities in the project are focused on the refinement and definition of the specifications of the new generation of universal ear simulators, its calibration and manufacturing. DFM is involved in activities related to the calibration of the ear simulator, and the development of the traceability chain for ultrasound measurements.

Further information about the project can be found in the project's homepage <http://www.ears-project.eu/empir/ears2.html>.

DFM participates also in the project 15RPT02 "Underwater acoustic calibration standards for frequencies below 1 kHz," which is concerned with

“develop(ing) the European Metrological Capacity in underwater acoustic calibration for acoustic frequencies below 1 kHz by providing traceable measurement capabilities to meet the need for calibration of hydrophones and autonomous underwater acoustic noise recording systems... to underpin the absolute measurement of sound in the ocean in support of regulation and EU Directives (such as the Marine Strategy Framework Directive).” DFM’s activities are focused on the definition of a calibration procedure based on the comparison of a hydrophone to a reference microphone in a closed coupler in air.

Further information about the project can be found in the project’s homepage <http://empir-unaclow.com>.