INTERNATIONAL STANDARD

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

Part 2:
Direct method for determination of the dynamic stiffness of resilient supports for translatory motion

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

Partie 2: Méthode directe pour la détermination de la raideur dynamique en translation des supports élastiques

Reference number
ISO 10846-2:2008(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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

ISO 10846-2 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*, and ISO/TC 108, *Mechanical vibration, shock and condition monitoring*.

This second edition cancels and replaces the first edition (ISO 10846-2:1997), which has been technically revised.

ISO 10846 consists of the following parts, under the general title *Acoustics and vibration — Laboratory measurement of vibro-acoustic transfer properties of resilient elements*:

— *Part 1: Principles and guidelines*

— *Part 2: Direct method for determination of the dynamic stiffness of resilient supports for translatory motion*

— *Part 3: Indirect method for determination of the dynamic stiffness of resilient supports for translatory motion*

— *Part 4: Dynamic stiffness of elements other than resilient supports for translatory motion*

— *Part 5: Driving point method for determination of the low-frequency transfer stiffness of resilient supports for translatory motion*

Introduction

Passive resilient elements of various kinds are used to reduce the transmission of vibrations. Examples are automobile engine mounts, resilient supports for buildings, resilient 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 resilient supports. This includes resilient supports with non-linear static load-deflection characteristics, as long as the elements show an approximate linearity for vibration 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 an indirect method and on a driving point method. ISO 10846-1 provides guidance for the selection of the appropriate International Standard.

The laboratory conditions described in this part of ISO 10846 include the application of static preload.

The results of the method described in this part of ISO 10846 are useful for resilient supports that are used to prevent low-frequency vibration problems and to attenuate structure-borne sound in the lower part of the audible frequency range. However, for complete characterization of resilient elements that are used to attenuate low- frequency vibration or shock excursions, additional information is needed, which is not provided by this method.

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

Part 2:
Direct method for determination of the dynamic stiffness of resilient supports for translatory motion

1 Scope

This part of ISO 10846 specifies a method for determining the dynamic transfer stiffness for translations of resilient 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 test elements with parallel flanges (see Figure 1).

Resilient elements, which are the subject of this part of ISO 10846, are those which are used to reduce

— the transmission of vibration in the lower part of the audible frequency range (typically 20 Hz to 500 Hz) to a structure which may, for example, radiate unwanted fluid-borne sound (airborne, waterborne or others), and

— 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.

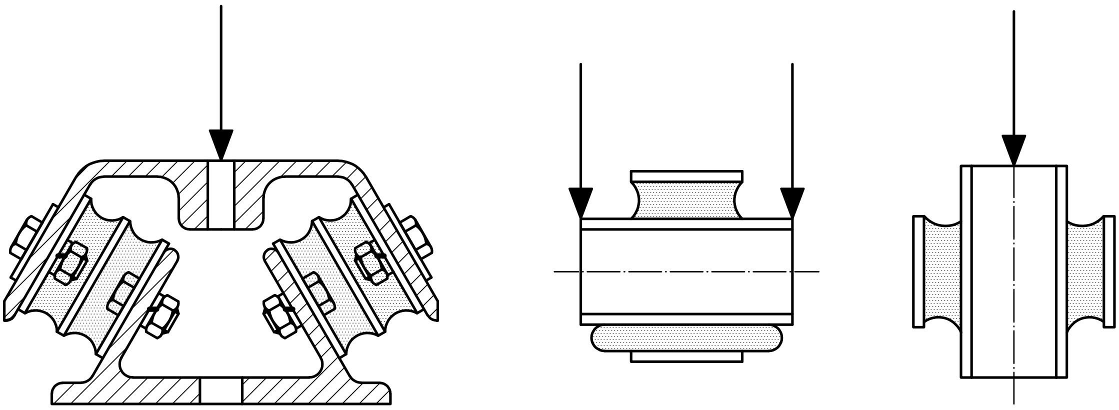
NOTE 1 In practice, the size of the available test rig(s) can restrict the use of very small or very large resilient supports.

NOTE 2 Samples of continuous supports of strips and mats are included in this method. Whether or not the sample describes the behaviour of the complex system sufficiently is the responsibility of the user of this part of ISO 10846.

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

The direct method covers the frequency range from 1 Hz up to a frequency f_{UL}, which is usually determined by the test rig.

NOTE 3 Because of the large variety of test rigs and test elements, f_{UL} is variable. In this part of ISO 10846, the adequacy of the test rig is not defined for a fixed frequency range, but on the basis of measured data, as described in 6.1 to 6.4.



NOTE 1 When a resilient support has no parallel flanges, an auxiliary fixture is included as part of the test element to arrange for parallel flanges.

NOTE 2 The arrows indicate the load direction.

Figure 1 — Example of resilient supports with parallel flanges

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

— product information provided by manufacturers and suppliers;

— information during product development;

— quality control;

— calculation of the transfer of vibration energy through isolators.

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.

ISO 266, *Acoustics — Preferred frequencies*

ISO 2041:—[1], *Mechanical vibration, shock and condition monitoring — Vocabulary*

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

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

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

ISO 16063-21, *Methods for the calibration of vibration and shock transducers — Part 21: Vibration calibration by comparison to a reference transducer*

ISO/IEC Guide 98-3[2], *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement* (*GUM 1995*)

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1) To be published. (Revision of ISO 2041:1990)

2) ISO/IEC Guide 98-3 will be published as a re-issue of the *Guide to expression of uncertainty in measurement* (GUM), 1995.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2041 and the following apply.

3.1
vibration isolator
resilient element
isolator designed to attenuate the transmission of the vibration in a certain frequency range

NOTE Adapted from ISO 2041:—[1)], definition 2.120.

3.2
resilient support
vibration isolator(s) suitable for supporting a machine, a building or another type of structure

3.3
test element
resilient support undergoing testing, including flanges and auxiliary fixtures, if any

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 transfer stiffness
$k_{2,1}$
frequency-dependent ratio of the blocking force phasor $\underline{F}_{2,b}$ on the output side of a resilient element to the displacement phasor $\underline{u}_1$ on the input side

$$k_{2,1} = \underline{F}_{2,b}/\underline{u}_1$$

NOTE 1 The subscripts “1”and “2” denote the input and output sides, respectively.

NOTE 2 The value of $k_{2,1}$ can be dependent on the static preload, temperature, relative humidity and other conditions.

NOTE 3 At low frequencies, $k_{2,1}$ is solely determined by elastic and dissipative forces and $k_{1,1} \approx k_{2,1}$ ($k_{1,1}$ denotes the ratio of force and displacement on the input side). At higher frequencies, inertial forces in the resilient element play a role as well and $k_{1,1} \neq k_{2,1}$.

3.6
loss factor of resilient element
η
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

3.7
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

NOTE See 8.2.

3.8
point contact
contact area that vibrates as the surface of a rigid body

3.9
normal translation
translational vibration normal to the flange of a resilient element

3.10
transverse translation
translational vibration in a direction perpendicular to that of the normal translation

3.11
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 $ax_1(t) + bx_2(t)$ produces the output $ay_1(t) + by_2(t)$. This must hold for all values of a, b and $x_1(t)$, $x_2(t)$; a and b are arbitrary constants.

NOTE 2 In practice, the above test for linearity is impractical and a limited check of linearity is performed 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).

3.12
direct method
method in which either the input displacement, velocity or acceleration and the blocking output force are measured

3.13
indirect method
method in which the vibration transmissibility (for displacement, velocity or acceleration) of a resilient element is measured, with the output loaded by a known mass

NOTE The term “indirect method” can be permitted to include loads of any known impedance other than a mass-like impedance. However, ISO 10846 does not cover such methods.

3.14
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 resilient element blocked

3.15
force level
L_F
level defined by the following formula

$$L_F = 10 \lg \frac{F^2}{F_0^2} \text{ dB}$$

where

F^2 denotes the mean square value of the force in a specific frequency band and F_0 is the reference force ($F_0 = 10^{-6}$ N)

3.16
acceleration level
L_a
level defined by the following formula

$$L_a = 10 \lg \frac{a^2}{a_0^2} \text{ dB}$$

where

a^2 denotes the mean square value of the acceleration in a specific frequency band and a_0 is the reference acceleration (a_0 = 10^{-6} m/s^2)

3.17
level of dynamic transfer stiffness
$L_{k_{2,1}}$
level defined by the following formula

$$L_{k_{2,1}} = 10 \lg \frac{|k_{2,1}|^2}{k_0^2} \text{ dB}$$

where

$|k_{2,1}|^2$ is the square magnitude of the dynamic transfer stiffness (3.5) at a specified frequency and k_0 is the reference stiffness (k_0 = 1 N/m)

3.18
level of frequency-band-averaged dynamic transfer stiffness
$L_{k_{av}}$
level defined by the following formula

$$L_{k_{av}} = 10 \lg \frac{k_{av}^2}{k_0^2} \text{ dB}$$

where

k_{av} is the frequency-averaged dynamic transfer stiffness (3.7) and k_0 is the reference stiffness (k_0 = 1 N/m)

3.19
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 resilient element under test

3.20
upper limiting frequency
f_{UL}
frequency up to which the results are valid, according to the criteria given in this part of ISO 10846

NOTE See 6.1 to 6.4.

4 Principle

The measurement principle of the direct method for measuring the dynamic transfer stiffness (3.5) is discussed in ISO 10846-1. The characteristic feature of this method is that the blocking output force is measured between the output side of the resilient support 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 Requirements for apparatus

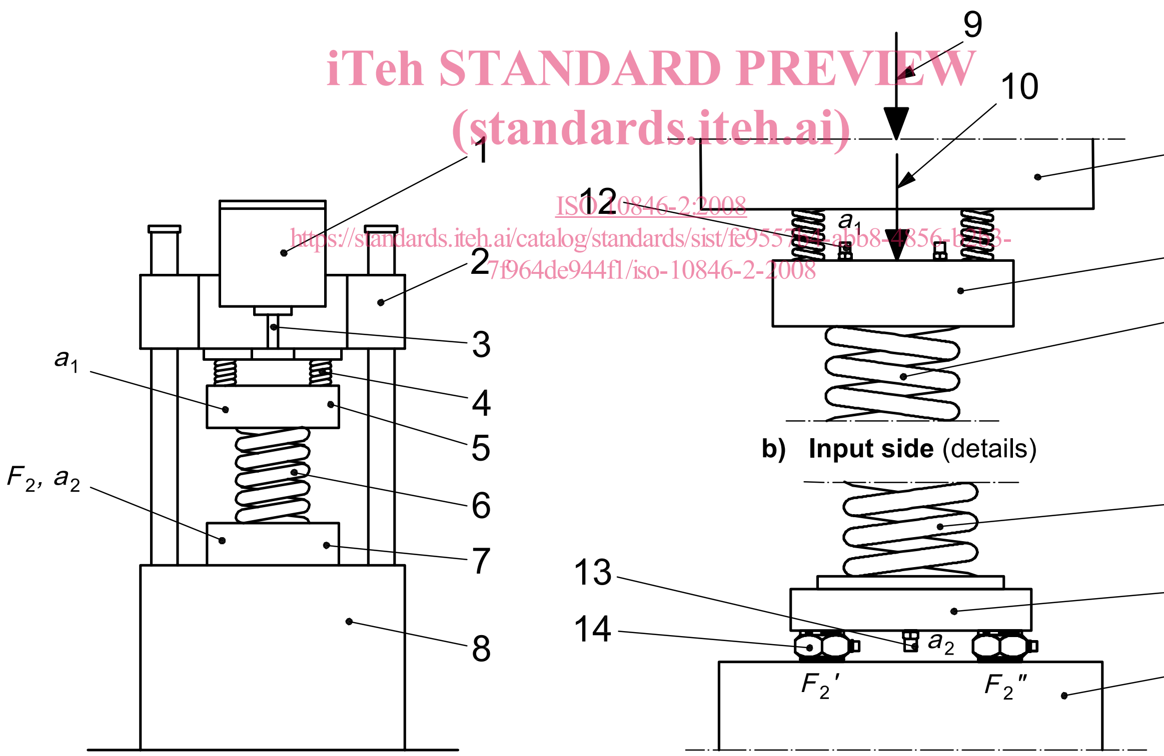
5.1 Normal translations

5.1.1 Overview

A schematic representation of a test rig is shown in Figure 2. The test element is exposed to translatory vibration in the normal load direction. The test element shall be mounted in a way that is representative of its use in practice.

NOTE The test rig example of Figure 2 is not intended to form a limitation for test arrangements.

To be suitable for the measurements according to this part of ISO 10846, a test rig shall include the items described in 5.1.2 to 5.1.7.



a) **Overview** c) **Output side** (details)

Key

1 vibration exciter
2 traverse
3 connection rod
4 dynamic decoupling springs, static preload
5 excitation mass
6 test element
7 output force and acceleration measurement
8 rigid foundation
9 static preload
10 dynamic excitation
11 output-force distribution plate
12 input acceleration measurement (a_1)
13 output acceleration measurement (a_2)
14 normal output-force measurement $\left(F_2 = F_2' + F_2''\right)$

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

