IEC 60268-22

Edition 1.0 2020-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Sound system equipment –
Part 22: Electrical and mechanical measurements on transducers

Équipements pour systèmes électroacoustiques –
Partie 22: Mesurages électriques et mécaniques sur transducteurs

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INTERNATIONAL
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SOUND SYSTEM EQUIPMENT –

Part 22: Electrical and mechanical measurements on transducers

FOREWORD

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International Standard IEC 60628-22 has been prepared by technical area 20: Analogue and digital audio, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

The text of this International Standard is based on the following documents:

CDV	Report on voting
100/3311/CDV	100/3424/RVC

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60268 series, published under the general title *Sound system equipment*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

Measurements of the electrical and mechanical state variables have become increasingly important for the following reasons:

- Maximum sound pressure output is limited by voice coil heating and transducer nonlinearities. The large signal behaviour of loudspeakers can be described by nonlinear and thermal models using lumped parameters. These physical characteristics are important for transducer design and system integration.
- Mechanical vibration of the diaphragm determines the radiated sound. The modal vibration of the radiator's surface can be predicted by numerical simulations (FEA) and directly measured by laser vibrometry. This data represents important transducer characteristics that can be used to design the desired directivity into the system's acoustical output.
- DSP plays an important role in active systems. Digital pre-processing of the audio stream requires reliable transducer property information to protect the transducer against thermal and mechanical overload and to actively compensate for linear and nonlinear distortion generated in the output signal.

SOUND SYSTEM EQUIPMENT –

Part 22: Electrical and mechanical measurements on transducers

1 Scope

This part of IEC 60268 applies to transducers converting an electrical input signal into a mechanical or acoustical output signal. However, if the electrical input terminals and the surface of the radiator are accessible, this document can also apply to passive and active sound systems such as loudspeakers, headphones, TV-sets, multi-media devices, personal portable audio devices, automotive sound systems and professional equipment. This document describes only electrical and mechanical measurements that help assess the transfer behaviour of the device under test (DUT). This includes operating the DUT in both the small- and large-signal domains. The influence of the target application's acoustical boundary conditions (e.g. car interior) can also be considered in the physical evaluation of the sound system. Perception and cognitive evaluations of the reproduced sound and the impact of perceived sound quality are outside the scope of this document.

NOTE This document does not apply to microphones and other sensors. Implementation of this document does not require access to the sound pressures generated in the near or far fields of the radiator. Directivity and other characteristics describing the electro-acoustical transfer properties are described in IEC 60268-21, which covers acoustical measurements. The practical application of the measurements for research and development (R&D), end-of-line testing (QC) and evaluation in the final target application (TA) is discussed in Annex A.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60263:1982, *Scales and sizes for plotting frequency characteristics and polar diagrams*

IEC 60268-1:1985, *Sound system equipment – Part 1: General*

IEC 60268-2:1987, *Sound system equipment – Part 2: Explanation of general terms and calculation methods*

IEC 60268-11:1987, *Sound system equipment – Part 11: Application of connectors for the interconnection of sound system components*

IEC 60268-12:1987, *Sound system equipment – Part 12: Application of connectors for broadcast and similar use*
IEC 60268-12:1987/AMD1:1991

IEC 60268-21:2018, *Sound system equipment – Part 21: Acoustical (output-based) measurements*

IEC 62458:2010, *Sound system equipment – Electroacoustical transducers – Measurement of large signal parameters*

IEC 62459:2010, *Sound system equipment – Electroacoustical transducers – Measurement of suspension parts*

ISO 3:1973, *Preferred numbers – Series of preferred numbers*

ISO/IEC GUM:1995, *Guide to the expression of uncertainty in measurement (GUM)*

3 Terms, definitions and abbreviated terms

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Terms and definitions

3.1.1
linear behaviour
behaviour of the DUT at small amplitudes where the relationship between input and output signal can be modelled by a linear system and described by a linear transfer function

3.1.2
reference unit
DUT having measured properties representative of units in the sample lot passing the end-of-line test

3.2 Abbreviated terms

DUT device under test
SPL sound pressure level
FEA finite element analysis
FT Fourier transform

4 Type description

The type description shall be provided by the manufacturer, including the following information:

- transduction principle (e.g. electro-dynamical, capacitive, electro-magnetic transducer);
- system description including operation principle (e.g. the number of the transducers used in the loudspeaker system;
- acoustical loading (e.g. horn loading and enclosure types, such as bass reflex, column, line array, ...);
- power amplification (e.g. maximum output power, class type, minimum load impedance, ...);
- DSP processing (e.g. equalizer, active protection), if any.

5 Marking of terminals and controls

The terminals and controls shall be marked in accordance with IEC 60268-1 and IEC 60268-2.

6 Physical characteristics

6.1 Dimensions

The outer dimensions of the DUT shall be specified.

6.2 Mass

The total mass of the DUT when ready for use shall be specified.

6.3 Connectors and cable assemblies

Cable assemblies and connectors shall be in accordance with IEC 60268-11 and IEC 60268-12.

NOTE In some circumstances, the connectors that are currently standardized are unsuitable and the use of other types is unavoidable.

7 Conditions

7.1 Rated conditions

Standard measuring conditions are defined in 7.3. To obtain the actual conditions for the measurement, some values (known as "rated conditions") shall be taken from the manufacturer's specification.

These rated conditions are not subject to measurement, but they constitute the basis for performing the measurements to determine the other characteristics.

The following rated conditions are of this type and shall be stated by the manufacturer:

- rated maximum input voltage (or the rated maximum sound pressure level);
- rated maximum input power;
- evaluation point of the reference displacement;
- rated frequency range;
- rated impedance;
- rated climate conditions.

7.2 Climatic conditions

7.2.1 Conditions for normal testing

IEC 60268-1 states that tests should be carried out in the following environment in order to prevent the influence of temperature and humidity that can affect the properties of the drive unit suspensions:

- ambient temperature T_{norm}: 15 °C to 35 °C;
- relative humidity: 25 % to 75 %;
- air pressure: 86 kPa to 106 kPa.

7.2.2 Conditions for climatic testing

The manufacturer shall specify the ambient temperature T_A and other climatic conditions under which the DUT is operated during thermal testing in accordance with 25.1.4.

7.3 Standard measuring conditions

The DUT shall be understood to be under standard measuring conditions if all of the following conditions are specified and implemented:

a) the DUT to be measured is mounted in accordance with Clause 13;

b) the acoustical environment is specified and selected from those given in Clause 9;

NOTE The environment (e.g. car interior) might influence the acoustical load and the mechanical state of the transducer. If the amplitude of the stimulus used in the measurements is adjusted based on the rated maximum (output) sound pressure level L_{MAX} in accordance with IEC 60268-21, the acoustical environment is considered.

c) unwanted electrical, mechanical or acoustical signals (e.g. noise) generated by other sources shall be kept at the lowest levels possible because their presence can obscure low-level signals. Data related to signals that are less than 20 dB above the noise level in the frequency band being considered shall be discarded or marked as corrupted by noise;

d) the DUT is acclimatized to the normal climatic conditions (normal ambient temperature $T_A = T_{norm}$) in accordance with 7.2.1;

e) additional cooling periods are required between successive tests if the amplitude compression $C(f)$ > 0,5 dB is in accordance with IEC 60268-21;

f) the DUT is supplied with a test signal with specified properties (spectrum, duration, etc.) in accordance with Clause 8 at a specified RMS input value $\tilde{u}$ for the rated frequency range in accordance with Clause 16;

g) attenuators, equalizers, dynamics and any other active control elements shall be set to their "normal" position as stated by the manufacturer. If other positions are chosen, for example, those providing a maximally flat frequency response or minimum attenuation, they shall be specified;

h) measuring equipment suitable for determining the wanted characteristics is connected in accordance with Clause 11.

8 Test signals

8.1 General

Some measurements can be performed by using any audio signal $s(t)$ as an input signal (stimulus) applied to the electro-acoustical device under test (DUT) while other measurement techniques use test signals as specified in IEC 60268-21.

8.2 Small-signal condition

The device under test shall be excited by a stimulus $s(t)$ generating the voltage $u(t) = \alpha \tilde{u}_{max} s(t)$ at the terminals scaled by the maximum input value $\tilde{u}_{max}$ and scaling factor α. The rated maximum input value $\tilde{u}_{max}$ shall be specified by the manufacturer of the DUT in accordance with 16.1. The scaling factor α shall be less than 0,1 to ensure negligible heating of the voice coil in electro-dynamic transducers (ΔT_V < 5 K) and linear behaviour of the device under test. The nonlinear distortion components measured through the excitation of a single tone, two tone or multitone stimulus shall be 40 dB below the fundamental signal components.

9 Acoustical environment

9.1 General

Electrical and mechanical measurements shall be made under one of the conditions in 9.2 to 9.8. The acoustical environment used for testing shall be stated.

9.2 Free-field conditions

An environment, which fullfills free-field conditions in full space in accordance with IEC 60268-21, can be used for electrical and mechanical measurements. If the environment (e.g. anechoic room at low frequencies) does not fulfil these free-field conditions over the entire frequency range of the measurement, the manufacturer shall state the valid frequency range.

9.3 Half-space, free-field conditions

An environment, which fulfills free field condition in a half space in accordance with IEC 60268-21 can be used for electrical and mechanical measurements. These conditions shall be satisfactorily met with a reflecting plane of sufficient size.

If the environment (e.g. half space anechoic room at low frequencies) does not fulfil these half-space free field conditions over the entire frequency range of the measurement, the manufacturer shall state the valid frequency range.

9.4 Free-air condition

Acoustical conditions that approach free-field condition over the frequency range of interest shall be used. Other environments shall be considered satisfactory when the reflected sound components are sufficiently suppressed to ensure an accuracy of ±5 % in the measured amplitude and phase values of the electrical input impedance curve at the specified frequency. If the environment (e.g. a small measurement room at low frequencies) does not fulfil these conditions over the entire frequency range of the measurement, the manufacturer shall state the valid frequency range.

NOTE The free-air condition is usually applied to transducers operated without enclosure but firmly clamped by a fixture to measure the electrical and mechanical state of the transducer.

9.5 Target application conditions

Acoustical conditions that correspond with the final target application of the device under test (e.g. sound system mounted in a car, horn compression driver mounted on a horn).

9.6 Vacuum condition

9.6.1 General

Acoustical conditions which approach those of no air.

9.6.2 Method of measurement

Transducer electrical impedance are measured and stored. The transducer is then placed in a vacuum chamber and the evacuation is started. Note if any outgassing from glues or plastic materials occurs – the vacuum will be drawn down slower than expected. Transducer electrical impedance is then measured and stored. The vacuum is then released to restore normal atmospheric pressure. The transducer electrical impedance is measured and stored, and the data is then compared to the initial stored measurement to see if any changes have occurred due to material(s) changes from outgassing.

9.7 Plane-wave tube condition

A plane-wave tube is intended to provide an approximately constant acoustical impedance with a value $\rho_0 c$ identical to the specific impedance of air.

NOTE Plane-wave tubes are used to provide a standard load for the testing of compression drivers, see AES-1id-2012 [1][1].

9.8 Non-acoustical measurement condition

Electrical and mechanical measurements can be performed in a room of sufficient size (typically > 8 m^3). The size of the room depends on the space required around the DUT to avoid any additional acoustical loading of the DUT and to ensure stable climate conditions during the test.

[1] Numbers in square brackets refer to the Bibliography.

10 Positioning of the radiator

10.1 Rated geometrical conditions

10.1.1 General

The position and orientation of the diaphragm, cone or other kind of radiator used in the DUT shall be stated using the radiator's reference point $\mathbf{r}_{r,ref}$, the normal vector $\mathbf{n}_r$ and the orientation vector $\mathbf{o}_r$ as illustrated in Figure 1.

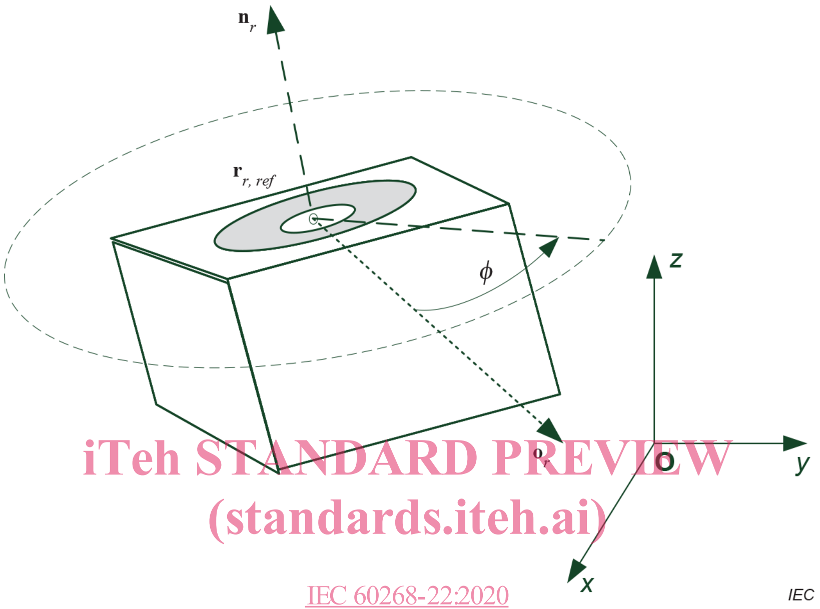

Figure 1 – Rated conditions used to describe the geometry and position of the radiator in the coordinate system

10.1.2 Reference plane and normal vector

The reference plane with the normal vector $\mathbf{n}_r$ shall be used to define the reference axis and the reference point $\mathbf{r}_{r,ref}$.

NOTE For symmetrical structures, the reference plane is usually parallel to the radiating surface at the rest position of the radiator. For asymmetrical structures, the reference plane is better indicated by means of a diagram.

10.1.3 Reference point

The reference point $\mathbf{r}_{r,ref}$ shall be a point on the radiator's surface intersecting the reference plane. The position of the reference point $\mathbf{r}_{r,ref}$ shall be specified by the manufacturer.

NOTE For symmetrical structures, reference point $\mathbf{r}_{r,ref}$ is usually the point of axial symmetry of the radiator within the reference plane. For asymmetrical structures, the reference point is better indicated by means of a diagram.

10.1.4 Orientation vector

The orientation vector $\mathbf{o}_r$ defines the orientation of the radiator within the reference plane and the direction of the azimuthal angle ϕ in spherical coordinates.

NOTE The preferred orientation vector places the reference point $\mathbf{r}_r$ at the origin O of the coordinate system, pointing the normal vector $\mathbf{n}_r$ of the reference plane into the z-direction while the polar angle $\theta = 0$ turns the audio system in such a way that the orientation vector $\mathbf{o}_r$ (e.g. top of the enclosure) points into the x-direction.