

# Joint Report of Activities from DFM and BKSVDPLA

## Joint Report of Activities, September 2019

### 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 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 2018-2019

#### **Calibration activities**

DFM and BKSVDPLA conduct their calibration services independently.

The number of certificates issued by BKSVDPLA in 2018 amounts to 104 for primary reciprocity calibration of microphones, and 141 for primary calibration of accelerometers.

For DFM the number of accredited calibration services has increased significantly since 2017. From around 20 certificates for primary and second-

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ary calibration of microphones and sound calibrators in earlier years to almost a triplication in average in 2017 and 2018; a similar number is expected in 2019.

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 continuous refinement of the ISO16063-11 method 3, gaining experience in the extended LF-frequency range as well as DC using the earth's gravitation as per ISO16063-16, both of which with accreditation and CMCs in place.

#### *Microphone calibration at DFM*

##### *Low-frequency calibration and primary calibration of working standard microphones*

Through the past few years, calibration of LS1 and LS2 microphones to frequencies down to 2 Hz has become an established and stable service at DFM. Likewise 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 both in pressure and free field is investigated and implemented in the calibration laboratory.

##### *High-Frequency calibration*

Earlier research on high frequency free-field calibration in which a system for free-field calibration of working standard microphones up to 150 kHz has been developed, and the environmental coefficients of the free-field sensitivity of working standard microphones type 3 (WS3) have been experimentally determined has continued. Also focusing on the transfer of the accuracy of primary methods towards the use of the primary calibrated microphones as references for comparison methods.

In addition to the above, in order to complete the traceability chain, pressure calibration of working standard microphones of type 3 has been investigated. The main methods are pressure reciprocity, optical measurements of the membrane displacement, and electrostatic actuator.

#### *Microphone calibration at BKSVDPLA*

##### Very low frequency calibration

Research has continued with the aim of establishing well documented and reliable references at frequencies below 1 Hz, although the activity has been reduced in the period due to resource limitations. Focus is on extending the frequency range of pressure sensitivity reciprocity calibrations and sustaining the results with other, independent methods. Recent results are promising. The work is in continuation of the effort to resolve the ambiguities in the international standard governing these measurements (IEC 61094-2).

#### *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 adequate experience within the LF-field and further development and research in this frequency range.

#### ***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 BKSVDPLA is 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. BKSVDPLA is at present participating in CCAUV.A-K6 that similarly deals with calibration of LS2 microphones in both Modulus and Phase at frequencies down to 2 Hz. BKSVDPLA made the measurements for the comparison March-April 2019.

DFM is participating in the regional supplementary comparison EURAM-ET.AUV.A-S2 concerned with free-field secondary calibration of WS microphones which is expected to be completed in 2019.

BKSVDPLA has participated in Pilot Study APMP.AUV.A-P2 (calibration of multifrequency calibrator). The final Draft A report has been sent to APMP TC-AUV for review. The closure of the project is, however, pending.

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), 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 is currently providing items and is pilot laboratory in the EURAMET AUV.V.K5 Key Comparison currently being initialized.

### ***International research collaboration***

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

DFM and BKSVDPLA participated in the project 15HLT03 "Metrology for modern hearing assessment and protecting public health from emerging noise sources," which was 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 were focused on the refinement and definition of the specifications of the new generation of universal ear simulators, its calibration and manufacturing. DFM was involved in activities related to the calibration of the ear simulator, and the development of the traceability chain for ultrasound measurements. The project has successfully been completed by the end of April 2019.

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

DFM has also participated 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 were 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. During the project, DFM produced a refined version of the calibration coupler.

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