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AES information document for acoustics - Loudspeaker driver comparison chambers

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Abstract

Acoustic performance measurements on loudspeaker drivers that are measured in different sites or with different equipment or methods are subject to variations in accuracy and repeatability. Similarly, end-of-line loudspeaker test systems often utilize small, arbitrarily shaped, driver measurement chambers that do not correlate from line to line, or from site to site. This document is motivated by the need for engineers in different locations to share accurate measurement data on specific or same type loudspeaker drivers and addresses some of the factors affecting repeatability of measurements in different locations.

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Foreword

This foreword is not part of AES-73id *AES information document for acoustics – Loudspeaker driver comparison chambers*.

This document was developed in project AES-73id, in the SC-04-03 Working Group on Loudspeaker Modelling and Measurement, under the leadership of Steve Hutt.

The members of the writing group that developed this document in draft are: Geoff Hill, Steve Hutt, David Murphy, Ed Simon.

Steve Hutt
Chair, working group SC-04-03, 2019-02-28

Note on normative language

In AES standards documents, sentences containing the word “shall” are requirements for compliance with the document. Sentences containing the verb “should” are strong suggestions (recommendations). Sentences giving permission use the verb “may”. Sentences expressing a possibility use the verb “can”.

AES information document for acoustics – Loudspeaker driver comparison chambers

0 Introduction

0.1 General

In the design of loudspeaker drivers, numerous engineering acoustical tests are performed throughout the development cycle to ascertain the loudspeaker driver's performance characteristics and capabilities. And, during the manufacturing phase end-of-line quality tests place each driver into a relatively compact test chamber and measure the acoustic and electrical response based on a set of test signals. Results are compared with stored values derived from a reference such as a sample that has typically been quantified by the engineering acoustical tests or, with reference values derived from the mean capability of the loudspeaker production variance. End-of-line tests are not usually set up to provide full performance measurements however they can identify deviation and variance from the expected performance defined by reference parameters. Such test chambers are typically built only to meet local needs. As a result, the measurements derived from a chamber in one location do not compare well with measurements derived from another. It would be beneficial for collaboration over different sites if the loudspeaker measurement data was directly transferable.

This information document will set out some relevant issues and suggest loudspeaker test chamber designs and construction methods to achieve measurement results that will be comparable between different testing sites.

0.2 Patents

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. AES shall not be held responsible for identifying any or all such patent rights.

1 Scope

This document considers factors affecting the interchangeability of measurement data from simple loudspeaker comparison chambers and discusses some performance capabilities.

2 Normative references

The following standard contains provisions that, through reference in this text, constitute provisions of this document. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent edition of the indicated standard.

ISO 266, *Acoustics — Preferred frequencies for measurement*. Geneva, Switzerland: International Organization for Standardization, 1975

ISO 80000-8, *Quantities and units — Part 8: Acoustics*, Switzerland: International Organization for Standardization, 2007

IEC 60268-5, *Sound system equipment - Part 5: Loudspeakers*, Switzerland: International Electrotechnical Commission, 2007

IEC 60268-21, *Sound system equipment - Part 21: Acoustical (output based) measurements*, Switzerland: International Electrotechnical Commission, 2018

3 Definitions

For the purposes of this document, the following terms, definitions, and abbreviations apply.

3.1

Reference point

A point positioned with respect to some physical feature of the loudspeaker or loudspeaker system

NOTE The position shall be that specified by the manufacturer.

3.2

Reference axis

A line that passes through the reference point

NOTE The direction of the reference axis shall be specified by the manufacturer and shall be used as the zero-reference axis for frequency response measurements.

3.3

Measuring axis

The line joining the microphone to the nominal centre of the loudspeaker under test

3.4

Frequency response

3.4.1

Magnitude response

The generated sound pressure level as a function of frequency, measured under free-field or simulated free-field conditions, with a constant voltage source and at a stated position with respect to the reference axis and point.

3.4.2

Transfer function

The ratio as a complex variable between generated sound pressure and loudspeaker input voltage as a function of frequency, measured under free-field or simulated free-field conditions, with a constant voltage source and at a stated position with respect to the reference axis and point

3.4.3

Internal response

The generated sound pressure level as a function of frequency, measured inside a test chamber, with a constant voltage source and at a stated position with respect to the reference axis and point.

3.4.4

Correction response

The calculated or calibrated, sound pressure level as a function of frequency, such that if applied to a measurement 3.4.3 will effectively correct such a measurement that it corresponds to a measurement 3.4.1

3.5

Amplitude smoothing

The modification of measured quantities by averaging on a mean-square basis over a band of frequencies

NOTE Amplitude smoothing can be done in successive bands by, for example, using third octave bands per ISO 266 and their centre frequencies or in a continuous or sliding way by using the FFT bin frequencies as centre frequencies. Enough frequency lines need to be present within a given band for smoothing to be valid. This modification is often called "frequency smoothing" or "bandwidth smoothing."

3.6

Far field

The part of the radiated sound field more distant from the radiator in which the inverse-distance law (that is, sound pressure is inversely proportional to distance) is obeyed

3.7

Very near field

The part of the radiated sound field, normally very close to the radiator typically a distance of 2 mm to 5 mm maximum from the radiating surface

4 Loudspeaker test chambers

4.1 General

Accurate and repeatable loudspeaker driver measurements require that environmental and boundary influences have minimal impact on the measurement. This conventionally implies that loudspeaker driver measurement methods rely both implicitly and explicitly upon the use of an anechoic environment that has no impact on the measurement. Alternatively, measurements may employ a standard baffle or simulated anechoic environment that is understood and can be replicated:

- a. Small anechoic chambers are bandwidth limited, relative to dimensions vs. wavelength.
- b. The cost or size of an anechoic chamber of adequate size may be prohibitive.
- c. Anechoic chambers are impractical for line or production use.
- d. Measurement methods utilizing "windowing" may restrict usage over the full audio band and are difficult to control on a measurement-to-measurement basis, dependent on mechanical setup.
- e. An anechoic chamber is often not available, often reserved for engineering development or continuing conformance validation.

This document considers loudspeaker test chambers that produce measurements that may be replicated predictably and repeatably.

4.2 Definition

A loudspeaker test chamber is defined in this document as a chamber that may be used for the measurement of loudspeaker drivers. In the context of this document, the term 'test chamber' refers to an enclosure, not an anechoic chamber. Typical enclosures may be rectangular, asymmetric with non-parallel walls, have spherical walls, or any combination of these characteristics.

5 General function

5.1 Acoustic characteristics

Unlike a conventional anechoic chamber, the acoustic absorption in a loudspeaker test chamber is not intended to absorb all the acoustic energies of a device under test:

- (i) It is intended that the acoustic dampening be enough to minimize the medium frequency modes and the higher frequencies produced by the device under test.
- (ii) It is preferable to minimize conventional standing waves by design of the structure.

5.2 Usable bandwidth

5.2.1 Calibration corrections

Like an anechoic chamber it is envisaged that an acoustic tolerance be established. However, the specification and tolerance of a loudspeaker test chamber may benefit from applying a calibration correction which is normally applied by the test analyser either during the measurement cycle or may be subsequently applied to the data.

In the same way that a microphone calibration file would be normally be applied, one could also apply a calibration correction for a loudspeaker test chamber.

5.2.2 High-frequency limit

The high-frequency limit is determined by several factors:

- (a) Microphone performance
- (b) Analyzer performance
- (c) Sampling rate/bandwidth
- (d) Absorption and reflection coefficients
- (e) Absorption geometry
- (e) High frequency scattering
- (f) Bandwidth of the device under test

5.2.3 Low-frequency limit

The low-frequency limit is determined by many of the same factors plus others:

- (a) Microphone performance
- (b) Analyzer performance
- (c) Sampling rate/bandwidth
- (d) Absorption and reflection coefficients
- (e) Absorption geometry
- (f) Maximum SPL of the measurement system
- (g) Front pressure or acoustic load provided to a loudspeaker by a test chamber

5.2.4 Measurement tolerance

Loudspeaker frequency response is often described with some tolerance in dB over a specified bandwidth for example, ± 3 dB, 20 Hz to 20 kHz. Due to the complex nature of loudspeakers, measurement equipment and environmental variances, repeatability of measurements with a small tolerance is difficult. However, a deviation reference of ± 3 dB should not be considered adequate for comparison between similar drivers measured in the same manner. An appropriate tolerance would be a range where error or deviation does not significantly affect the results, for example ± 0.1 dB to 0.2 dB over a specified frequency range. If mechanical setup is not strictly adhered to frequency dependent boundary influences may increase the deviation.

Comparison of tolerance specifications for measurements made in different locations and with different equipment should be defined by the user for specific devices. This will require careful documentation of mechanical setup and environmental conditions, including temperature, humidity, and barometric pressure that impact not just the measurement results but may also affect the driver under test. The user specification should include all information necessary to replicate and process the measurements accurately.

The core requirement for any loudspeaker test chamber is in establishing whether the measurement system is consistent, accurate and stable. Gage repeatability and reproducibility techniques and statistical tools cover much of this in detail. However most of the analysis upon which this is based is of single dimensional data, such as length, width and diameter. The primary concept is of statistical analysis together with normal distribution of the dimension being measured.

Most of the Loudspeaker data measured in a test chamber is inherently multi-dimensional. For example, amplitude (SPL) or impedance (Ohms) vs. frequency (Hz).

Data can be defined in an understandable form, with discrete and repeatable steps taking a hypothetical set such as the example shown in table 1.

Table 1 - SPL vs Frequency data example

#	20Hz	40Hz	80Hz	160Hz	320Hz	640Hz	1,280Hz	2,560Hz	5,120Hz	10,240Hz	20,480Hz
1	50	62	74	86	87	88	89	90	95	87	80
2	45	65	75	86	88	90	88	90	91	88	77
3	55	67	79	81	83	85	87	88	94	85	79