International Standard 5344

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Electrodynamic test equipment for generating vibration — Methods of describing equipment characteristics

Moyens d'essais électrodynamiques utilisés pour la génération des vibrations — Méthodes de description des caractéristiques

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 5344 was developed by Technical Committee ISO/TC 108, *Mechanical vibration and shock*, and was circulated to the member bodies in March 1978.

It has been approved by the member bodies of the following countries :

Australia	France	Sweden
Austria	Germany, F.R.	Turkey
Belgium	Italy	United Kingdom
Brazil	Japan	USA
Bulgaria	Mexico	USSR
Chile	Netherlands	Yugoslavia
Czechoslovakia	South Africa, Rep. of	
Denmark	Spain	

No member body expressed disapproval of the document.

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Electrodynamic test equipment for generating vibration — Methods of describing equipment characteristics

0 Introduction

This International Standard concerns the characteristics to be standardized for test equipment used to generate vibration by electrodynamic means and serves as a guide to the selection of such equipment.

In the context of this International Standard, the term "electrodynamic" means that the vibratory force created by the generator results from the interaction of a constant magnetic field and an alternating current in a built-in coil.

This International Standard applies to the following :

a) electrodynamic vibration generators (see clauses 3 to 7, and annexes);

b) power amplifiers (see clauses 3, 4, 5, 6 and 8, and annexes);

c) vibration generator and associated power amplifiers (see clauses 3 to 9, and annexes).

A test equipment system comprises : vibration generators and amplifiers combined as in this International Standard, and control consoles, auxiliary tables (see ISO 6070) and other test equipment to be standardized later.

The division into separate classes, a), b) and c) above, has been made to permit the performance of vibration generators and their associated amplifiers to be predicted from the characteristics of separate portions of the test equipment. Classes a) and b) are provided primarily to permit a prospective user to calculate the performance of a vibration generator from one manufacturer with a power amplifier from another manufacturer. Class c) may be all that a prospective user requires if both the vibration generator and the power amplifier are from the same manufacturer.

1 Scope and field of application

The test equipment used for the electrodynamic generation of vibration possesses many characteristics which can be evaluated in many very different ways.

To permit comparison of test equipment from different sources, this International Standard establishes the following :

a) a list of the characteristics;

b) the standard method of obtaining certain characteristics.

This International Standard provides three levels of description to be used in describing test equipment, as follows :

a) minimum level of description;

b) medium level of description;

c) high level of description.

This International Standard gives, for each level of description, a list of the characteristics to be specified by the manufacturer in his tender and in his literature.

2 References

ISO/R 468, *Surface roughness.*

ISO 2041, *Vibration and shock — Vocabulary.*

ISO 3744, *Acoustics — Determination of sound power levels of noise sources — Engineering method for free-field conditions over a reflecting plane.*

IEC Publication 268-3, *Sound system equipment — Part 3 : Sound system amplifiers.*

3 Symbols

a Acceleration

a_b rms acceleration in random mode

b Damping coefficient of the moving element suspension

d Total harmonic distortion (see 5.9)

F Maximum sinusoidal force (see 5.2)

F_b Maximum random force, broad band

F_o Rated sinusoidal force (see 5.3)

F_{ob} Rated random force, broad band (see 5.4)

F_{omt} Rated sinusoidal force (see 7.2.3) (subscript t represents the various loads)

f Frequency

f_{max} Maximum frequency for which the value of a specified parameter is never less than a specified or rated value of this parameter

f_{min} Minimum frequency for which the value of a specified parameter is never less than a specified or rated value of this parameter

f_{mt} First mechanical resonance frequency of the moving element (subscript t represents the various loads) (see 5.7)

f_{st} Resonance frequency of the moving element suspension (subscript t represents the various loads) (f_{s0} is the particular case for no load) (see 5.5)

$H_i(f)$ Acceleration per unit current in the moving element coil

$H_v(f)$ Acceleration per unit voltage across the moving element coil terminals

I Current

I_b Available effective current under random conditions

I_o Complex output current

I_{so} Rated effective current under sinusoidal conditions

K Dynamic stiffness of the moving element suspension

m_e Effective mass of the moving element

m_t Masses of test loads ($t = 0$, $t = 1$, $t = 2$, $t = 3$, $t = 4$)

P Maximum apparent sinusoidal power

P_b Apparent random power, broad band

P_{so} Rated apparent sinusoidal power (see 5.8)

P_{ob} Rated apparent random power

P_{obc} Rated apparent peak random power

R_{so} Resistive test load

U_E Complex input voltage

U_o Complex output voltage

V_g Overall output noise voltage

V_o Rated output signal voltage

V_{so} Rated sinusoidal voltage

v_s Velocity of moving element

Z_b Generator impedance in the random vibration mode

Z_{so} Inductive test load

γ_i Acceleration/current response

Δf Frequency bandwidth

Φ_a Acceleration power spectral density

Φ_F Maximum force power spectral density

Φ_{Fo} Rated force power spectral density

Φ_P Power spectral density for maximum random power

Φ_{Po} Power spectral density for rated random power

Ψ Force or acceleration crest factor

φ Phase shift (phase angle)

4 Units and quantities

When the manufacturer or the user gives the values for the parameters required by this International Standard, he should clearly define the units that have been used, and state whether the quantities are given as rms, peak or peak-to-peak values.

5 Definitions

This clause defines only some of the terms used in this International Standard. See ISO 2041 for definitions of a general nature.

5.1 force : In this International Standard, force is the force developed by an electrodynamic vibration generator which can be delivered to a load mounted on the test table or connected to the force take-off. This force differs from the force generated by currents flowing in the moving element primarily due to the effects of moving element mass, moving element resonances, suspension stiffness, suspension damping, and the limits of vibration travel.

5.2 maximum force under sinusoidal conditions, F : The upper limit of the force which the vibration generator is capable of delivering at a given frequency and for a specified test load.

5.3 rated force under sinusoidal conditions, F_o : The minimum value of all the values of F_{omt} which the vibration generator is capable of delivering; expressed in another way, it is the minimum value of the function F for test loads m_t.

5.4 rated random force, broad band, F_{ob} : The minimum value, for any test load, of the random force, broad band. This force corresponds to a spectral power density of uniform acceleration between lower and upper frequency limits.

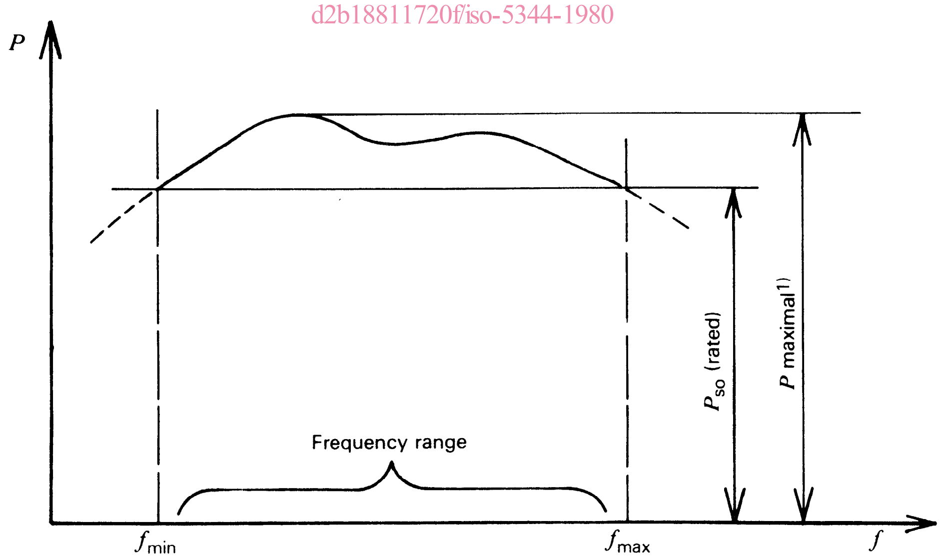
5.5 mechanical resonance frequency of the moving element suspension, f_{st} : This frequency is determined by the effective mass of the moving element and test load and the dynamic stiffness of the moving element suspension.

5.6 electrical resonance frequency of the moving element : The frequency at which the current in the moving coil is in phase with the voltage, and the electrical impedance is a minimum.

5.7 mechanical resonance frequency of the moving element, f_{mt} : This frequency is the first mechanical resonance frequency of the moving element found above the mechanical resonance frequency of the moving element suspension.

5.8 rated apparent power under sinusoidal conditions, P_{so} : The minimum value of curve P (see figure 1). This curve results from the product of the current and voltage which the amplifier can deliver within the frequency range.

NOTE — The quantity "rated apparent power" shall be used with either a resistive, or an inductive, or a mixed load. The power factor must be stated.



1) See ISO 2041, sub-clause 2.043.

Figure 1 — Curve of maximum apparent power versus frequency

5.9 total harmonic distortion, d : Referred to the output signal, it is expressed as a percentage by the following equation :

$$d = \frac{\sqrt{X_2^2 + X_3^2 + \ldots + X_n^2}}{\sqrt{X_1^2 + X_2^2 + \ldots + X_n^2}} \times 100$$

where X_1 is the value of the fundamental term and X_2, X_3, . . ., X_n represent the harmonic components of the nth order of the signal.

NOTES

1 Some instruments measure the total harmonic distortion d by suppressing the fundamental acceleration, and noise is then present; in this case the ratio of the total harmonic distortion to the background noise, expressed as a percentage of the rms value of the total harmonic distortion, must be at least 10 dB.

2 The total harmonic distortion d can also be calculated by summing the values of the harmonic distortion of nth order according to the "square law" (see IEC Publication 268-3).

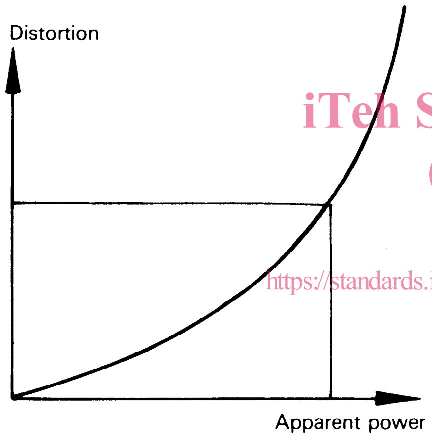


Figure 2 — Total harmonic distortion as a function of apparent power at a given frequency

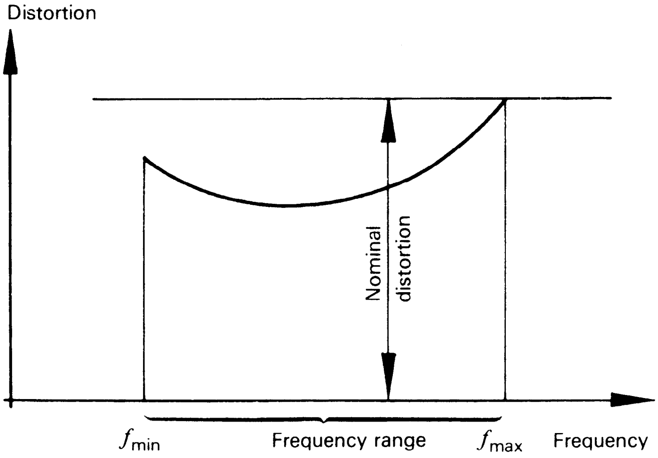


Figure 3 — Total harmonic distortion as a function of frequency at the rated apparent power

5.10 transverse acceleration ratio : The ratio of the transverse acceleration to the axial acceleration.

5.11 effective mass of the moving element, m_e : The moving element, its suspension system, connectors and other devices attached to the moving element constitute a vibration system which is both discrete and continuous. It exhibits the vibratory characteristics attributable to an equivalent discrete system with one degree of freedom, where the parameters of mass and stiffness are functions of the frequency.

It is arbitrarily assumed that the stiffness does not vary and that any variation in the dynamic characteristics is therefore attributable to a variation in mass. In the frequency band

$$3 f_{st} \leqslant f \leqslant \frac{f_{mt}}{3},$$

which excludes resonances, the maximum value of the mass, determined by the method of clause B.1 of annex B, defines the effective mass m_e of the moving element.

5.12 rated travel : The limits between which the moving element of the generator normally operates and beyond which performance is no longer guaranteed by the manufacturer.

6 Characteristics to be supplied by the manufacturer

Attention is drawn to the fact that the three levels of description as adopted in this International Standard are not related to the quality or size of the equipment.

A higher level of description may, for example, be required for a vibration generator of small size and medium quality, whereas under certain circumstances a medium level of description can be sufficient for a large size, high quality equipment.

The level of description required will normally depend on the use to which the equipment is to be put by the customer.

This International Standard also gives characteristics useful in matching an electrodynamic vibration generator acquired from one source or at one time to a power amplifier acquired from another source or at another time.

The characteristics shown by a cross in tables 1 to 3 shall be supplied where demanded by the particular level of description.

Those characteristics which are not required for the particular level of description (those not shown by a cross) can however be supplied by agreement between manufacturer and user.

NOTE — Attention is drawn to the necessity of specifying such particular characteristics at the time of enquiry and ordering because their cost, which can be high, has to be taken into consideration.

Clauses 7, 8 and 9 describe the characteristics listed in tables 1 to 3 without specifying their level of description. Methods of measurement of some of these characteristics are given in annex B.

Table 1 — Vibration generator

Characteristic	Reference to corresponding sub-clause	Level of description		
		minimum	medium	high
Rated frequency ranges	7.2.1		x	x
Frequency range limitation	7.2.2		x	x
Rated sinusoidal force, F_{oml}	7.2.3	x	x	x
Rated random force, broad band, F_{ob}	7.2.4		x	x
Uniformity of the test table motion at the load fixing surface	7.2.5			x
Transverse motion of the test table	7.2.6			x
Total acceleration distortion	7.2.7			x
Response characteristics	7.2.8			
Impedance in random vibration mode	7.2.9			
Response characteristics in random vibration mode	7.2.10			
Stray magnetic field	7.2.11		x	x
Background noise	7.2.12		x	x
Effective mass of the moving element, m_e	7.3.1	x	x	x
Rated travel	7.3.2	x	x	x
Static stiffness of the moving element suspension	7.3.3		x	x
Dynamic stiffness of the moving element suspension	7.3.4			
Mechanical resonance frequency of the moving element suspension	7.3.5		x	x
Mechanical resonance frequencies of the moving element	7.3.6		x	x
Damping coefficient of the moving element suspension	7.3.7			
Permissible static load on the moving element, with the axis vertical and central test load	7.3.8		x	x
Permissible static load on the moving element, with the axis vertical and offset test load	7.3.9			
Permissible static load on the moving element, with the axis horizontal	7.3.10			x
Means of attaching the loads	7.3.11	x	x	x
Maximum torque on each threaded insert or fixing element	7.3.12		x	x
Maximum permissible axial force per threaded insert	7.3.13		x	x
Flatness of the test table	7.3.14		x	x
Perpendicularity of the threaded inserts with respect to the plane of the test table	7.3.15			x
Perpendicularity of the motion with respect to the test table plane	7.3.16			
Coincidence of axes (exciter free take-off)	7.3.17			
Test table dimensions	7.3.18	x	x	x
Tolerances on the coupling of an auxiliary table	7.3.19			
General layout	7.4.1	x	x	x
Masses composing the vibration generator and auxiliary services	7.4.2	x	x	x
Vibration generator pedestal	7.4.3.1	x	x	x
	7.4.3.2		x	x
	7.4.3.3		x	x
	7.4.3.4			x
	7.4.3.5	x	x	x
Sound power level of the emitted noise	7.4.4	x	x	x
Heat dissipation	7.4.5		x	x
Temperature of test table	7.4.6		x	x
Built-in pickup	7.5.1		x	x
Cooling system	7.5.2	x	x	x
Field supply system	7.5.3	x	x	x
Demagnetizing system	7.5.4		x	x
Protective and safety system	7.5.5	x	x	x
Permissible working site environment	7.6.1	x	x	x
Combined tests	7.6.2			
Technical specifications and operating instructions	7.6.3	x	x	x

Table 2 — Power amplifier

Characteristic	Reference to corresponding sub-clause	Level of description		
		minimum	medium	high
Frequency range for a given rated power	8.2.1	x	x	x
Rated apparent sinusoidal power, P_{so}	8.2.2	x	x	x
Total rated harmonic distortion	8.2.3		x	x
Rated apparent random power, P_{ob}	8.2.4			x
Input characteristics	8.3.1	x	x	x
Output characteristics	8.3.2	x	x	x
Frequency response curves	8.3.3			x
Signal-to-noise ratio	8.3.4		x	x
Output voltage stability	8.3.5			x
Gain stability	8.3.6			
Installation requirements	8.4	x	x	x
Miscellaneous characteristics	8.5.1	x	x	x
	8.5.2.1		x	x
	8.5.2.2		x	x
	8.5.2.3		x	x
	8.5.3			
Technical specifications and operating instructions	8.5.4	x	x	x

Table 3 — Generator/amplifier system

Characteristic	Reference to corresponding sub-clause	Level of description		
		minimum	medium	high
Rated frequency range	9.2.1	x	x	x
Frequency range limitations	9.2.2		x	x
Rated sinusoidal force, $F_{\mathrm{om}t}$	9.2.3	x	x	x
Rated random force, broad band, F_{ob}	9.2.4		x	x
Uniformity of table motion at the load fixing surface	9.2.5			x
Transverse motion of the test table	9.2.6			x
Total acceleration distortion	9.2.7		x	x
Stray magnetic field	9.2.8			x
Background noise acceleration	9.2.9		x	x
Background noise output voltage of the power amplifier	9.2.10		x	x
Input characteristics of generator/amplifier system	9.2.11	x	x	x
Signal-to-noise ratio	9.2.12		x	x
Output force stability	9.2.13			x
Erratic movements of the moving element	9.2.14		x	x
Response characteristics	9.4			
General layout	9.5.1	x	x	x
Masses composing the principal parts of the generator/amplifier system	9.5.2	x	x	x
Pedestal of the generator/amplifier system	9.5.3.1	x	x	x
	9.5.3.2		x	x
	9.5.3.3		x	x
	9.5.3.4			x
	9.5.3.5	x	x	x
Generated sound power level	9.5.4	x	x	x
Heat dissipation	9.5.5		x	x
Test table temperature	9.5.6		x	x
Auxiliary equipment required by the installation	9.5.7	x	x	x
Built-in control transducer	9.6.1		x	x
Cooling system	9.6.2	x	x	x
Field supply system	9.6.3	x	x	x
Demagnetizing system	9.6.4		x	x
Protective and safety system	9.6.5	x	x	x
Miscellaneous	9.7.1	x	x	x
	9.7.2.1		x	x
	9.7.2.2		x	x
	9.7.2.3			x
	9.7.3			
Combined tests	9.7.4			
Technical specifications and operating instructions	9.7.5	x	x	x

7 Electrodynamic vibration generators

Diagrams showing the principles of electrodynamic vibration generators with vibrating tables and force take-off (exciter) are given in annex A (figures 7, 8 and 9).

7.1 Test loads, m_t

Electrodynamic vibration generators shall be tested using the mechanical test loads defined below.

The test shall be carried out in a frequency band including the frequency for which the rated force has been specified.

The test loads shall meet the following requirements :

— Fixing screws shall be used in all available mounting locations.

— The length of fixing screws between the head and the thread engagement part shall be such that the resonance frequency of the fixing is outside the frequency range of the test.

— The torque to be applied to fixing screws shall be such that the test load remains in contact with the test table at the fixing points but shall not exceed the limiting value given by the manufacturer (see 7.3.11).

— The surface texture of the contact area of the test load shall be as follows :

$R_a \leqslant 1,6\ \mu m$[1)]

(ground finish).

— The flatness tolerance for the contact area shall be 0,1 mm per metre.

— The test load used on test tables shall consist of a right cylinder with a diameter equal to the largest fixing diameter increased by six times the screw diameter.

— The use of a thin test load shall be avoided in order to maintain adequate rigidity. The recommended ratio of thickness to diameter shall be greater than 0,4 and shall be achieved by changing the nature of the material used for the manufacture of the test load.

Furthermore, in the case of vibration generators with force take-offs (exciters), the coupling arrangements and shape of test load shall be described by the manufacturer.

NOTES

1 Some test loads may require the use of a load compensating system.

2 By agreement between the manufacturer and the user, eccentric test loads may be used; in this case, the loads and fixing means shall be described.

7.1.1 test load m_0 : The particular case where the test load is zero and where the moving element alone is driven.

7.1.2 test load m_1 : A load permitting an acceleration of approximately 40 g_n amplitude under sinusoidal conditions.

7.1.3 test load m_2 : A load permitting an acceleration of approximately 10 g_n amplitude under sinusoidal conditions.

7.1.4 test load m_3 : A load permitting an acceleration of approximately 4 g_n amplitude under sinusoidal conditions.

NOTE — This test load m_3 shall be used only when required, and by agreement between the manufacturer and the user.

7.1.5 test load m_4 : A load permitting an acceleration of approximately 1 g_n amplitude under sinusoidal conditions.

NOTE — This test load m_4 is used only for generators with force take-offs (exciters), and by agreement between the manufacturer and the user.

7.1.6 test load m_5 : A load permitting an acceleration of approximately 20 g_n under sinusoidal conditions.

NOTE — This test load m_5 shall be used only when test load m_1 cannot be used because an acceleration of 40 g_n exceeds the capability of the vibration generator. At the option of the manufacturer, data with this load m_5 may be provided wherever this document calls for data with the test load m_1; however, such substitution shall be called to the attention of the user by adding the subscript 5 to the symbols for all such data and adding to each page of data the note : test load m_5 replaces test load m_1.

1) See the definition of R_a in ISO/R 468.