INTERNATIONAL STANDARD

ISO 10846-2

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Acoustics and vibration — Laboratory measurement of vibro-acoustic transfer properties of resilient elements —

Part 2:
Dynamic stiffness of elastic supports for translatory motion — Direct method

Acoustique et vibrations — Mesurage en laboratoire des propriétés de transfert vibro-acoustique des éléments élastiques —

Partie 2: Raideur dynamique en translation des supports élastiques — Méthode directe

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ISO 10846-2:1997(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 10846-2 was prepared jointly by Technical Committees ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*, and ISO/TC 108, *Mechanical vibration and shock*.

Annexes A and B of this part of ISO 10846 are for information only.

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Introduction

Passive vibration isolators of various kinds are used to reduce the transmission of vibrations. Examples are automobile engine mounts, elastic supports for buildings, elastic mounts and flexible shaft couplings for shipboard machinery and small isolators in household appliances.

This part of ISO 10846 specifies a direct method for measuring the dynamic transfer stiffness function of linear elastic supports. This includes elastic supports with non-linear static load-deflection characteristics as long as the elements show an approximate linearity for vibrational behaviour for a given static preload. This part of ISO 10846 belongs to a series of International Standards on methods for the laboratory measurement of vibro-acoustic properties of resilient elements, which also includes documents on measurement principles, on a indirect method and on a driving point method. ISO 10846-1 provides guidance for the selection of the appropriate part of the series.

The laboratory conditions described in this part of ISO 10846 include the application of static preload. The results of the direct method are useful for isolators which are used to prevent low-frequency vibration problems and to attenuate structure-borne sound. The method is not sufficiently appropriate to characterize completely isolators which are used to attenuate shock excursions.

Acoustics and vibration — Laboratory measurement of vibro-acoustic transfer properties of resilient elements —

Part 2:
Dynamic stiffness of elastic supports for translatory motion — Direct method

1 Scope

This part of ISO 10846 specifies a method for determining the dynamic transfer stiffness for translations of elastic supports, under specified preload. The method concerns the laboratory measurement of vibrations on the input side and blocking output forces and is called the direct method.

The method is applicable to elastic supports with parallel flanges (see figure 1).

NOTE 1 Vibration isolators which are the subject of this part of ISO 10846 are those which are used to reduce:

a) the transmission of audiofrequency vibrations (structure-borne sound, 20 Hz to 20 kHz) to a structure which may, for example, radiate unwanted fluidborne sound (airborne, waterborne or other);

b) the transmission of low-frequency vibrations (typically 1 Hz to 80 Hz) which may, for example, act upon human subjects or cause damage to structures of any size when vibration is too severe.

NOTE 2 In practice the size of the available test rig(s) may restrict the use of very small or very large elastic supports.

NOTE 3 When an elastic support has no parallel flanges, an auxiliary fixture should be included as part of the test element to arrange for parallel flanges.

NOTE 4 Portions of continuous supports of strips and mats are used as test samples in this method. Whether or not the portion describes the behaviour of the complex system sufficiently is the responsibility of the user of this part of ISO 10846.

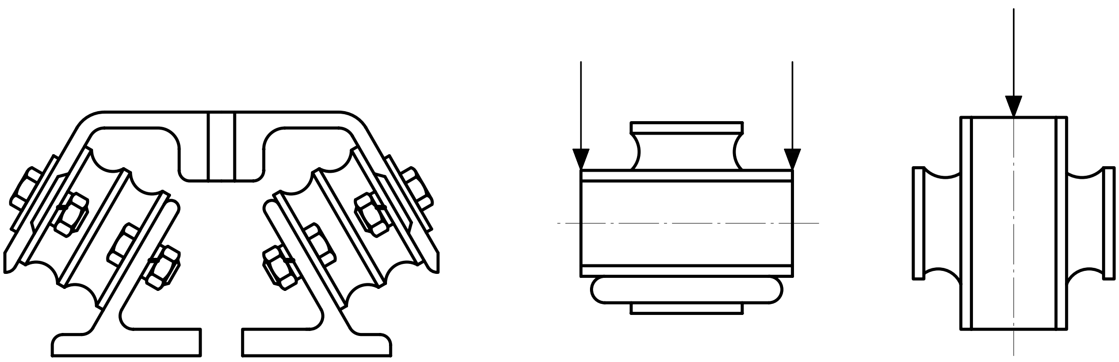

Figure 1 — Example of elastic supports with parallel flanges

Measurements for translations normal and transverse to the flanges are covered in this part of ISO 10846.

The method covers the frequency range from 1 Hz up to a frequency f_1, which is usually determined by the test rig.

The data obtained according to the method specified in this part of ISO 10846 can be used for:

— product information provided by manufacturers and to suppliers;

— information during product development;

— quality control;

— calculation of the transfer of vibrational energy through isolators.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 10846. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 10846 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of ISO maintain registers of currently valid International Standards.

ISO 266:—[1)], *Acoustics — Preferred frequencies.*

ISO 2041:1990, *Vibration and shock — Vocabulary*.

ISO 10846-1:1997, *Acoustics and vibration — Laboratory measurement of vibro-acoustic transfer properties of resilient elements — Part 1: Principles and guidelines.*

ISO 5347-3:1993, *Methods for the calibration of vibration and shock pick-ups — Part 3: Secondary vibration calibration*.

ISO 5348:1987, *Mechanical vibration and shock — Mechanical mounting of accelerometers*.

ISO 7626-1:1986, *Vibration and shock — Experimental determination of mechanical mobility — Part 1: Basic definitions and transducers*.

ISO 7626-2:1990, *Vibration and shock — Experimental determination of mechanical mobility — Part 2: Measurements using single-point translational excitation with an attached vibration exciter*.

3 Definitions

For the purposes of this part of ISO 10846, the definitions given in ISO 2041 and the following apply.

3.1
resilient element
(see vibration isolator)

3.2
vibration isolator
isolator designed to attenuate the transmission of vibration in frequency range [ISO 2041:1990, 2.110]

3.3
elastic support
vibration isolator suitable for supporting part of the mass of a machine, a building or another type of structure

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1) To be published. (Revision of ISO 266:1975)

3.4
blocking force
F_b
dynamic force on the output side of a vibration isolator which results in a zero displacement output

3.5
dynamic driving point stiffness
$k_{1,1}$
frequency-dependent complex ratio of the force on the input side of a vibration isolator with the output side blocked to the complex displacement on the input side during simple harmonic vibration

NOTE 1 $k_{1,1}$ may depend on static preload, temperature and other conditions.

NOTE 2 At low frequencies $k_{1,1}$ is solely determined by elastic and dissipative forces. At higher frequencies inertial forces in the resilient element play a role as well.

3.6
dynamic transfer stiffness
$k_{2,1}$
frequency-dependent complex ratio of the force on the blocked output side of a vibration isolator to the complex displacement on the input side during simple harmonic vibration

NOTE 1 $k_{2,1}$ may depend on static preload, temperature and other conditions.

NOTE 2 At low frequencies $k_{2,1}$ is solely determined by elastic and dissipative forces and $k_{2,1} = k_{1,1}$. At higher frequencies inertial forces in the resilient element play a role as well and $k_{2,1} \neq k_{1,1}$.

3.7
loss factor of resilient element
η
frequency-dependent ratio of the imaginary part of $k_{2,1}$ to the real part of $k_{2,1}$ (i.e. tangent of the phase angle of $k_{2,1}$) in the low-frequency range where inertial forces in the element are negligible

3.8
frequency-averaged dynamic transfer stiffness
k_{av}
function of the frequency of the average value of the dynamic transfer stiffness over a frequency band Δf

3.9
point contact
contact area which vibrates as the surface of a rigid body

3.10
normal translation
translational vibration normal to the flanges of the isolator and parallel to the direction of the static preload

3.11
transverse translation
translational vibration in a direction perpendicular to that of the normal translation

3.12
linearity
property of the dynamic behaviour of a vibration isolator if it satisfies the principle of superposition

NOTE 1 The principle of superposition can be stated as follows: if an input $x_1(t)$ produces an output $y_1(t)$ and in a separate test an input $x_2(t)$ produces an output $y_2(t)$, superposition holds if the input $\alpha x_1(t) + \beta x_2(t)$ produces the output $\alpha y_1(t) + \beta y_2(t)$. This must hold for all values of α, β and $x_1(t)$, $x_2(t)$; α and β are arbitrary constants.

NOTE 2 In practice the above test for linearity is impractical and a limited check of linearity is done by measuring the dynamic transfer stiffness for a range of input levels. For a specific preload, if the dynamic transfer stiffness is nominally invariant the system can be considered linear. In effect this procedure checks for a proportional relationship between the response and the excitation (see 7.7).

3.13
direct method
method in which either the input displacement, velocity or acceleration and the blocking output force are measured

3.14
indirect method
method in which the vibration transmissibility (for displacement, velocity or acceleration) of an isolator is measured, with the output loaded by a known mass

3.15
driving point method
method in which either the input displacement, velocity or acceleration and the input force are measured, with the output side of the vibration isolator blocked

3.16
vibratory force level
L_F
level calculated by the following formula:

$$L_F = 20 \lg \frac{F_{\mathrm{rms}}}{F_0} \text{ dB}$$

where F_{rms} is the r.m.s. value of the force in a specific frequency band and F_0 is the reference force ($F_0 = 10^{-6}$ N)

3.17
vibratory acceleration level
L_a
level calculated by the following formula:

$$L_a = 20 \lg \frac{a_{\mathrm{rms}}}{a_0} \text{ dB}$$

where a_{rms} is the r.m.s. value of the acceleration in a specific frequency band and a_0 is the reference acceleration ($a_0 = 10^{-6}$ m/s^2)

3.18
level of dynamic transfer stiffness
$L_{k_{2,1}}$
level calculated by the following formula:

$$L_{k_{2,1}} = 20 \lg \frac{|k_{2,1}|}{k_0} \text{ dB}$$

where $|k_{2,1}|$ is the magnitude of the dynamic transfer stiffness at specified frequency and k_0 is the reference stiffness ($k_0 = 1$ N·m^{-1})

3.19
level of frequency-averaged dynamic transfer stiffness
$L_{k_{\mathrm{av}}}$
level calculated by the following formula:

$$L_{k_{\mathrm{av}}} = 20 \lg \frac{k_{\mathrm{av}}}{k_0} \text{ dB}$$

where k_{av} is the frequency-averaged dynamic transfer stiffness (3.8) and k_0 is the reference stiffness ($k_0 = 1$ N·m^{-1})

3.20
flanking transmission
forces and accelerations at the output side caused by the vibration exciter at the input side but via transmission paths other than through the elastic support under test

4 Principle

The measurement principle of the direct method is discussed in ISO 10846-1. The basic principle is that the blocking output force is measured between the output side of the vibration isolator and a foundation. The foundation must provide a sufficient reduction of the vibrations on the output side of the test object compared to those on the input side.

5 Apparatus

5.1 Normal translations

A schematic representation of a test rig for resilient supports exposed to normal translational vibrations is shown in figure 2. The test rig shall include the items listed in 5.1.1 to 5.1.5.

5.1.1 Resilient support under test, positioned on a heavy and stiff foundation table.

The resilient support under test is mounted using a force measurement system and under the appropriate static preload.

NOTE — In principle the static and dynamic actuator may be placed underneath the test object and the force measurement system on top between the test object and the moveable frame traverse. However, in practice this may lead to a more limited frequency range for valid measurements.

5.1.2 Preloading system, consisting of one of the following options:

a) a hydraulic actuator in a frame, which serves also as vibration exciter;

b) a frame, which provides static preload only (if this is applied, auxiliary vibration isolators shall be used for dynamic decoupling of the test object from the frame, see figure 2);

c) gravity load using a mass on top of the test object (with or without support frame).

NOTE — In many cases it will be necessary to apply a force distribution plate directly on top of the elastic support. Besides its function of load distribution, it also provides a uniform vibration of the top flange under dynamic forces.

5.1.3 Force measurement system on the output side of the elastic support, consisting of one or more force transducers.

NOTE 1 It may be necessary to apply a force distribution plate between the test element and the force transducers.

NOTE 2 Besides its function of load distribution, the force distribution plate also provides a high contact stiffness to the force transducers. Moreover, it provides a uniform vibration of the bottom flange.

5.1.4 Acceleration measurement systems on the input and output sides of the test object.

The accelerometers on the flanges or on the force distribution plates may be placed on the vertical axis of symmetry. When such a placement is not feasible, the measurement may be made by taking the linear average of the signals of two symmetrically positioned accelerometers.

NOTE — Provided that their frequency range is appropriate, displacement or velocity transducers may be used instead of accelerometers.

5.1.5 Dynamic excitation system, consisting of either

a) a hydraulic actuator which also can provide a static preload; or

b) one or more electrodynamic vibration exciters (shakers) with connection rods.

NOTE Dynamic decoupling of the vibration source from the test frame reduces the flanking transmission via the frame. In rigs which use a hydraulic actuator for both static and dynamic loading, such decoupling is usually avoided because it would have adverse affects on low-frequency measurements.

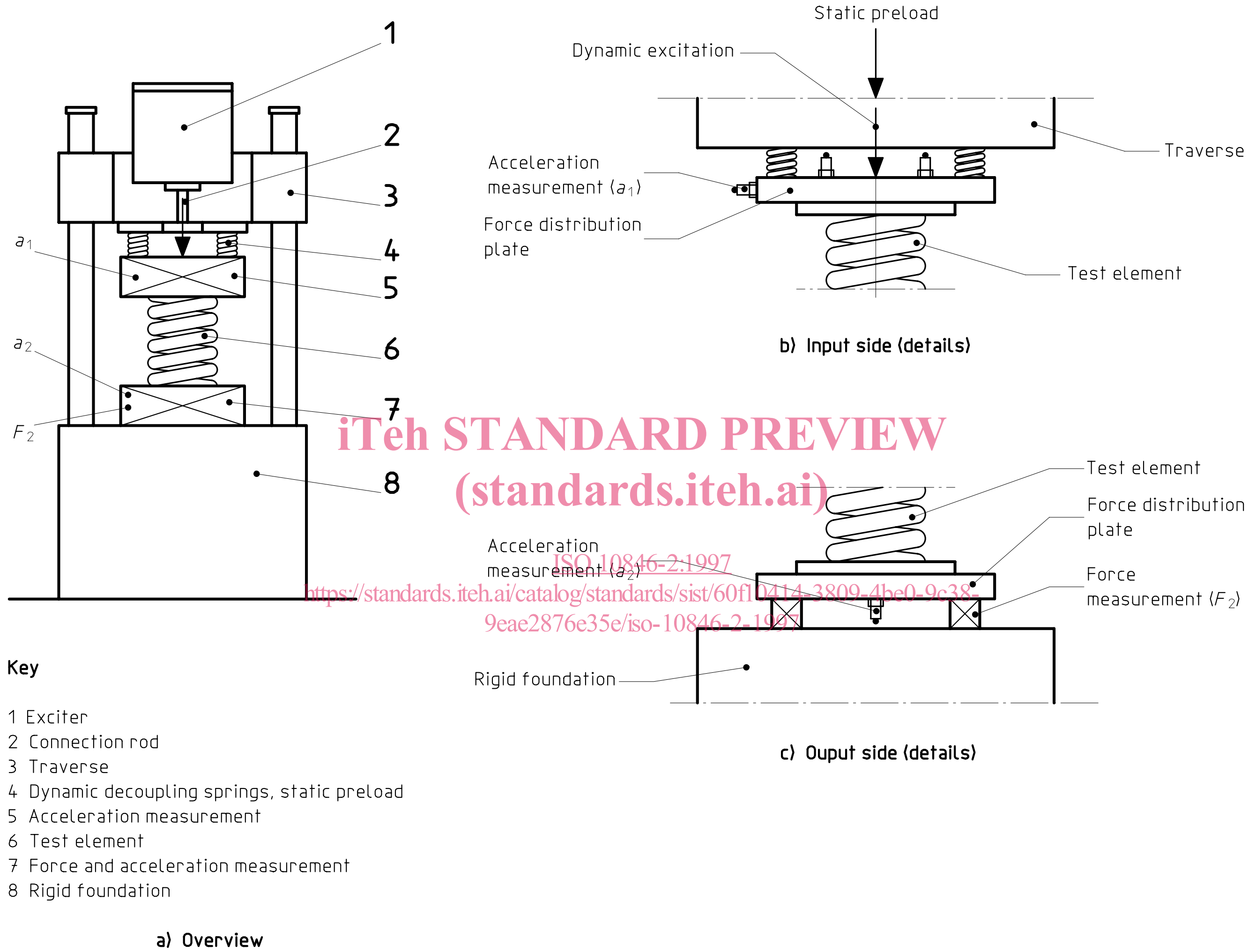

Figure 2 — Example of laboratory test rig for measuring the dynamic transfer stiffness for normal translations

A schematic representation of a test rig for elastic supports exposed to translational vibrations perpendicular to the normal load direction is shown in figure 3 a). The test rig shall include the items listed in 5.2.1 to 5.2.5.

5.2.1 Resilient support under test, positioned on a heavy, stiff foundation table [if necessary with auxiliary supports, see figure 3 c)]. The foundation table shall provide a high degree of stiffness to the force measurement system in the measurement direction.

5.2.2 Preloading system, [see figure 3 b)] consisting of:

a) a force distribution plate (see the note in 5.1.2);

b) low friction bearings;

c) a top plate or beam for applying the static preload;

d) a hydraulic actuator or a mass supported by a frame, to apply the required static preload.

5.2.3 Force measurement system, consisting of one of the following options.

a) One or more force transducers for the measurement of shear forces [see figure 3 d)]. It may be necessary to apply a force distribution plate between the test element and the force transducers (see note 2 in 5.1.3).

b) Low friction bearings and one or more normal force transducers [see figure 3 c)]. It may be necessary to apply a force distribution plate between the test element and the force transducers (see note 2 in 5.1.3).

5.2.4 Acceleration measurement systems on the input and output sides of the test object.

The accelerometers on the flanges or on the force distribution plates may be placed on a horizontal symmetry axis of these components. Alternatively the measurement may be made by taking the linear average of the signals of two symmetrically positioned accelerometers.

NOTE — Provided that their frequency range is appropriate, displacement or velocity transducers may be used instead of accelerometers.

5.2.5 Vibration exciter, with connection rod.

NOTE — See the note in 5.1.5 on dynamic decoupling of the exciter.

6 Criteria for adequacy of the test arrangement

6.1 Frequency range

Each test facility has a limited frequency range in which valid tests can be performed. One limitation is given by the usable bandwidth of the vibration actuator. Another limitation follows from the requirements for measuring the blocking output force. In figures 2, 3 and 4 the following dynamic measurement quantities are given:

F_2 blocking output force;

a_1 acceleration of input flange and input force distribution plate;

a_2 acceleration of output flange and output force distribution plate.

The measurements according to this part of ISO 10846 are valid only for those frequencies where

$$\Delta L_{12} = L_{a_1} - L_{a_2} \geq 20 \text{ dB} \quad (1)$$

NOTE — A too small value for the level difference ΔL_{12} can be explained by an insufficient stiffness mismatch between the test element and the foundation table or flanking transmission via the traverse and the columns to the output side of the test elements or by airborne sound. Use of vibration isolators to decouple the top test element from the load frame (see figure 2) and also to decouple the vibration exciter from the frame would reduce flanking transmission significantly.