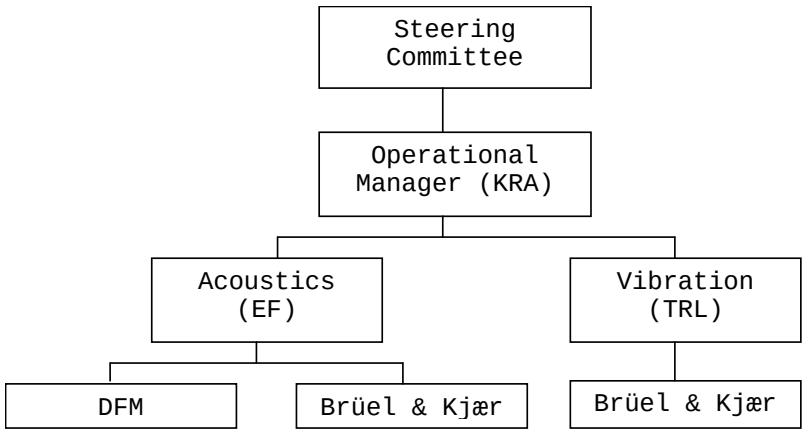
# Danish Primary Laboratory of Acoustics

## Short Report on Activities, September 2008

### 1. Introduction

The Danish Primary Laboratory of Acoustics (DPLA) is an entity co-operated by Brüel & Kjær S&V A/S and Danish Fundamental Metrology Ltd. (DFM). DPLA is nominated as Primary Laboratory in the field of acoustics in gases and solids by the Department of Trade and Industry (EFS).

The activities of DPLA are supervised by a Steering Group formed by staff from DFM and DPLA: The operational manager of DPLA is Knud Rasmussen (KRA, DFM), and the members of the Steering Committee are Salvador Barrera-Figueroa (SBF, DFM), Kim Carneiro (KC, DFM), Erling Frederiksen (EF, B&K), Torben R. Licht (TRL, B&K), and Ole E. Sørensen (OES, B&K). The organisational structure is shown in the diagram below.




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

DPLA is member of DANIAmet. This is an umbrella organization that covers and coordinates multiple aspects of decentralised Danish metrological infrastructure such as: fundamental metrology, legal metrology, and the network of primary and reference laboratories.

Acoustics is one of the four priority subject fields for Danish Metrology. This implies that acoustic metrology should undergo a special effort for marketing and dissemination among the Danish acoustical community.

*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 calibrations in this field. This responsibility is partially undertaken by offer-

22. september 2008
Ref 1107-08 SBF
Direkte 4525 5888
sbf@dfm.dtu.dk

**Brüel & Kjær S&V Measurement A/S**
307, Skodsborgvej
DK-2850 Nærum
Denmark

Tel.: +45 45 80 05 00
Telex: 37316 bruka dk
Fax: +45 45 80 1405
www.bksv.com

**Dansk Fundamental Metrologi A/S**
Matematiktorvet 307
DK-2800 Kgs. Lyngby

Tel +45 4593 1144
Fax +45 4593 1137
www.dfm.dtu.dk

ing services of microphone and accelerometer calibration at primary and secondary level. DPLA's services are accredited by DANAK (accr. 255 and 277). 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 2006-2008

***Calibration activities***

The number of certificates issued to external costumers in 2006-2007 on primary pressure reciprocity calibration of microphones is about 60 and about 150 on laser-calibration of accelerometers. In addition to the calibrations for customers a large number of internal microphone calibrations are performed to maintain the unit of sound pressure and for research and development activities. For this purpose DPLA holds about 22 B&K Type 4160 and 28 B&K Type 4180 microphones, which generally are calibrated each year. DPLA further holds four sets of reference accelerometers, including the associated preamplifiers, which are maintained and used as transfer standards. The four sets are calibrated every month.

Since December 2006 DPLA has offered accredited free-field reciprocity calibration service to customers. The service refers to microphones type BK 4160 and 4180 only. From December 2007, free-field comparison calibration has been added to the accredited services offered by DPLA.

***Research activities***

The major 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 acoustics in solids have mainly been focused on implementing and refining the ISO 16063-11 method 3 using off the shelf FFT analysers and extending the frequency range.

*Microphone calibration at DFM*

The project on diffuse-field calibration of microphones financed by the "Forskningsrådet for Teknologi og Produktion" (FTP) started in 2005 and finished by the end of 2007. The purpose of the project was to study the possibility of determining the sensitivity of measurement microphones in a diffuse field. Three procedures were investigated: a) random-incidence measurements, b) reciprocity in a reverberant room, and c) a theoretical link between the radiation impedance and the diffuse-field sensitivity. Numerical calculations supplement the experimental results. The activities of the project have been carried out as planned. As a result of the activities, several papers have been published in international refereed journals, and presentations given at different international conferences. Further papers are being prepared and will be submitted to international publications.

A set-up for sequential free-field comparison calibration of WS-microphones has been developed at DFM. The new system is based on the same equipment and technique as used for free-field reciprocity calibrations. This service is available as an accredited service.

Additionally, a source for simultaneous free-field comparison calibration has been designed in collaboration with SENSE-SDU. This source is to be tested and used in preliminary investigations of the simultaneous calibration technique.

Simultaneous pressure comparison in a free field has been also investigated. Marta Diaz Baz, student of the University of Vigo, Spain, made her final project at DFM carrying out numerical calculations and experimental measurements.

*Microphone calibration at B&K*

A new technique for low frequency, pressure calibration of condenser microphones has been developed by the B&K DPLA staff. A paper on the subject was presented at the 13th ICSV held in Vienna, Austria on the 2nd – 6th of July 2006. The new method has been tested and found to work well over the frequency range from 0.1 Hz to 250 Hz. As the interest for low-frequency calibration is increasing the new method may lead to a new calibration service from B&K or DPLA.

*Vibration transducer calibration at B&K*

ISO 16063-11 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. During 2007 funding has been found to establish such a system at DPLA. The new method and system is expected to be available as an accredited service ultimo 2008.

Double beam laser calibration is another field of interest, but this has not been pursued further recently. This is especially of interest due to the non-perfect vibration generation possible with present vibration exciters.

***International cooperation***

DPLA is an active player in the global cooperation in CCAUV and in the regional cooperation within EURAMET. Some of the above-mentioned research activities make parts of EURAMET projects.

DPLA's free-field facility at DFM is listed as a Special Facility under the European project iMERA. In 2006 and 2007, DFM's special facility has been visited by experts from UME (Turkey), NIM (China), and NMISA (South Africa).

DPLA-DFM participated in the formulation of the Work Package "Artificial Ear" (WP2) of the Joint Research Project "Towards the virtual human" (JRP5) under the Targeted Program "Health" (TP2) of EURAMET's iMERA+ and ERMP. Unfortunately, this particular JRP5 was not granted funding from the EMRP at the current stage.

Staff members of DPLA are active members of IEC TC29 and ISO 108/SC3 in which they act as specialists and project leaders for specific standards. KRA is the Chairman of IEC TC 29 and TRL is chairman of ISO 108/SC3.

DPLA-DFM role as pilot laboratory in the regional comparison COOMET.A-K3 on primary pressure reciprocity calibration of LS2 microphones in the frequency range 30 Hz – 25000 Hz finished in 2007 with the publication of the final report.

DPLA-DFM is acting as pilot laboratory for the Key Comparison CCAUV.AK4, concerned with the free-field calibration of Laboratory Standard microphones. The measurement round is finished by the end of March, 2008. A draft A report will be circulated to the participants before the meeting of the CCAUV in the fall of 2008.

DPLA participates in an international key comparison covering pressure calibration of LS1 microphones in the range down to 1 Hz/2 Hz that has just been finished (CCAUV-A.K2). BEV (Austria) act as pilot laboratory and a draft B report is under discussion.

## 3. Activities planned for 2008-

***Expansion of services***

DPLA intend to increase its services by:

1. Calibration of Pistonphones at primary level (DFM)
2. Calibration of 4226 (and 4231) sound calibrators at primary level (B&K)
3. Primary low-frequency calibration of LS1 (B&K 4160) microphones (B&K with support of DFM).
4. Pressure comparison calibration under free-field conditions of LS2 and WS2 microphones (DFM)
5. B&K intend to offer multipoint lasercalibrations at a competitive price within the existing accreditation ranges and later to expand these.
6. Updating and modernisation of MP.EXE in order to comply with the coming IEC 61094-2 standard.

The new services should be accredited by DANAK.

***Potential multilateral research activities***

- Centre of Excellence for Acoustic Metrology

DFM has received extra resources for establishing the Centre of Excellence for Acoustic Metrology. This Centre is a co-operation between DFM and partners from industry and academy that contribute to the development of the Centre. The objectives of the Centre are a) to develop a 5-year strategy, b) to co-operate with leading institutions in research on acoustic metrology, c) to participate in the international interchange of knowledge, and d) to support the Danish Society. A number on areas of interest and pilot projects will run up to the end of 2009. These include: a) Calibration of microphones at low frequencies, b) Calibration of acoustic transducers at high frequencies (ultrasound), c) Diffuse field calibration, d) Technical audiometry, and e) Interdisciplinary techniques for establishing the standard of sound in air.