INTERNATIONAL STANDARD

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Mechanical vibration and shock — Experimental determination of mechanical mobility —

Part 2:
Measurements using single-point translation excitation with an attached vibration exciter

Vibrations et chocs — Détermination expérimentale de la mobilité mécanique —

Partie 2: Mesurages avec utilisation d'une excitation de translation en un seul point, au moyen d'un générateur de vibrations solidaire de ce point

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 108, *Mechanical vibration, shock and condition monitoring*.

This second edition cancels and replaces the first edition (ISO 7626-2:1990), which has been technically revised.

ISO 7626 consists of the following parts, under the general title *Mechanical vibration and shock — Experimental determination of mechanical mobility*:

— *Part 1: Basic terms and definitions, and transducer specifications*

— *Part 2: Measurements using single-point translational excitation with an attached vibration exciter*

— *Part 5: Measurements using impact excitation with an exciter which is not attached to the structure*

Introduction

General introduction to the ISO 7626- series **on mobility measurement**

Dynamic characteristics of structures can be determined as a function of frequency from mobility measurements or measurements of the related frequency-response functions, known as accelerance and dynamic compliance. Each of these frequency-response functions is the phasor of the motion response at a point on a structure due to a unit force (or moment) excitation. The magnitude and the phase of these functions are frequency-dependent.

Accelerance and dynamic compliance differ from mobility only in that the motion response is expressed in terms of acceleration and displacement, respectively, instead of in terms of velocity. In order to simplify the various parts of ISO 7626, only the term “mobility” is used. It is understood that all test procedures and requirements described are also applicable to the determination of accelerance and dynamic compliance.

Typical applications for mobility measurements are for:

a) predicting the dynamic response of structures to known or assumed input excitation;

b) determining the modal properties of a structure (natural frequencies, damping ratios and mode shapes);

c) predicting the dynamic interaction of interconnected structures;

d) checking the validity and improving the accuracy of mathematical models of structures;

e) determining dynamic properties (i.e. the complex modulus of elasticity) of materials in pure or composite forms.

For some applications, a complete description of the dynamic characteristics can be required using measurements of translational forces and motions along three mutually perpendicular axes as well as measurements of moments and rotational motions about these three axes. This set of measurements results in a 6 × 6 mobility matrix for each location of interest. For N locations on a structure, the system thus has an overall mobility matrix of size $6N \times 6N$.

For most practical applications, it is not necessary to know the entire $6N \times 6N$ matrix. Often it is sufficient to measure the driving-point mobility and a few transfer mobilities by exciting with a force at a single point in a single direction and measuring the translational response motions at key points on the structure. In other applications, only rotational mobilities might be of interest.

Mechanical mobility is defined as the frequency-response function formed by the ratio of the phasor of the translational or rotational response velocity to the phasor of the applied force or moment excitation. If the response is measured with an accelerometer, conversion to velocity is required to obtain the mobility. Alternatively, the ratio of acceleration to force, known as accelerance, can be used to characterize a structure. In other cases, dynamic compliance, the ratio of displacement to force, can be used.

NOTE Historically, frequency-response functions of structures have often been expressed in terms of the reciprocal of one of the above-named dynamic characteristics. The arithmetic reciprocal of mechanical mobility has often been called mechanical impedance. It should be noted, however, that this is misleading because the arithmetic reciprocal of mobility does not, in general, represent any of the elements of the impedance matrix of a structure. Rather, conversion of mobility to impedance requires an inversion of the full mobility matrix. This point is elaborated upon in ISO 7626-1.

Mobility test data cannot be used directly as part of an impedance model of the structure. In order to achieve compatibility of the data and the model, the impedance matrix of the model is converted to mobility or vice versa (see ISO 7626-1 for limitations).

Introduction to this part of ISO 7626

For many applications of mechanical mobility data, it is sufficient to determine the driving-point mobility and a few transfer mobilities by exciting the structure at a single location in a single direction and measuring the translational response motions at key points on the structure. The translational excitation force can be applied either by vibration exciters attached to the structure under test or by devices that are not attached.

Categorization of excitation devices as “attached” or “unattached” has significance in terms of the ease of moving the excitation point to a new position. It is much easier, for example, to change the location of an impulse applied by an instrumented hammer than it is to relocate an attached vibration exciter to a new point on the structure. Both methods of excitation have applications to which they are best suited. This part of ISO 7626 deals with measurements using a single attached exciter; measurements made by impact excitation without the use of attached exciters are covered by ISO 7626-5.

Mechanical vibration and shock — Experimental determination of mechanical mobility —

Part 2: Measurements using single-point translation excitation with an attached vibration exciter

1 Scope

This part of ISO 7626 specifies procedures for measuring linear mechanical mobility and other frequency-response functions of structures, such as buildings, machines and vehicles, using a single-point translational vibration exciter attached to the structure under test for the duration of the measurement.

It is applicable to measurements of mobility, accelerance, or dynamic compliance, either as a driving-point measurement or as a transfer measurement. It also applies to the determination of the arithmetic reciprocals of those ratios, such as free effective mass. Although excitation is applied at a single point, there is no limit on the number of points at which simultaneous measurements of the motion response may be made. Multiple-response measurements are required, for example, for modal analyses.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2041, *Mechanical vibration, shock and condition monitoring — Vocabulary*

ISO 7626-1, *Mechanical vibration and shock — Experimental determination of mechanical mobility — Part 1: Basic terms and definitions, and transducer specifications*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7626-1 and ISO 2041 and the following apply.

Note As this part of ISO 7626 deals with mechanical mobility, the notes to the definitions below provide more detail than is given in ISO 2041.

3.1
frequency-response function
frequency dependent ratio of complex motion response to complex excitation force for a linear system

Note 1 to entry: Excitation may be harmonic, random or transient functions of time. The frequency-response function does not depend on the type of excitation function if the tested structure can be considered a linear system in a certain range of the excitation or response. In such a case, the test results obtained with one type of excitation may be used for estimating the response of the system to any other type of excitation. Phasors and their equivalents for random and transient excitation are discussed in Annex B.

Note 2 to entry: Linearity of the system is a condition which, in practice, is met only approximately, depending on the type of system and on the magnitude of the input. Care has to be taken to avoid nonlinear effects, particularly when applying impulse excitation. Structures which are known to be nonlinear (e.g. structures with fluid elements) should not be tested with impulse excitation and great care is required when using random excitation for testing of such structures.

Note 3 to entry: Motion may be expressed in terms of velocity, acceleration or displacement; the corresponding frequency response function designations are mobility, accelerance and dynamic compliance, respectively. In some publications, these quantities are alternately referred to (in whole or in part) as mechanical admittance, inertance and receptance, respectively. These alternate terms are avoided herein, and are provided only for reference.

[SOURCE: ISO 2041:2009, 1.53, modified]

3.2
mobility
mechanical mobility
complex ratio of the velocity, taken at a point in a mechanical system, to the excitation force, taken at the same or other point in the system

Note 1 to entry: Mobility is the ratio of the complex velocity-response at point *i* to the complex excitation force at point *j* with all other measurement points on the structure allowed to respond freely without any constraints other than those constraints which represent the normal support of the structure in its intended application.

Note 2 to entry: The term “point”, as used here, designates both a location and a direction. The terms “coordinate” and “degree-of-freedom” have also been used with the same meaning as “point”.

Note 3 to entry: The velocity response can be either translational or rotational, and the excitation force can be either a rectilinear force or a moment.

Note 4 to entry: If the velocity response measured is a translational one and if the excitation force applied is a rectilinear one, the units of the mobility term are m/(N · s) in the SI system.

Note 5 to entry: Mechanical mobility is an element of the inverse of mechanical impedance matrix.

[SOURCE: ISO 2041:2009, 1.54, modified]

3.3
driving-point mobility
Y_{jj}
frequency-response function formed by the complex velocity-response at point *j* to the complex excitation force applied at the same point with all other measurement points on the structure allowed to respond freely without any constraint other than those constraints which represent the normal support of the structure in its intended application

[SOURCE: ISO 2041:2009, Note to 1.55, modified]

3.4
transfer mobility
Y_{ij}
frequency-response function formed by the complex velocity-response at point *i* to the complex excitation force applied at point *j* with all points on the structure, other than *j*, allowed to respond freely without any constraint other than those constraints which represent the normal support of the structure in its intended application

[SOURCE: ISO 2041:2009, 1.56, modified]

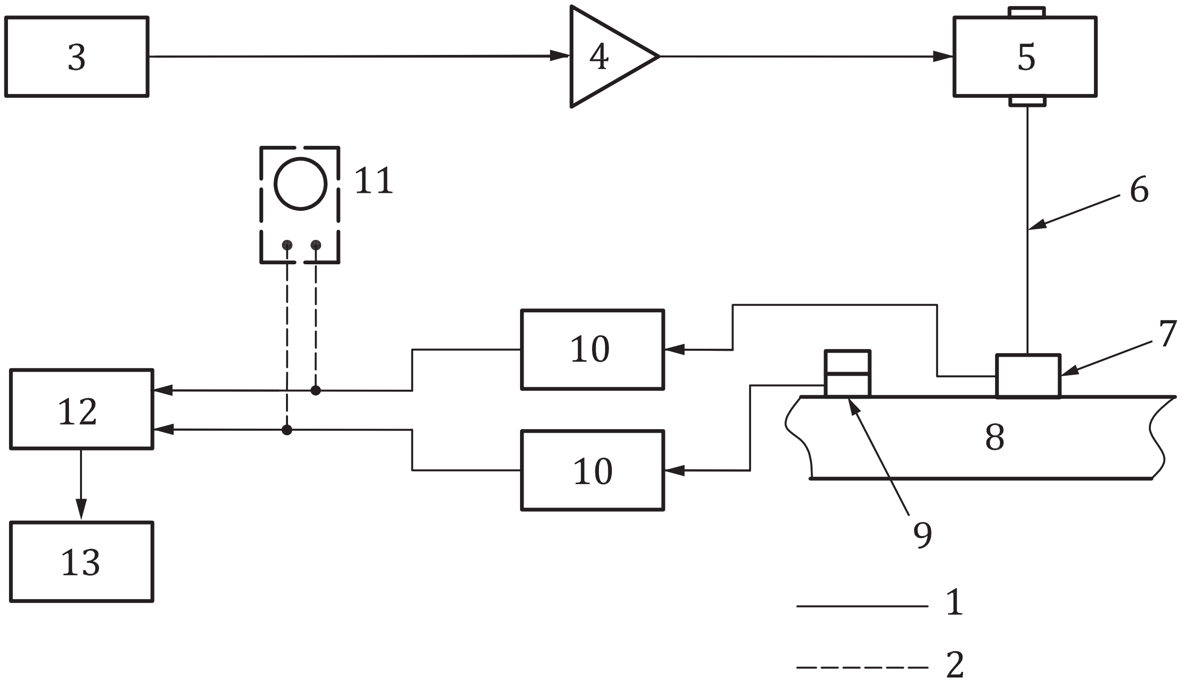
3.5
frequency range of interest
span between the lowest frequency to the highest frequency at which mobility data are to be obtained in a given test series

[SOURCE: ISO 7626-1:2011, 3.1.5, modified]

4 Overall configuration of the measurement system

Individual components of the system used for mobility measurements carried out in accordance with this part of ISO 7626 shall be selected to suit each particular application.

However, all such systems should include certain basic components arranged as shown in Figure 1. Requirements for the characteristics and usage of those components are given in the relevant clauses.



Key

1	basic feature	8	structure under test
2	optional feature	9	motion response transducer(s)
3	signal generator	10	signal conditioners
4	power amplifier	11	monitoring oscilloscope
5	vibration exciter	12	analyser
6	drive rod	13	plotter or other output device
7	force transducer		

Figure 1 — Block diagram of mobility measurement system

5 Support of the structure under test

5.1 General

Mobility measurements are performed on structures either in an ungrounded condition (freely suspended) or in a grounded condition (attached to one or more supports), depending on the purpose of the test. The restraints on the structure induced by the application of the vibration exciter are dealt with in 6.4.

5.2 Grounded measurements

The support of the test structure shall be representative of its support in typical applications unless it has been specified otherwise. A description of the support should be included in the test report.

5.3 Ungrounded measurements

A compliant suspension of the test structure shall be used. The magnitude of driving-point mobility of the suspension at each point of attachment to the structure under test should be at least 10 times greater than that of the structure at the same attachment point, within the frequency range of interest. Details of the suspension system used shall be included in the test report.

In the absence of quantitative information, design of the suspension is largely a matter of judgment depending on the frequency range of interest. As a minimum requirement, all resonance frequencies of the rigid-body modes of the suspended structure shall be less than half the lowest frequency of interest.

Items commonly used to provide compliant suspension include shock cords and resilient pads of material such as foam and rubber. Since some suspension systems have mass but little damping, care shall be taken to ensure that the frequencies of the suspension resonances are well away from the modal frequencies of the test structure itself. The masses of any suspension components, such as hooks and turnbuckles, located close to the structure under test shall also be less than one-tenth of the free effective mass of the structure at each frequency of interest.

Preliminary testing should be performed to identify locations for the attachment of the suspension with the minimum possible effect on the intended measurements. Suspension near nodal points of the structure under test will minimize the interaction of the suspension system with the structure. Suspension cables should run normal to the direction of excitation, if practical, and even in this case, transverse string vibrations of suspension cables can affect the data.

CAUTION — Attention should also be paid to any added damping of the structure due to the suspension system.

6 Excitation

6.1 General

The selection of appropriate excitation depends on the particulars of the measurement application. Factors to consider when selecting the appropriate excitation include the frequency-response and amplitude characteristics of the exciter to be used, desired signal-to-noise ratio, available test time, and the capabilities of the available analyser and signal-generation equipment. Prior to the advent of modern Fast Fourier Transform (FFT) analysers, the most common waveforms were sinusoidal. This allowed determination of a response at a single frequency, requiring a process of stepping through the frequency range of interest one frequency at a time. With modern FFT analysers, more complex waveforms can be used to excite wider frequency bands to produce frequency response functions via Fourier processing methods. Features of various types of waveforms and exciters are provided in 6.2 and 6.3.

6.2 Excitation waveforms

6.2.1 General

Applicable excitation waveforms include, but are not limited to, those described in 6.2.2 to 6.2.5. This part of ISO 7626 reflects technology in wide use during its drafting and is not inclusive of all possible waveforms that may be used. Comparative advantages and disadvantages of the different types of waveforms and structures are discussed in Reference [4].

6.2.2 Discretely dwelled sinusoidal excitation

The excitation for a given measurement consists of a set of individual discrete-frequency sinusoidal signals, applied sequentially. The frequencies of the signals are incrementally spaced over the frequency range of interest; requirements for selecting the frequency increment are given in 9.2.2. At each frequency, the excitation is applied over a small interval of time. The length of the time interval shall be sufficiently long to achieve steady-state response of those natural vibration modes of the structure that are excited at the particular frequency and to achieve proper processing of the signal.

