Report from Poland

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Low-frequency pressure chamber system for determination of low-frequency response of acoustic measuring equipment

1. INTRODUCTION

GUM infrasound calibration setup for acoustic measuring equipment (fig. 1) was developed in 2006 as the response to growing demand for testing and evaluation of sound level meters equipped with G frequency weighting according to ISO 7196. These instruments are submitted for calibration mainly by Polish institutions responsible for environment and labour protection, obliged to carry out measurements and evaluation of noise also in infrasound range.
Our setup is also used for calibration of microphone-preamplifier units in low-frequency range by simultaneous comparison.

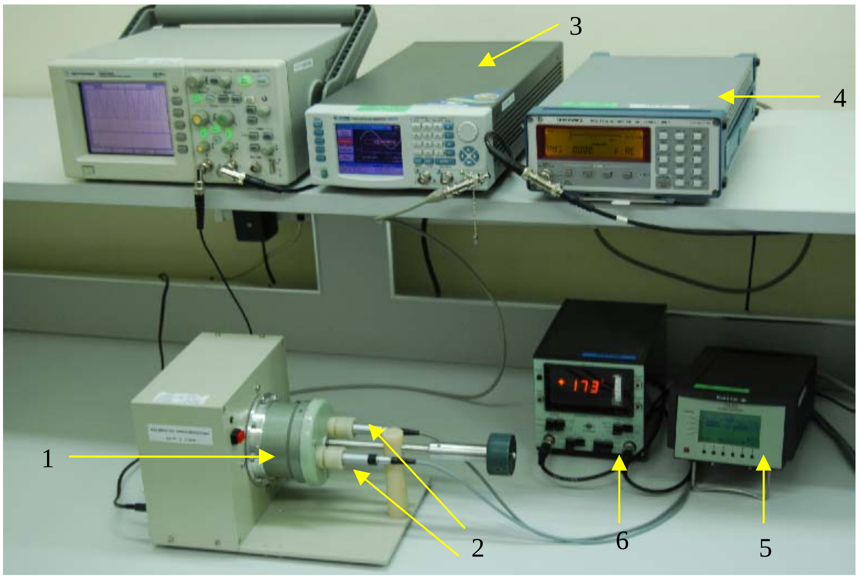

Figure 1 Low-frequency pressure chamber system for microphone frequency response determination:
1 – low-frequency pressure chamber, 2 – microphone-preamplifier units: reference and under calibration, 3 – signal generator, 4 – low-frequency RMS voltmeter, 5 - microphone power supply, 6 – phase meter

2. TECHNICAL SPECIFICATION

The main part of measuring setup is low-frequency sound pressure source consisting of electrodynamically-driven piston producing pressure signal within air-tight pressure chamber. Two microphone-preamplifier units (reference unit and unit under calibration) are driven by uniformly distributed sound field. Sound field uniformity is positively verified by the observations of phase shift between signals from reference and calibration channel.

Low-frequency microphone-preamplifier unit B&K 4193-L-004 is used here as reference unit. Its frequency response is determined by DPLA at frequencies between 0,5 Hz and 250 Hz, using the method described by Frederiksen (*Infra Sound Calibration of Measurement Microphones*, 13th ICSV, Vienna 2006, paper No. 384).

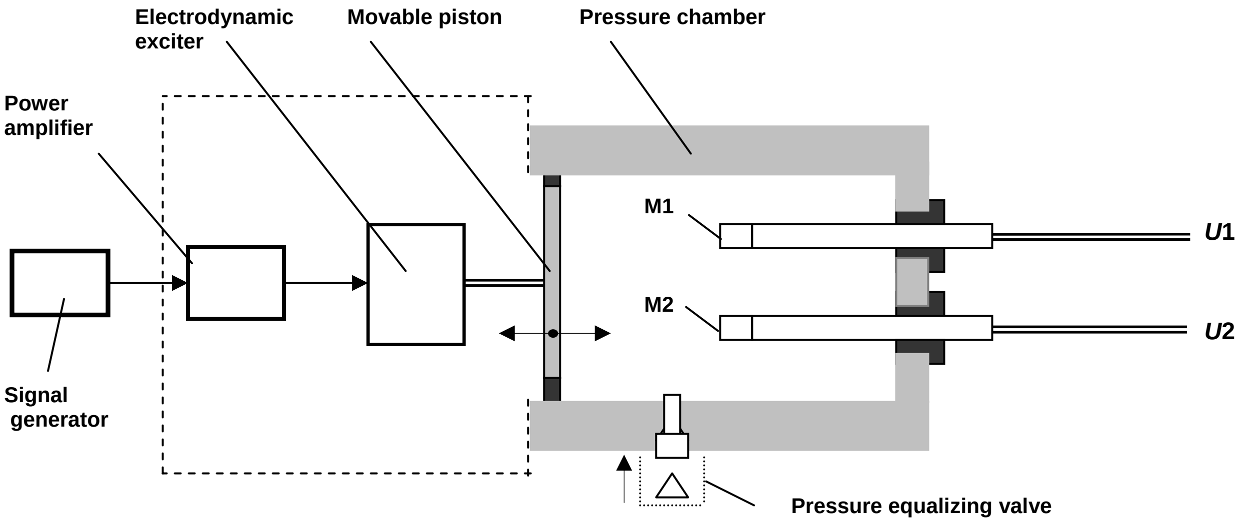

Figure 2 Main parts of low-frequency pressure chamber system

Specifications:

- SPL at 10 Hz (THD < 2 %) — 120 dB
- Nonlinear distortion — < 2 %
- Frequency range — 0,2 Hz to 250 Hz
- Pressure chamber volume — 460 cm^3
- Built-in electrically-driven valve for static pressure equalization
- Built-in driving power amplifier for electrodynamic exciter

3. MICROPHONE FREQUENCY RESPONSE DETERMINATION

The frequency response (normalized at 250 Hz) of microphone-preamplifier unit under calibration is calculated using:

– output voltages measured for this unit and reference unit,
– DPLA results of reference unit calibration.

$$L_{\mathrm{M2,rel}}(f) = L_{\mathrm{M1,rel}}(f) + 20\log\frac{U_{\mathrm{M2}}(f)}{U_{\mathrm{M1}}(f)} - 20\log\frac{U_{\mathrm{M2}}(f_{\mathrm{ref}})}{U_{\mathrm{M1}}(f_{\mathrm{ref}})}$$

where:

$L_{\mathrm{M2,rel}}(f)$	frequency response of unit under calibration at frequency f, normalized at 250 Hz;
$L_{\mathrm{M1,rel}}(f)$	frequency response of reference unit at the same frequency, normalized at 250 Hz;
$U_{\mathrm{M1}}(f)$, $U_{\mathrm{M2}}(f)$	output voltages measured at the same frequency;
f_{ref}	reference frequency of 250 Hz

The absolute sensitivity of microphone-preamplifier unit under calibration at 250 Hz reference frequency is determined using calibrated sound calibrator.

In order to verify measuring setup performance the differences between frequency response levels for two B&K 4193-L-004 low-frequency microphone-preamplifier units have been determined and compared with similar differences calculated from calibration results given in B&K calibration certificates issued for the same units. Measurement results have shown good repeatability (experimental standard error below 0,005 dB). Comparison between differences obtained by measurement and calculated from certificate data has shown satisfactory consistency (divergences do not exceed 0,04 dB).

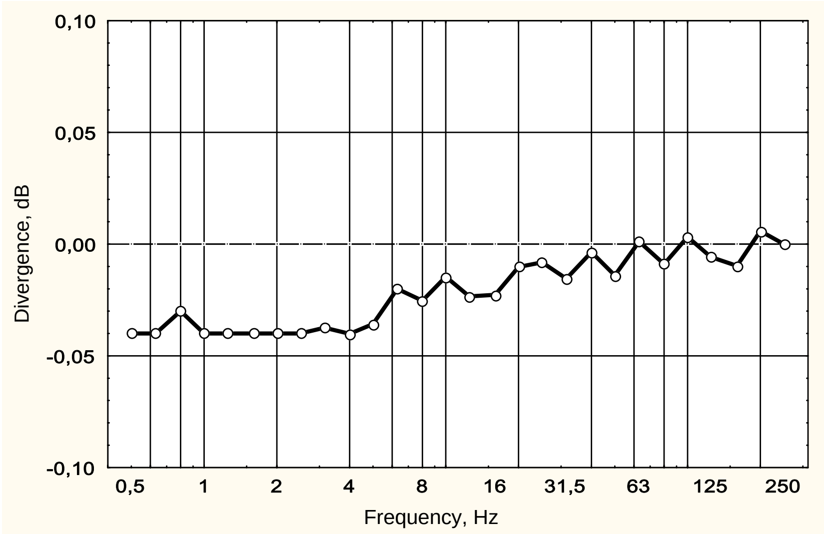

Figure 3 Divergence between frequency response levels differences for two B&K low-frequency units determined in GUM by measurement and the same differences calculated from certificate data of the same units

The frequency dependence of experimental standard error for frequency response levels difference determination by measurement is shown below.

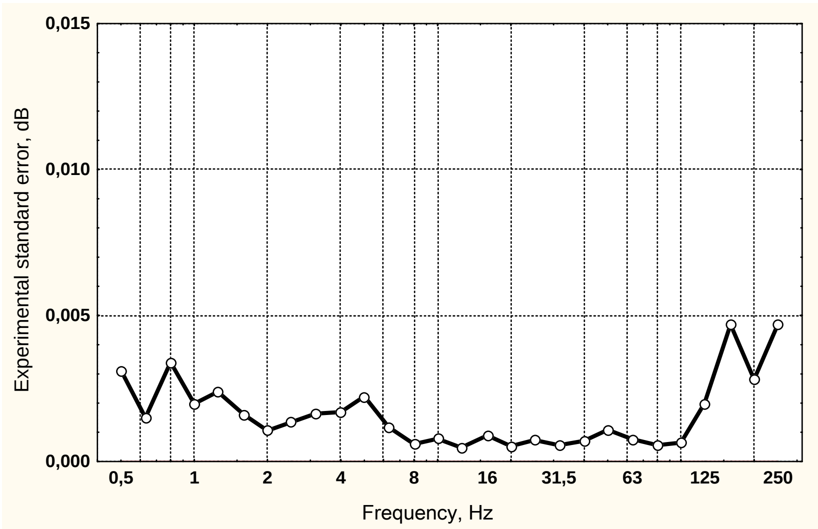

Figure 4 Experimental determination of differences between frequency response levels for two B&K low-frequency units – frequency dependence of experimental standard error

Tentatively estimated expanded uncertainty of microphone frequency response level determination using low-frequency pressure chamber system described above and B&K 4193-L-004 microphone-preamplifier unit as reference instrument does not exceed values shown below.

Frequency range	< 1 Hz	< 2 Hz	< 4 Hz	< 8 Hz	< 160 Hz	< 250 Hz
Expanded uncertainty	0,10 dB	0,09 dB	0,08 dB	0,07 dB	0,06 dB	0,07 dB

4. DETERMINATION OF FREQUENCY RESPONSE OF SOUND LEVEL METER WHEN SET TO MEASURE G-WEIGHTED SOUND PRESSURE LEVEL

The low-frequency pressure chamber system has been originally developed for determination of SLM frequency response with G frequency weighting selected. Considering wide range of SLM frequency response level values for G-weighting (-76 dB at 250 Hz to +9 dB at 20 Hz) this frequency response is determined in three steps:

Step 1: Determination of SLM frequency response normalized at 250 Hz with FLAT frequency response selected, $L_{\mathrm{FLAT,M}}$, by comparison with reference microphone-preamplifier unit using low-frequency chamber system. Extension microphone cable is used to connect SLM preamplifier to SLM main unit. AC output of SLM may be used.

Step 2: Determination of SLM frequency responses (normalized at 250 Hz) for FLAT and G settings using electrical signals ($L_{\mathrm{FLAT,el}}$ and $L_{\mathrm{G,el}}$, respectively). Test signal is delivered to SLM preamplifier input through actual electrical capacitance of SLM microphone using special signal-delivering adaptor connected between SLM microphone and its preamplifier. In order to reduce the influence of disturbing sound the SLM microphone is placed within special low-frequency sound-insulating head (fig. 3).

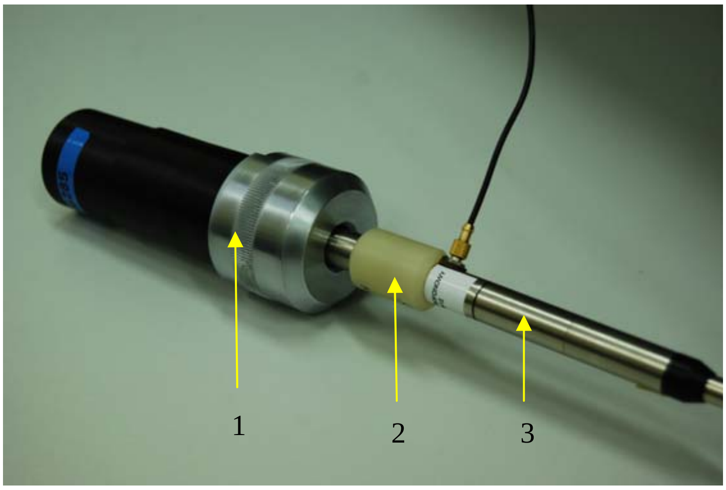

Figure 3 Setup for SLM frequency response determination using electrical signal delivered through actual electrical capacitance of SLM microphone: 1 – low-frequency sound-insulating head, 2 – signal-delivering adaptor, 3 – SLM preamplifier

Step 3: Calculation of SLM frequency response with G weighting selected, $L_{\mathrm{G,M}}(f)$ by combining frequency responses determined in steps 1 and 2 according to the formula:

$$L_{\mathrm{G,M}}(f) = L_{\mathrm{G,el}}(f) + L_{\mathrm{FLAT,M}}(f) - L_{\mathrm{FLAT,el}}(f)$$

The best measurement capability for determination of SLM frequency response with G weighting selected is estimated to be about 0,3 dB in the range 10 Hz to 125 Hz .