Free-Field Calibration of Microphones and Sound Level Meters in an Anechoic Chamber

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More often than not, the results of acoustic measurements have far-reaching consequences for technical, financial and legal decisions – that is why high precision is required. Careful calibration of the employed measuring instrumentation is one of the basic preconditions to achieve this goal. The method presented is of fundamental importance, as it is the only one that applies the type of sound field on which the standardized requirements for sound level meters are based.

1 Calibration Methods - An Overview

Measuring microphones and sound level meters are precision instruments, the characteristics of which must be checked by on-site calibration each time they are used. Furthermore every acoustic meter must be re-calibrated more thoroughly on a regular base after a longer period of use, e.g. every year or every other year. The standard on sound level meters (DIN EN 60651) requires every sound level meter (or its measuring microphone) to have as perfect as possible an omni directional (spherical) directional characteristic and as flat (linear) as possible a free-field-response on which any further frequency weightings (e. g. A weighting, octave-band and third octave-band analysis) can be based.

The object to be calibrated can be a single measuring microphone, the sensitivity (transfer coefficient) of which is determined versus frequency. If, however, a complete sound level meter with indicating instrument shall be calibrated, it is the aim of calibration to adjust its overall sensitivity such that its indication is in agreement with the sound pressure level to which the device is exposed.

For the on-site calibration of sound measuring equipment, two types of Working Standards are mostly used:

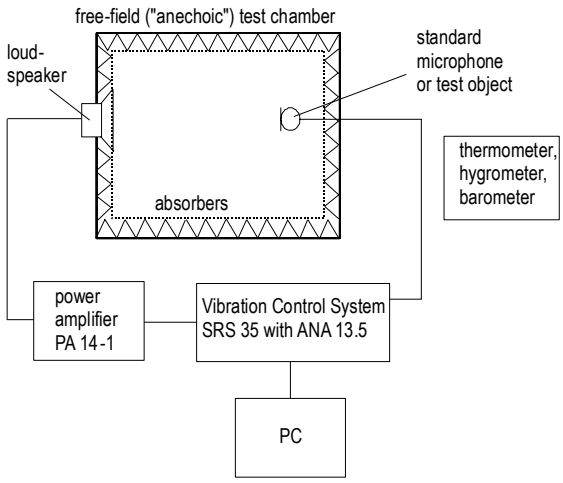
- Pistonphone (one sound pressure level, usually 124 dB; 1 frequency, usually 250 Hz)
- Acoustic calibrator or coupler (one or more levels and frequencies, usually including 94 dB at 1,000 Hz)

These devices are well suited for everyday calibration. They are not suited, however, for an overall check-up under free-field conditions in a wide range of frequencies and pressure levels. This can only be accomplished in a dedicated laboratory with an anechoic (acoustically dead) chamber to generate the required free-field conditions.

The Calibration System CS 18 by SPEKTRA follows this line. It allows very small measurement uncertainties to be achieved according to GUM (Guide to the Expression of Uncertainty in Measurement, ISO) and is at present under evaluation for being certified as a DKD (German Calibration Service) laboratory. Its characteristics are permanently traced back to the national standard of sound pressure preserved by PTB (Federal Physical-Technical Institution of Germany). Its main application is the regular check-up of microphones and sound level meters, so complementing their everyday on-site calibration by means of pistonphones, sound calibrators and acoustic couplers.

2 Free-Field Acoustic Calibration System by SPEKTRA

Below the block diagram of the system is shown. It works by the method of comparison where the standard microphone and the test object are exposed to the same acoustic signal simultaneously or one after the other. Thus the sensitivity of the standard microphone used as reference or working standard is compared to the sensitivity of the object to be calibrated.

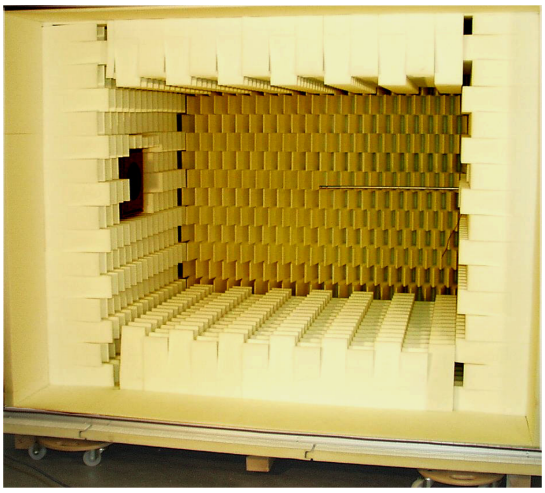


It is obvious that the *method of direct comparison*, where standard microphone and test object are exposed to the same sound signal simultaneously, does not guarantee true free-field conditions, since either object distorts the sound field of the other one by reflections ("pressure increase"). These effects will not necessarily cancel out. For this reason SPEKTRA apply the *method of substitution* where

standard microphone and object under test are put in exactly the same place in the sound field one after the other. The required high stability of sound excitation is ensured by frequently performing replication tests (testing the same object repeatedly).

2.1 Anechoic Chamber

Creation of a free sound field of plane progressive waves requires an ideal environment without any reflecting surfaces or obstacles. To this end a special non-reflecting test room (free-field room, acoustically dead room, anechoic chamber) was constructed, the boundaries of which are completely lined with wedge-shaped high-



grade sound absorbers. Its outside dimensions are 2 m x 2 m x 2.4 m, it can easily be disassembled or shifted by means of small trolleys put underneath.

The chamber was developed as a dedicated calibration tool for the frequency range 250 Hz to 20 kHz. It is far less costly than a large universal room of the walk-in type. Moreover such a special chamber makes it easier to implement excellent free-field conditions without any reflections from fixtures and other objects, as the only items within the room are the source of sound (loudspeaker, on the left) and the object to be calibrated with its holding fixture (on the right).

The chamber meets the requirements for anechoic chambers used for the determination of sound power (DIN EN ISO 3745). Extensive test measurements proved its excellent free-field characteristics in the specified frequency range.

2.2 Calibration System CS 18 MIC – the Complete Instrumentation

Apart from the chamber, the complete system includes a set of *Reference standard microphones* and other equipment as shown in the block diagram. At present SPEKTRA has two 1/2" microphones of types B&K 4180/2673 and MTG MK 221/ MV203 as well as one 1" cartridge B&K 4160 and one 1/4" cartridge MTG MV 301 with the necessary adapters and accessories. They were calibrated together with a Vibration Control System by PTB and thus directly traced back to the German national standard of sound pressure.

As in other Calibration Systems of generic type CS 18 made by SPEKTRA, the Vibration Control System SRS 35 shown above is used for signal generation and processing. Its CPU module 13.5 takes on the tasks of generating the excitation signal, pre-processing the input signals (filtering, rms measurement) and communication with the external PC. The Analogue Unit ANA 13.5 included in the SRS 35 has two microphone inputs which accept all common types of measuring microphones. The power amplifier (smaller device on top) supplies the electric power that drives the loudspeaker in the chamber.

3 Results

Main specifications of Calibration System CS 18 MIC:

- Objects to be calibrated: Microphones and acoustic instruments of any type and size
- Frequency range: 250 Hz to 20 kHz (50 Hz to 250 Hz at reduced precision, as free-field conditions are not met any more)
- Expanded measurement uncertainty to GUM:
  ± 0.5 dB from 250 Hz to 1.6 kHz,
  ± 0.6 dB from 1.6 kHz to 8 kHz,
  ± 0.8 dB up to 20 kHz
  (for sound level meters add 0.1 dB)

SPEKTRA offer their services to calibrate microphones and sound level meters on assignment. The result will be a factory calibration certificate (after DKD certification of lab: a DKD calibration certificate) of every test object, stating its frequency response of sensitivity level (or indication error relative to true sound pressure level) versus frequency in form of a graph and/or table. As all results are traceable directly to the National standard, the owner of such equipment can be sure that he can further rely on his meters and acoustic calibrators.

Owners of large stocks of microphones and sound level meters should think about buying a Calibration System CS 18 MIC so as to be able re-calibrate their equipment on their own.