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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Sound system equipment – Electroacoustical transducers – Measurement of suspension parts

Équipements pour systèmes électroacoustiques – Transducteurs électroacoustiques – Mesurage des pièces de suspension

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SOUND SYSTEM EQUIPMENT – ELECTROACOUSTICAL TRANSDUCERS – MEASUREMENT OF SUSPENSION PARTS

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 62459 has been prepared by IEC technical committee 100: Audio, video and multimedia systems and equipment.

This first edition cancels and replaces the IEC/PAS 62459 published in 2006. It constitutes a technical revision. The main changes are listed below:

– descriptions of the methods of measurement are adjusted to the state of the technology;
– addition of Clauses 5 to 13;
– integration of Annex A "Code of practice" at the main part of the standard;
– overall textual review.

The text of this standard is based on the following documents:

FDIS	Report on voting
100/1625/FDIS	100/1648/RVD

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

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

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

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

The contents of the corrigendum of November 2011 have been included in this copy.

IMPORTANT – The "colour inside" logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

The properties of the suspension parts such as spiders and surrounds have a significant influence on the final sound quality of the loudspeaker. This International Standard defines measurement methods and parameters required for development and quality-assurance by suspension-part manufacturers and loudspeaker manufacturers.

Static and dynamic methods have been developed for measuring the suspension parts at small and high amplitudes. Due to the visco-elastic properties of the suspension material (fabric, rubber, foam, paper) the measurement results depend on the measurement conditions and are not comparable between different methods. For example, the properties measured by static method significantly deviate from the dynamic behaviour of the suspension material when excited by an audio signal. This standard defines the terminology, the characteristics which should be specified and the way the results should be reported. The goal is to improve the reproducibility of the measurement, to simplify the interpretation of the results and to support the communication between manufacturers of suspension parts and complete drive units.

SOUND SYSTEM EQUIPMENT – ELECTROACOUSTICAL TRANSDUCERS – MEASUREMENT OF SUSPENSION PARTS

1 Scope

This International Standard applies to the suspension parts of electroacoustic transducers (for example, loudspeakers). It defines the parameters and measurement method to determine the properties of suspension parts like spiders, surrounds, diaphragms or cones before being assembled in the transducer. The measurement results are needed for engineering design purposes and for quality control. Furthermore, this method is intended to improve the correlation of measurements between suspension-part manufacturers and loudspeaker manufacturers.

The measurement methods provide parameters based on linear and nonlinear modelling of the suspension part and uses both static and dynamic techniques.

2 Normative references

The following referenced documents are indispensable for the application 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 60268-1, *Sound system equipment – Part 1: General*

3 Terms and definitions

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

3.1
suspension part
surround of the cone made of rubber, foam, paper and fabric and the spider which is usually made out of impregnated fabric

3.2
displacement
x
perpendicular direction at the inner rim of the suspension part

3.3
peak displacement
x_{peak}
peak value of the displacement occurring during a dynamic measurement at resonance frequency

3.4
driving force
F
total effect of the restoring force, friction and inertia of both the suspension part and the inner clamping parts at the neck of the suspension

3.5
transfer function
***H*(*f*)**
amplitude response given by

$$H(f) = \frac{|X(j\omega)|}{|F(j\omega)|} \quad (1)$$

between the displacement spectrum $X(\mathrm{j}\omega) = FT\{x(t)\}$ and the force spectrum $F(\mathrm{j}\omega) = FT\{F(t)\}$

3.6
dynamic stiffness
$K(x_{ac})$
reciprocal of the dynamic compliance $C(x_{ac})$; it is the ratio of instantaneous force F_{ac} to instantaneous displacement x_{ac}, for an a.c. excitation signal at point x_{ac}, given by the following equation

$$K(x_{ac}) = \frac{1}{C(x_{ac})} = \frac{F_{ac}}{x_{ac}} \quad (2)$$

NOTE The dynamic stiffness $K(x_{ac})$ corresponds to the secant between origin and working point defined by x_{ac} in the force-displacement curve.

3.7
incremental stiffness
$K_{inc}(x_{dc})$
reciprocal of the incremental compliance $C_{inc}(x_{dc})$; it is the ratio of a small a.c. force F_{ac} to the small a.c. displacement x_{ac} produced by it at working point x_{dc} under steady-state condition as given by the following equation

$$K_{inc}(x_{dc}) = \frac{1}{C_{inc}(x_{dc})} = \frac{F_{ac}}{x_{ac}} \quad (3)$$

NOTE The incremental stiffness $K_{inc}(x_{dc})$ corresponds to the gradient at the working point defined by x_{dc} in the force-deflection curve.

3.8
static stiffness
$K_{static}(x_{dc})$
reciprocal of the static compliance $C_{static}(x_{dc})$; it is the ratio of a d.c. force F_{dc} and the d.c. displacement x_{dc} produced by it at the working point x_{dc} under steady-state condition; the static stiffness $K_{static}(x_{dc})$ corresponds to the secant between origin and working point in the force-displacement curve, given by the following equation

$$K_{static}(x_{dc}) = \frac{1}{C_{static}(x_{dc})} = \frac{F_{dc}}{x_{dc}} \quad (4)$$

3.9
moving mass
m
defined by

$$m = \delta m_s + m_c \quad (5)$$

where

m_s is the mass of the suspension part,
m_c is the additional mass of the inner clamping parts,
δ is the clamping factor (with $0 < \delta \le 1$), describing the fraction of the suspension which contributes to the moving mass.

NOTE If factor δ is not known, the moving mass is approximated by using the total weight of the suspension part (δ = 1) and ensuring that the mass, m_c, of the inner clamping part dominates the moving mass, m ($m_c >> m_s$).

3.10
resonance frequency
f_R
frequency of an a.c. displacement x_{ac} at which the restoring force, $F_K = K(x_{ac})x_{ac}$ of the suspension part equals the inertia of the moving mass, m, given by the following equation

$$F_K = K(x_{ac})x_{ac} = m\frac{d^2 x_{ac}}{dt^2} \tag{6}$$

3.11
lowest cone resonance frequency
f_0
frequency at which the cone mass and suspension stiffness resonate

NOTE The lowest cone resonance frequency can be approximated by

$$f_0 \approx \frac{1}{2\pi}\sqrt{\frac{K(x_{off})}{\delta m_s}} \tag{7}$$

using the stiffness $K(x_{off})$ at the offset x_{off} due to gravity, the clamping factor δ and the cone mass m_s.

3.12
effective stiffness
K_{eff}
stiffness given by

$$K_{eff}(x_{peak}) = (2\pi f_R)^2 m \tag{8}$$

describing the conservative properties of the suspension part performing a vibration at the resonance frequency, f_R, using the moving mass, m

NOTE The effective stiffness, $K_{eff}(x_{peak})$, or the reciprocal, compliance, $C_{eff}(x_{peak}) = 1/K_{eff}(x_{peak})$, are integral measures of the corresponding non-linear parameters, $K(x)$ and $C(x)$, in the working range used, defined by the peak value, x_{peak}. The effective parameters are directly related to the resonance frequency and may be measured with minimal equipment. However, the effective parameters can only be compared if the measurements are made at the same peak displacement, x_{peak}.

3.13
loss factor
Q
factor estimated by the ratio

$$Q = \frac{|H(f_R)|}{|H(f_{dc})|} \tag{9}$$

between the magnitude of the transfer function, $H(f_R)$, at resonance frequency, f_R, and the magnitude of the transfer function, $H(f_{dc})$, at very low frequencies, f_{dc} (with $f_{dc} << f_r$).

NOTE If the losses are sufficiently high ($Q > 2$), the transfer function, $H(f)$, has a distinct maximum (peak) at the resonance frequency, f_R.

3.14
mechanical resistance
R
given by

$$R = \frac{2\pi f_R m}{Q} \tag{10}$$

where
m is the moving mass,
f_R is the resonance frequency,
Q is the Q-factor.

3.15
inner clamp dimension
D_i
diameter at the neck of the suspension part which is clamped by inner clamping parts (for example, cone and cap)

3.16
outer clamp dimension
D_o
inner diameter of the outer rim of the suspension part which is clamped by the outer clamping parts (for example, the upper and lower clamping rings)

4 Test conditions

The test should be made at 15 °C to 35 °C ambient temperature, preferably at 20 °C, 25 % to 75 % relative humidity and 86 kPa to 106 kPa air pressure, as specified in IEC 60268-1.

Prior to the measurement the suspension part under test should be stored under these climatic conditions for 24 h.

5 Clamping of the suspension part

5.1 General

The suspension part should be clamped during the dynamic testing in a similar way as mounted in the final loudspeaker.

5.2 Destructive measurement

In some cases, it may be convenient to use adhesive and original loudspeaker parts (voice coil former, frame) for clamping.

5.3 Non-destructive measurement

However, non-destructive testing is preferred for comparing samples, storing reference units and for simplifying communication between manufacturer and customer. Since tooling of special clamping parts fitted to the particular geometry of the suspension is costly and time-consuming, a more universal clamping system comprising a minimal number of basic elements (for example, rings, caps and cones) may be preferred.

The moving mass, m, depends on the mass of the moving parts of the suspension, the air load and the mass of the inner clamping parts. If the mass of the inner clamping part is much higher than the mass of the suspension, the total moving mass, m, can be approximated by the total weight of the suspension together with inner clamping parts, ($\delta = 1$). In this case, the mass of the clamped areas at the outer rim of the suspension and the influence of the air load can be neglected.

5.4 Clamping position

A vertical position of the suspension part during measurement (displacement in horizontal direction) is mandatory if the weight of the inner clamping parts or the weight of the suspension part is not negligible. A horizontal position (displacement in vertical direction) may cause an offset in cone displacement due to gravity, giving a higher stiffness value.

5.5 Guiding the inner clamping part

An additional guide for the inner clamping parts may be used to prevent eccentric deformation or tilting of the suspension and to suppress other kinds of vibration (rocking modes).

5.6 Reporting the clamping condition

The clamping factor according 3.9 shall also be stated; if not, the default value, $\delta = 1$, is used. It is strongly recommended that the inner clamping dimension, D_i, and the outer clamping dimension, D_o, as well as the geometry of the inner clamping parts be reported. The orientation of the suspension part (which side of the suspension part is used as front and back side in the measurement jig) should also be reported. The repeatability of the measurement can be improved by using the same clamping parts and the same orientation of the suspension.

6 Methods of measurement

6.1 Static measurement

This technique for measuring the static stiffness according to Equation (4) uses a d.c. signal of certain magnitude (for example, a constant force F_{dc}) as stimulus and measures a d.c. response of the suspension part (for example, the displacement x_{dc}) under steady-state condition. The measurement time required to get a steady-state response depends on the visco-elastic behaviour of the suspension material (creep) which is usually much longer than the settling time for an a.c. signal corresponding to the resonance frequency f_R.

6.2 Quasi-static measurement

This technique is similar to the static measurement as described in 6.1, using a relatively short measurement time T. The ratio of d.c. force F_T and d.c. displacement x_T is the quasi-static stiffness $K_{quasi}(x_T)$ at the working point x_T. Since the suspension part has not reached the final equilibrium the quasi-static stiffness is usually higher than the static stiffness ($K_{quasi}(x) > K_{static}(x)$). Settling/reading time that has a great influence on the results shall be stated with the results.

6.3 Incremental dynamic measurement

This technique for measuring the incremental stiffness $K_{inc}(x_{dc})$ according to Equation (3) uses a superposition of a d.c. signal of certain magnitude (for example, constant restoring force F_{dc} generating a d.c. position x_{dc}) and a small a.c. signal (e.g. restoring force F_{ac}) as stimulus and measures the a.c. response of the suspension part (e.g. the a.c. part of the displacement x_{ac}) under steady-state condition. Neglecting the visco-elastic behaviour of the suspension material, the incremental stiffness, $K_{inc}(x_i)$ can be transformed into the regular stiffness $K(x)$ by

$$K(x) = \frac{1}{x}\int_0^x K_{inc}(x)dx \tag{11}$$

6.4 Full dynamic measurement

This technique for measuring the dynamic stiffness $K(x_{ac})$ uses an a.c. signal of certain magnitude (for example, the a.c. restoring force F_{ac}) and measures the a.c. response of the suspension part (for example, a displacement x_{ac}).