# INTERNATIONAL STANDARD

# ISO 7626-1

Second edition
2011-07-15

# Mechanical vibration and shock — Experimental determination of mechanical mobility —

## Part 1:
## Basic terms and definitions, and transducer specifications



*Vibrations et chocs mécaniques — Détermination expérimentale de la mobilité mécanique —*

*Partie 1: Termes et définitions fondamentaux et spécification des transducteurs*



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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 7626-1 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration, shock and condition monitoring*.



This second edition cancels and replaces the first edition (ISO 7626-1:1986), 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 translation excitation with an attached vibration exciter*

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

# Mechanical vibration and shock — Experimental determination of mechanical mobility —

# Part 1: Basic terms and definitions, and transducer specifications

## 1 Scope

This part of ISO 7626 defines basic terms and specifies the calibration tests, environmental tests and physical measurements necessary to determine the suitability of impedance heads, force transducers and motion response transducers for use in measuring mechanical mobility. Primarily, it provides guidelines for the selection, calibration and evaluation of the transducers and instruments for their suitability in making mobility measurements. Procedures for carrying out mobility measurements in various circumstances are dealt with in subsequent parts of this International Standard.

This part of ISO 7626 is limited to information which is basic to various types of driving-point and transfer mobility, accelerance and dynamic compliance measurements. Measurements of the blocked impedance are not dealt with.



## 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 2041:2009, *Mechanical vibration,shock and condition monitoring — Vocabulary*

ISO 5347 (all parts), *Methods for the calibration of vibration and shock pick-ups*

ISO 16063 (all parts), *Methods for the calibration of vibration and shock transducers*

IEC 60263, *Scales and sizes for plotting frequency characteristics and polar diagrams*

## 3 Terms, definitions, and symbols

### 3.1 Terms and definitions

For the purpose of this document, the terms and definitions given in 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.

**3.1.1**
**frequency-response function**
frequency-dependent ratio of the motion-response Fourier transform to the Fourier transform of the excitation force of a linear system

NOTE 1 Excitation can 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 as 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 can 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 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 non-linear effects, particularly when applying impulse excitation. Structures which are known to be non-linear (e.g. certain riveted structures) should not be tested with impulse excitation and great care is required when using random excitation for testing such structures.

NOTE 3 Motion may be expressed in terms of velocity, acceleration or displacement; the corresponding frequency-response function designations are mobility (sometimes called mechanical admittance), accelerance (sometimes unfortunately called inertance; this term should be avoided because it is in conflict with the common definition of acoustic inertance and also contrary to the implication carried by the term inertance) and dynamic compliance (sometimes called receptance), respectively. These are summarized in Table 1. 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. Typical magnitude graphs for accelerance and for dynamic compliance, corresponding to the mobility graph shown in Figure 1, are shown in Figures 2 and 3, respectively.



NOTE 4 Frequency response functions can be further differentiated as

a) *driving point response function*, where the excitation and response are measured at the same location for the evaluation of the frequency-response function, e.g. the use of an impedance head for the measurements ($i = j$ in the formulae in Table 1);

b) *transfer response function*, where the excitation and response are not measured at the same location for the evaluation of the frequency-response function ($i \neq j$ in the formulae in Table 1).

NOTE 5 Adapted from ISO 2041:2009, 1.53.

**3.1.2**
**mobility**
**mechanical mobility**
$Y_{ij}$
complex ratio of the velocity, taken at point $i$ in the mechanical system, to the excitation force, taken at the same or another point in the system

NOTE 1 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 The term “point” designates both a location and a direction.

NOTE 3 The velocity response can be either translational or rotational, and the excitation force can be either a rectilinear force or a moment.

 

NOTE 4 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. A typical graph is shown in Figure 1.

NOTE 5 Mechanical mobility is the matrix inverse of mechanical impedance.

NOTE 6 Adapted from ISO 2041:2009, 1.54.

**3.1.3**
**blocked impedance**
$Z_{ij}$
impedance at the input when all output degrees of freedom are connected to a load of infinite mechanical impedance

NOTE 1 Blocked impedance is the frequency-response function formed by the complex ratio of the blocking or driving-point force response at point $i$ to the applied excitation velocity at point $j$, with all other measurement points on the structure blocked, i.e. constrained to have zero velocity.

NOTE 2 All forces and moments necessary to constrain fully all points of interest on the structure need to be measured in order to obtain a valid blocked impedance matrix. Blocked impedance measurements (see Reference [16]) are, therefore, seldom made and are not dealt with in the various parts of this International Standard.

NOTE 3 Any change in the number of measurement points or their location changes the blocked impedances at all measurement points.

NOTE 4 The primary usefulness of blocked impedance is in the mathematical modelling of a structure using lumped mass, stiffness and damping elements or finite element techniques. When combining or comparing such mathematical models with experimental mobility data, it is necessary to convert the analytical blocked impedance matrix into a mobility matrix, or vice versa, as discussed in Annex A.



NOTE 5 Adapted from ISO 2041:2009, 1.52.



**3.1.4**
**free impedance**
$Z$
ratio of the applied excitation complex force to the resulting complex velocity with all other connection points of the system free, i.e. having zero restraining forces

NOTE 1 Historically, often no distinction has been made between blocked impedance and free impedance. Caution should, therefore, be exercised in interpreting published data.

NOTE 2 Free impedance is the arithmetic reciprocal of a single element of the mobility matrix. While experimentally determined free impedances could be assembled into a matrix, this matrix would be quite different from the blocked impedance matrix resulting from mathematical modelling of the structure and, therefore, would not conform to the requirements for using mechanical impedance in an overall theoretical analysis of the system.

NOTE 3 Adapted from ISO 2041:2009, 1.51.

**3.1.5**
**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

**Table 1 — Equivalent definitions to be used for various kinds of frequency-response functions related to mechanical mobility**

| | Motion expressed as velocity | Motion expressed as acceleration | Motion expressed as displacement |
|---|---|---|---|
| **Term** | Mobility[a] | Accelerance[b] | Dynamic compliance[c] |
| **Symbol** | $Y_{ij} = v_i/F_j$ | $a_i/F_j$ | $x_i/F_j$ |
| **Unit** | m/(N·s) | $\text{m/(N·s}^2) = \text{kg}^{-1}$ | m/N |
| **Boundary conditions** | $F_k = 0;\ k \neq j$ | $F_k = 0;\ k \neq j$ | $F_k = 0;\ k \neq j$ |
| **See** | Figure 1 | Figure 2 | Figure 3 |
| **Comment** | Boundary conditions are easy to achieve experimentally. | | |
| **Term** | Blocked impedance | Blocked effective mass | Dynamic stiffness |
| **Symbol** | $Z_{ij} = F_i/v_j$ | $F_i/a_j$ | $F_i/x_j$ |
| **Unit** | N·s/m | $\text{N·s}^2\text{/m} = \text{kg}$ | N/m |
| **Boundary conditions** | $v_k = 0;\ k \neq j$ | $a_k = 0;\ k \neq j$ | $x_k = 0;\ k \neq j$ |
| **Comment** | Boundary conditions are very difficult or impossible to achieve experimentally (see also A.2). | | |
| **Term** | Free impedance | Effective mass (free effective mass) | Free dynamic stiffness |
| **Symbol** | $F_j/v_i = 1/Y_{ij}$ | $F_j/a_i$ | $F_j/x_i$ |
| **Unit** | N·s/m | $\text{N·s}^2\text{/m} = \text{kg}$ | N/m |
| **Boundary conditions** | $F_k = 0;\ k \neq j$ | $F_k = 0;\ k \neq j$ | $F_k = 0;\ k \neq j$ |
| **Comment** | Boundary conditions are easy to achieve, but results shall be used with great caution in system modelling. | | |

[a] Mobility is sometimes called mechanical admittance.

[b] Accelerance is unfortunately sometimes called inertance. Inertance is not acceptable because it is in conflict with the common definition of acoustic inertance and also contrary to the implication carried by the word inertance.

[c] Dynamic compliance is also called receptance.

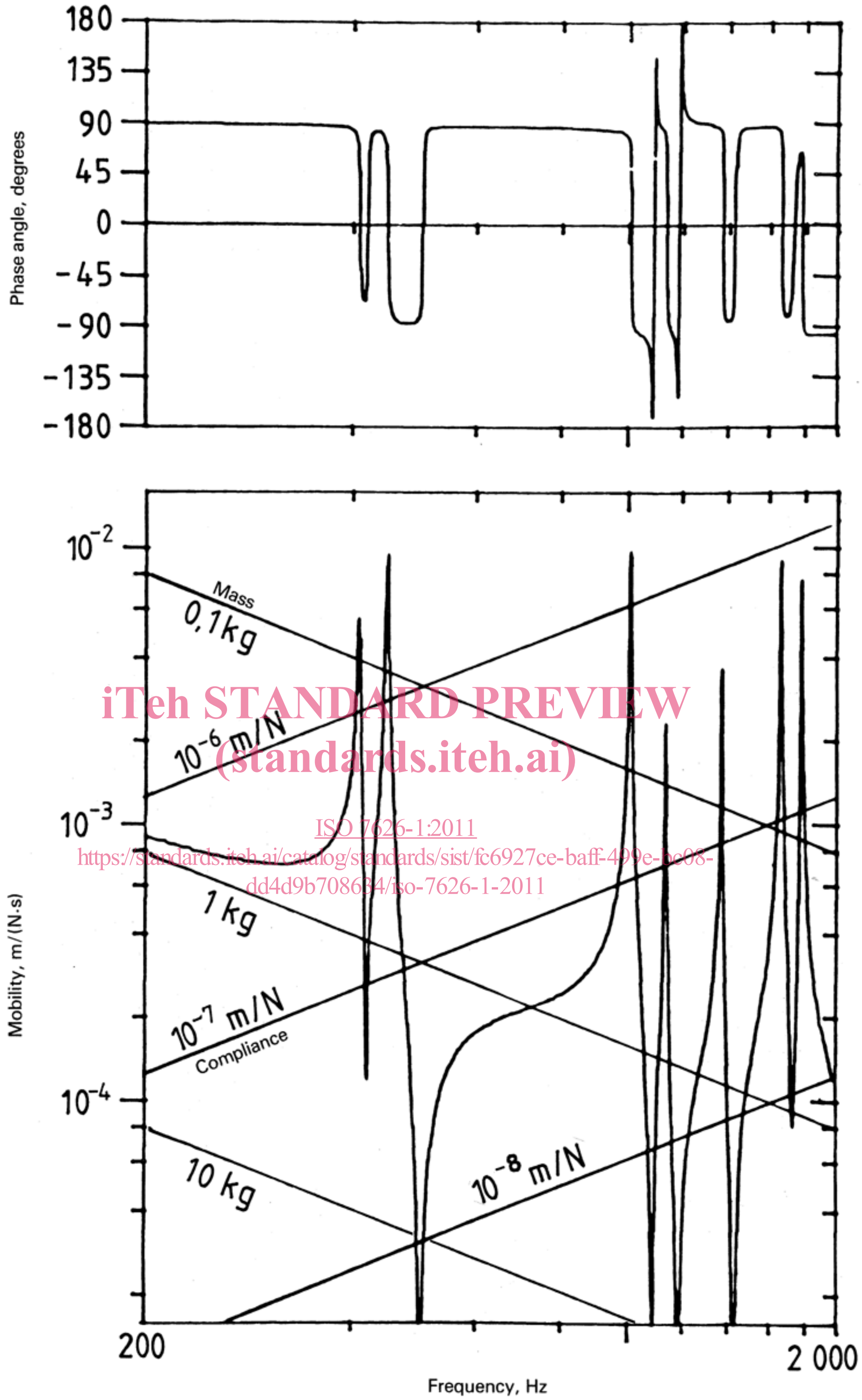




**Figure 1 — Typical graph of plotted mobility test results**

 

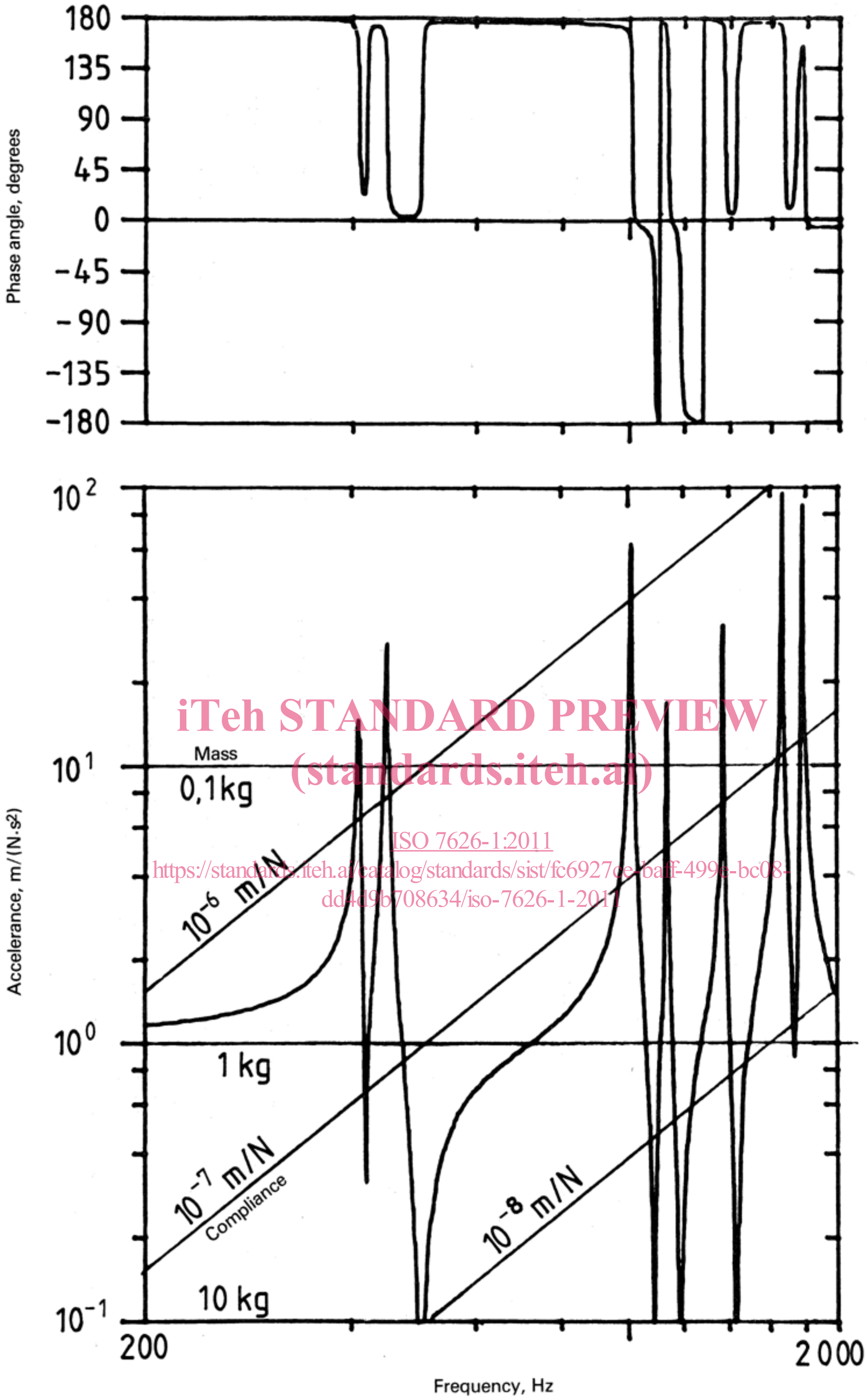




**Figure 2 — Accelerance graph corresponding to the mobility graph plotted in Figure 1**

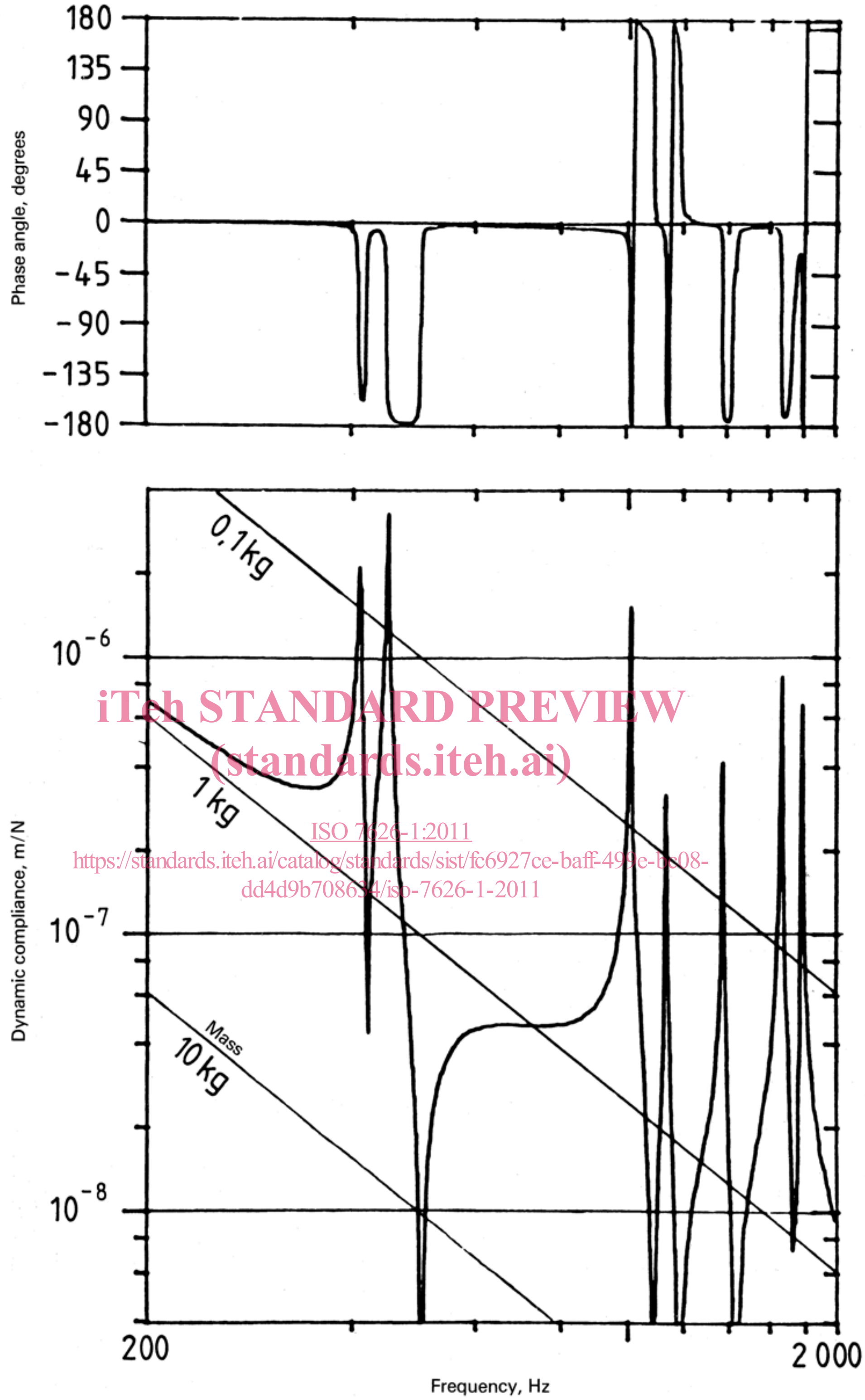




**Figure 3 — Dynamic compliance graph corresponding to the mobility graph plotted in Figure 1**

## 3.2 Symbols

| Symbol | Quantity | SI unit |
|---|---|---|
| $a$ | acceleration | m/s$^2$ |
| $a_i/F_j$ | accelerance | m/(N·s$^2$) |
| $U$ | transducer output | V |
| $f$ | frequency | Hz |
| $F$ | force | N |
| $k$ | stiffness | N/m |
| $m$ | mass | kg |
| $S$ | sensitivity | V/(unit of input variable) |
| $v$ | velocity | m/s |
| $x$ | displacement | m |
| $x_i/F_j$ | dynamic compliance | m/N |
| $Y_{ij}$ | mobility | m/(N·s) |
| $Z$ | free impedance | N·s/m |
| $Z_{ij}$ | blocked impedance | N·s/m |



# 4 Fundamentals and general relationships

Dynamic characteristics of structures can be determined as a function of frequency from mobility measurements or measurements of related frequency-response functions like accelerance and dynamic compliance (see Table 1). Accelerance and dynamic compliance differ from mobility (see 3.1.2) only in that the motion response is expressed in terms of acceleration or displacement, respectively, instead of in terms of velocity. In order to simplify the various parts of this International Standard, mostly only the term mobility is used. All test procedures and requirements specified in this International Standard 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, mode shapes and damping ratios);

c) predicting the dynamic interaction of interconnected structures;

d) checking the validity and improving the accuracy of mathematical models and 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 may 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 $6 \times 6$ mobility matrix for each location of interest. For $N$ locations on a structure, the system thus has an overall mobility matrix of size $6N \times 6N$.