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METROLOGY FOR INFRASOUND MEASUREMENTS

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There are a growing number of sound measurements at infrasound frequencies, i.e. below the classical audio frequency range. Examples are the assessment of noise produced by wind turbines or by detonations in open pit mining. A major problem concerning these infrasound measurements is that the calibration of the measurement equipment is usually only traceable down to 20 Hz. Due to these practical needs the frequency range for primary and secondary calibration methods is now being extended to the infrasound. With special care, pressure reciprocity calibration of laboratory standard microphones can give a primary reference down to 2 Hz and our newly developed secondary calibration method allows to calibrate microphones as well as sound level meters down to about 1 Hz. A bilateral comparison of secondary microphone calibration has been performed by PTB (Germany) and INMETRO (Brazil) to validate the new procedure. Combining both methods, a closed traceability chain becomes available for sound measurements in the infrasound frequency range. This enables us to provide both, working standards for calibration laboratories and direct calibration of end-user devices.
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1. Introduction

In the past years, a growing number of applications lead to the requirement of measuring sound pressure level at infrasound frequencies. For example in Brasil, the mining industry demands for the calibration of geophones that are used to monitor the sound emission of blasting in daylight mining. In Germany, the standard DIN 45680 for the measurement and assessment of low-frequency noise immission [1] asks for measurements in the low frequency region < 20 Hz.

Therefore, the national metrology institutes (NMI) of both countries have need to provide traceability to end user devices for sound pressure level in the infrasound frequency range. Independently, they developed measurement setups for primary as well as for secondary calibration. This opens a chance for a bilateral comparison on infrasound traceability to validate the calibration procedures of both NMIs.

This conference paper gives a short introduction to the measurement setups of both institutes and the background of the comparison. Since the comparison has just started at the time when this paper has been prepared, the final results will be published in a following journal paper.

2. Primary calibration

PTB and INMETRO extended both their primary calibration capabilities down to 2 Hz. Both institutes use a modified pressure reciprocity procedure. Compared to calibrations in the audio frequency range, the procedure for low frequencies has some special requirements on the test equipment and on the devices under test, too. The pressure chamber may not have any uncontrolled leakage to allow testing at the low frequencies. The pressure chamber is set up by pressing two microphone cartridges onto a cylindrical coupler (see Figure 1). The usage of any kind of grease sealing is not allowed to prevent the microphones from damage and to assure a precise volume enclosure. To avoid leakage, the coupler as well as the front surfaces of the microphones need to be extraordinary plane. This requirement can be realised by using a coupler made of sapphire. The microphones must be of type LS1P according to [2] and are not allowed to have any scratches, dents or other mechanical defects. Moreover, the front surface of the cartridges have to be carefully lapped to be as planar as possible. This leads to the fact that only selected microphone specimens can be calibrated. Figure 1 gives a photo of the core parts of a low frequency reciprocity calibration setup.

Figure 1: Two lapped LS1P-microphones B&K 4160 and a sapphire coupler with sealing needle.

This arrangement allows the reciprocity calibration down to a frequency of 2 Hz with a 95%-measurement uncertainty (k=2) of 0.25 dB. Selected LS1P microphones can so be calibrated to serve as a primary transfer standard. These microphones cannot directly be applied in practical measurements because their frequency response is not flat in free field and they are not designed to be used with a protection grid. That’s why a secondary calibration procedure is necessary to transfer the sound pressure level at low frequencies to any user’s instrumentation.

Several institutes worldwide have implemented the extended reciprocity calibration procedure and inter-laboratory comparisons have been performed. CCAUV.A-K5 was completed in 2014 [5]. The regional intercomparison EURAMET.AUV.A-K5 with 12 participants has been technically completed and the final report os expected for publication in 2017.

3. Secondary calibration

To desseminate the unit created by the primary standard, the low frequency pressure sensitivity of a primarily calibrated microphone need to be compared to further microphones under test. Both PTB and INMETRO realised this secondary calibration by use of the simultaneous (PTB additionally sequentially) comparison method. In both setups, a closed air volume in a pressure chamber is excited by a loudspeaker. The volume has to be sealed to assure a stable sound pressure even at low frequencies. The pressure chamber has to be large enough to completely hold the microphone under test including the preamplifier.

Special attention has to be given to the positioning of the microphone’s vent. This vent is a small opening that connects the inner cavity of a microphone to the outer sound field to prevent the membrane to be subjected to pressure changes. This leads to an acoustical short-cut and the characteristic roll-off of the frequency response of each microphone at low frequencies. During pressure reciprocity calibration, the vent is, according to the configuration, not exposed to the sound field in the coupler. However, the vent is exposed to the outer sound field in most practical applications. Both vent positions lead to different characteristic frequency responses. When comparing a pressure reciprocity calibrated microphone to a microphone under test that is intended for use with its vent exposed to the sound field, this needs to be carefully taken into account when positioning the microphones for secondary calibration.

Figure 2 shows a photo of the INMETRO setup. The pressure chamber has a diameter of about 250 mm and a height of 100 mm allowing to hold a complete microphone mounted on a preamplifier. The reference microphone is mounted in an opening on the side of the chamber with its vent not exposed to the sound field inside the chamber. The 95%-measurement uncertainty (k=2) is depending on frequency and on the kind of device under test 0.09 dB to 0.4 dB. For details of the INMETRO setup see [3].

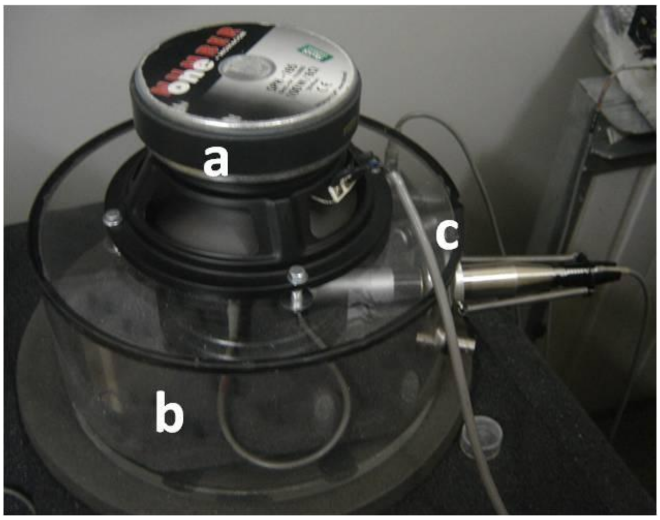

Figure 2: INMETRO setup for secondary calibration of microphones: (a) loudspeaker, (b) pressure chamber, (c) reference microphone (outside the chamber) and microphone under test (inside the chamber).

Figure 3 shows a photo of the PTB setup. The pressure chamber has a diameter of 0.35 m and a height of 1.14 m. The sound field distribution of this quite large chamber is less homogeneous and restricts the upper frequency limit of the setup, but it can hold even large sound level meters for alibration. The reference microphone is mounted on the top of the chamber with its vent not exposed to the sound field within the chamber. The estimated 95%-measurement uncertainty (k=2) is, depending on frequency and on the kind of device under test, 0.5 dB to 1.0 dB. Details of the PTB setup are described in [4].

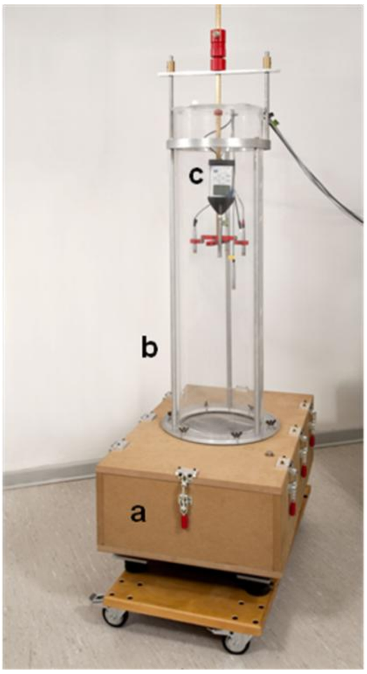

Figure 3: PTB setup for secondary calibration of microphones and sound level meters: (a) subwoofer, (b) pressure tube, (c) reference microphone and device under test.

Since there was no inter-laboratory comparison available for low-frequency secondary calibration, INMETRO and PTB decided to perform a bilateral comparison to validate both calibration setups. At the time of preparation of this text, the comparison had just started.

4. Summary

The combination of both, primary and secondary calibration methods, provides traceable sound pressure level measurement capabilities down to 2 Hz. Laboratory standard microphones can be calibrated by primary and by secondary procedures, accurately taken into account whether the vent is exposed to the sound field or not. Moreover, working standard microphones and end user devices, such as sound level meters and measurement microphones, can be calibrated. The measurement uncertainty is less than 0.25 dB for primary, and 0.1 dB to 1.0 dB for secondary calibration (depending on frequency and on the device under test). The intercomparisons for both primary and secondary calibration are now being completed and after that validated traceability will be available for calibration laboratories, manufacturers and users of infrasound measurement equipment down to a frequency of 2 Hz.

REFERENCES

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