Calibration of sound calibrators: an overview

Thiago Antônio Bacelar Milhomem, **Zemar Martins Defilippo Soares**

Electroacoustics Laboratory / Acoustics and Vibration Metrology Division / Scientific and Industrial Metrology Directory / National Institute of Metrology, Quality and Technology
Avenida Nossa Senhora das Graças, 50, Prédio 1, Xerém, Duque de Caxias, RJ, 25.250-020
Brazil

E-mail: tbmilhomem@inmetro.gov.br

Abstract: This paper presents an overview of calibration of sound calibrators. Initially, traditional calibration methods are presented. Following, the international standard IEC 60942 is discussed emphasizing parameters, target measurement uncertainty and criteria for conformance to the requirements of the standard. Last, Regional Metrology Organizations comparisons are summarized.

Keywords: sound calibrator, calibration, standard, comparison.

1. INTRODUCTION

Sound calibrators are devices that generate a known sound pressure level in a known frequency. They are mainly used for adjustment of sound pressure level measurement systems, but they are also used for calibration of measurement microphones by the electrostatic actuator method. They are calibrated according to the international standard IEC 60942 [1-3]. This calibration comprises in measuring sound pressure level, frequency and total harmonic distortion (THD) or total distortion (TD) according to the edition of standard used in their project. This is an interesting point: sound calibrators are calibrated according to edition of standard used in their project no matter which is the current edition.

2. CALIBRATION

Sound pressure level calibration can be performed by different methods being the more traditional the microphone method (using the insert voltage technique) and the sound calibrator comparison method.

In the microphone method, sound calibrator is coupled to a microphone, turned on and then it is measured the system output voltage. After that, sound calibrator is turned off and a voltage is inserted on preamplifier input (microphone output). This requires an insertion voltage unit and a preamplifier with insert voltage facility. When the inserted voltage is adjusted to give the same system output voltage as results from sound pressure level on microphone, this insert voltage is equal to the microphone output voltage (when the sound calibrator is turned on). Knowing the microphone open circuit sensitivity (determined from its calibration [4]), sound pressure and sound pressure level are calculated. Alternatively, from the inserted voltage and the system output voltage (measured when the voltage is inserted), system gain is calculated. From the system gain and system output voltage as results from sound pressure level on microphone, the microphone output voltage is calculated. Again, knowing the microphone open circuit sensitivity, sound pressure and sound pressure level are calculated.

In the sound calibration comparison method, sound calibrator under test is compared with a reference sound calibrator previously calibrated, usually by the microphone method. Sound calibrator under test is coupled to a microphone and it is measured the system output voltage. After that, reference sound calibrator is coupled to the same microphone and it is also measured the system output voltage. From measured voltages and knowing the sound pressure level of the reference sound calibrator, sound pressure level of the device under test is calculate. It should be paid attention to possible corrections for non-linearity of system if sound calibrators (reference and under test) generate sound pressure level at different frequencies i.e., for different microphone sensitivity or different preamplifier gain at each frequency.

Frequency and THD or TD (THD + noise) calibration is performed directly, measuring frequency in a frequency meter and THD or TD in a distortion meter. However, traceability for (low amplitude) distortion measurements is a global challenge [5].

3. IEC 60942

Standard that deals with calibration of sound calibrator is IEC 60942 [1-3]. It is in its third edition, being the first dated of 1988, the second one of 1997 and the newest of 2003. Nevertheless, a new edition is already under analyses by a technical committee of the International Electrotechnical Commission (IEC) [6]. Regards the measured parameters, 1988 edition indicates calibration of sound pressure level, frequency and THD while 1997 and 2003 editions replace THD by TD. Relative to the target measurement uncertainty, 1988 edition does not present anything about it, 1997 edition indicates different limits depending on microphone calibration and 2003 edition indicates an unique limit (independent on microphone calibration). Concerning to the criteria for conformance with the requirements of the standard, 1988 edition indicates that the measured deviations from designed goals do not exceed the applicable maximum permissible measurement error. The 1997 edition indicates that the measured deviations from designed goals extended by the expanded uncertainties of measurement do not exceed the applicable maximum permissible measurement error extended by the applicable target measurement uncertainties, and that the expanded uncertainties of measurement do not exceed the corresponding target measurement uncertainties. The 2003 edition indicates that the measured deviations from designed goals extended by the expanded uncertainties of measurement do not exceed the applicable maximum permissible measurement error that already includes the applicable target measurement uncertainties, and that the expanded uncertainties of measurement do not exceed the corresponding target measurement uncertainties [1-3].

The new edition under discussion uses the newest policy on conformance assessment of the technical committee number 29 of IEC. According to this policy, the conformance will be demonstrated when the measured deviations from design goals do not exceed the applicable maximum permissible measurement error not including the target measurement uncertainties, and that the uncertainties of measurement do not exceed the corresponding target measurement uncertainties.

4. COMPARISONS

According to International Bureau of Weights and Measures (BIPM), thirty four National Metrology Institutes (NMIs) are recognized for accomplishment of calibration of sound calibrator [7], but no comparison was performed under the

International Committee for Weights and Measures (CIPM), just under the Regional Metrology Organizations (RMO): the APMP.AUV.A-S1 in Asia Pacific Metrology Program (APMP) and the SIM.AUV.A-S1 in Inter-American Metrology System (SIM) [8].

The regional supplementary comparison APMP.AUV.A-S1 has been carried out for the measurement of sound pressure level, frequency, THD and TD of a multi-frequency sound calibrator. The pilot laboratory was the NMI of Thailand and a multi-frequency sound calibrator was circulated through thirteen NMIs. The measurements took place between September 2008 - July 2010 and the final report was presented in March 2014. Deviations from supplementary comparison reference values (SCRVs) for sound pressure level and frequency are mostly within declared expanded uncertainties. For THD and TD it was not possible to calculate a SCRV because the absence of any consistency in the approach to calculating uncertainty which varied a lot, e.g. for 1 kHz at 94 dB, THD reported expanded uncertainties varied from 0.00938 to 0.5% [9].

SIM.AUV.A-S1 has been carried out for the measurement of sound pressure level, frequency and THD of two pistonphones. Cenam, NMI from Mexico, was the pilot laboratory and five NMIs participated on this comparison. The measurements took place between July 2001 - February 2002 and the preliminary report (Draft A) was finished in April 2004. Final report was not presented yet.

Brazil, through Inmetro, is recognized for its accomplishment to perform the calibration of sound calibrator and participated in the comparison SIM.AUV.A-S1 [7,8].

5. CONCLUSIONS

There is a request for traceability for (low amplitude) distortion measurements.

The new edition of IEC 60942 under discussion proposes a significant change with regard to the criteria for conformance to the requirements of the standard.

The absence of a comparison performed under CIPM and the existence of only two regional comparisons carried out for the measurement of sound pressure level, frequency and distortion (TD and/or THD) argument the need of more comparisons.

6. REFERENCE

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