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**Akustika - Opredelitev virov zvoka in vibracij, ki jih prenaša konstrukcija -  
Posredno merjenje blokiranih sil (ISO 20270:2019)**

Acoustics - Characterization of sources of structure-borne sound and vibration - Indirect measurement of blocked forces (ISO 20270:2019)

Akustik - Charakterisierung von Körperschall- und Schwingungsquellen - Indirekte Messung von blockierten Kräften (ISO 20270:2019)

Acoustique - Caractérisation des sources de bruit solide et de vibrations - Mesurage indirect des forces bloquées (ISO 20270:2019)

**Ta slovenski standard je istoveten z: prEN ISO 20270**

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**ICS:**

17.140.20	Emisija hrupa naprav in opreme	Noise emitted by machines and equipment
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# INTERNATIONAL STANDARD

**ISO  
20270**

First edition  
2019-11

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## **Acoustics — Characterization of sources of structure-borne sound and vibration — Indirect measurement of blocked forces**

*Acoustique — Caractérisation des sources de bruit solide et de  
vibrations — Mesurage indirect des forces bloquées*

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## ISO 20270:2019(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.

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](http://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](http://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 of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

This document has been developed in response to demand from mechanical industries for an agreed method of specifying the "source strength" of sources of structure-borne sound and vibration. Quantities which independently characterize a source are the free velocity and blocked force: ISO 9611<sup>[2]</sup> specifies a measurement procedure for the former in which the machine, a vibration source, is mounted on soft mounts to approximate free suspension. The blocked forces are the forces the operating machine would exert when constrained by a perfectly rigid foundation. They can potentially be measured directly by inserting force transducers in between the operating machine and a rigid foundation. However, this document describes an indirect method for measurement of blocked forces using an inverse method. Whereas the measurement of free velocity requires the source to be resiliently mounted and direct measurement of blocked forces requires the machine mounts to be blocked, the indirect measurement, as defined in this document, can theoretically be carried out with the source attached to any receiver structure. Essentially the same measurement techniques are used in the diagnosis of structure-borne sound using "transfer path analysis" (TPA), also called "source path contribution" analysis (SPC).

A method of characterizing sources of structure-borne sound and vibration by the indirect measurement of blocked forces at the points of connection to supporting, or receiver, structures is described in this document. The measurement method is applied in situ, which means that the source is connected to a receiver structure while the measurements are performed. In theory, the use of any receiver structure is valid provided the vibration source mechanisms of the specimen remain representative of those in a real installation. Therefore, the receiver structure can be part of a real installation, such as a machine foundation or a building, but can also be a specially designed test stand if it provides representative dynamic loading for the source.

The method specifies a two-stage measurement procedure comprising, first, a passive test in which frequency response functions (FRF) of the assembled source-receiver structure are measured, and secondly, measurement of vibration in an operational test. The blocked forces are obtained by solving the inverse problem. It is well known that inverse solutions of this type can result in very large errors, particularly if there is inconsistency in the input data. Such errors vary significantly depending on the case and the skill of the operator. Therefore, a means of estimating the uncertainties in the blocked force, through a process called on-board validation, forms an essential part of this measurement procedure.

The blocked forces are obtained in narrow frequency bands that can subsequently be converted to approximate octave or third octave frequency bands.

The in situ blocked force method is intended to complement the reception plate method of EN 15657<sup>[3]</sup>. The reception plate method offers a simplified approach in which forces and velocities are effectively averaged over the feet of an operating machine by mounting on a standard plate. The approximations allow measurements to be simplified but information about distribution and phase of the forces and velocities is lost. This document aims to provide an alternative for structure borne sound sources not compatible with the reception plate approach or where more detail is needed about the distribution of the forces.

The blocked forces obtained from this document can be used for the following purposes:

- a) obtaining data for preparing technical specifications for vibrationally active components (sources);
- b) obtaining input data for prediction of vibration in, or sound radiated sound from, structures connected to the source;
- c) obtaining diagnostic information about the contribution of particular blocked forces to a target vibration or sound pressure (in situ transfer path analysis).

Prediction of sound and vibration in a new assembly [as in b) above] does not form a normative part of this document, although guidelines for prediction are provided in [Annex E](#). For prediction purposes, extra data are needed in addition to the measured blocked forces. Specifically, the frequency response functions (FRFs) of the new assembly (which consists of the source connected to the new receiver

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structure) need to be known. These FRFs can in principle be measured (if the assembly is available for measurement), calculated (for example using numerical methods) or calculated by combining the FRFs of the separate source and the receiver structures (dynamic substructuring) whether measured or calculated.

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# Acoustics — Characterization of sources of structure-borne sound and vibration — Indirect measurement of blocked forces

**IMPORTANT** — The electronic file of this document contains colours which are considered to be useful for the correct understanding of the document. Users should therefore consider printing this document using a colour printer.

## 1 Scope

This document specifies a method where a vibrating component (a source of structure-borne sound or vibration) is attached to a passive structure (or receiver) and is the cause of vibration in, or structure-borne sound radiation from, the assembly. Examples are pumps installed in ships, servo motors in vehicles or machines and plant in buildings. Almost any vibrating component can be considered as a source in this context.

Due to the need to measure vibration at all contact degrees of freedom (DOFs) (connections between the source and receiver), this document can only be applied to assemblies for which such measurement is possible.

This document is applicable only to assemblies whose frequency response functions (FRFs) are linear and time invariant.

The source can be installed into a real assembly or attached to a specially designed test stand (as described in 5.2).

The standard method has been validated for stationary signals such that the results can be presented in the frequency domain. However, the method is not restricted to stationary signals: with appropriate data processing, it is also applicable to time-varying signals such as transients and shocks (provided linearity and time invariance of the FRFs are preserved).

This document provides a method for measurement and presentation of blocked forces, together with guidelines for minimizing uncertainty. It provides a method evaluating the quality of the results through an on-board validation procedure but does not comment on the acceptability or otherwise of the results.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 7626-1, *Mechanical vibration and shock — Experimental determination of mechanical mobility — Part 1: Basic terms and definitions, and transducer specifications*

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

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

## 3.1

**blocked force**

dynamic force applied by an operational *source* (3.4) to a perfectly rigid *receiver* (3.5) structure

## 3.2

**frequency response function****FRF**

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

Note 1 to entry: Excitation can be harmonic, random or transient functions of time. The test results obtained with one type of excitation can thus be used for predicting the response of the system to any other type of excitation.

Note 2 to entry: Motion may be expressed in terms of velocity, acceleration or displacement; the corresponding frequency-response function designations are mobility, acceleration and dynamic compliance or impedance, effective (i.e. apparent) mass and dynamic stiffness, respectively.

[SOURCE: ISO 2041:2018, 3.1.53]

## 3.3

**in situ blocked force vector**

$\bar{\mathbf{f}}_c(f)$

complex *blocked force* (3.1) at the *contact degrees of freedom (DOFs)* (3.8), arranged into an  $n \times 1$  vector at each frequency according to:

$$\bar{\mathbf{f}}_c(f) = \begin{bmatrix} \bar{f}_{c,1}(f) \\ \bar{f}_{c,2}(f) \\ \vdots \\ \bar{f}_{c,n}(f) \end{bmatrix}$$

where  $\bar{f}_{c,i}(f)$  is the complex Fourier spectrum component of the blocked force at frequency  $f$  and at contact degree of freedom (DOF)  $i$

Note 1 to entry: Forces can be considered as generalized forces, that is, including rotational components like moments.

## 3.4

**source**

active substructure which contains the mechanisms of structure-borne sound or vibration generation and comprises all parts of the *assembly* (3.6) on the active side of the *source-receiver interface* (3.7)

Note 1 to entry: Typically, the source is a separable component although this is not a requirement for the method.

Note 2 to entry: See [Figure 1](#).

## 3.5

**receiver**

passive substructure comprising all parts of the *assembly* (3.6) on the passive side of the *source-receiver interface* (3.7)

Note 1 to entry: The receiver may comprise the remaining parts of an assembled machine other than the source, a test bench or a foundation structure such as a building.

Note 2 to entry: By definition, there are no source mechanisms within the receiver so it is a purely passive structure.

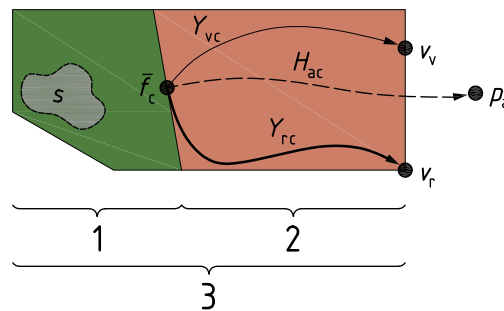
Note 3 to entry: See [Figure 1](#).

### 3.6

#### assembly

installation comprising the *source* (3.4) and *receiver* (3.5) connected together

Note 1 to entry: See [Figure 1](#).



#### Key

- 1 source (active structure)
- 2 receiver (passive structure)
- 3 assembly
- s internal source excitation (not accessible)

- $\bar{f}_c$  in situ blocked force vector at the set of contact DOFs,  $c$
- $v_v$  validation velocity (or acceleration) vector at the set of validation DOFs,  $v$
- $v_r$  indicator velocity (or acceleration) vector at the set of validation DOFs,  $r$
- $Y_{vc}$  typical structural FRF between validation DOFs,  $v$ , and contact DOFs,  $c$
- $Y_{rc}$  typical structural FRF between indicator DOFs,  $r$ , and contact DOFs,  $c$
- $H_{ac}$  typical vibro-acoustic FRF between prediction DOFs,  $a$ , and contact DOFs,  $c$  (see NOTE 3)
- $p_a$  structure-borne sound predicted at DOFs,  $a$ , in the fluid around the receiver (see NOTE 3)

NOTE 1 Indicator DOFs can be located anywhere on the receiver, including the source-receiver interface.

NOTE 2 The obtained blocked force vector can be used to predict vibration in, and radiated sound from, the receiver structure (see [Annex E](#)).

NOTE 3 A vibration source (1) connected to a passive receiver (2) causes vibration ( $v_r$ ) in, or structure-borne sound ( $p_a$ ) radiated from, the assembly (3) at interfaces ( $r$ ,  $v$ ) and ( $a$ ), respectively. The internal excitation,  $s$ , is unknown, requiring the source to be characterized at the source-receiver interface by blocked forces  $\bar{f}_c$ , inferred from  $v_r$  and the assembly FRF matrix  $Y_{rc}$ . Additional structural,  $Y_{vc}$ , and vibro-acoustic FRFs,  $H_{ac}$ , can be used for validation and prediction purposes.

**Figure 1 — Test assembly**

### 3.7

#### source-receiver interface

hypothetical surface which separates the *source* (3.4) structure from the *receiver* (3.5) structure

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## 3.8

**contact degrees of freedom****contact DOFs**

DOFs located on the source receiver interface through which structure-borne sound or vibration is transmitted from the *source* (3.4) to the *receiver* (3.5) structure

Note 1 to entry:  $n$  is the number of DOFs and  $c$  is the subscript used for contact DOFs.

Note 2 to entry: See 4.3 for a full definition.

## 3.9

**indicator degrees of freedom****indicator DOFs**

DOFs on the *receiver* (3.5) at which vibration responses are measured

Note 1 to entry:  $m$  is the number of DOFs and  $r$  is the subscript used for indicator DOFs.

Note 2 to entry: See 4.4.

## 3.10

**validation degrees of freedom****validation DOFs**

DOFs on the *receiver* (3.5) structure (not at the contact area) at which "spare" vibration responses are measured so as to provide a comparison for the on-board validation

Note 1 to entry:  $p$  is the number of DOFs and  $v$  is the subscript used for validation DOFs.

Note 2 to entry: See 4.5.

Note 3 to entry: The validation is described in [Clause 9](#).

## 3.11

**indicator velocity vector**

$\mathbf{v}_r(f)$

complex velocity (or acceleration) at the *indicator DOFs* (3.9), arranged into an  $m \times 1$  vector at each frequency according to:

$$\mathbf{v}_r(f) = \begin{Bmatrix} v_{r,1}(f) \\ v_{r,2}(f) \\ \vdots \\ v_{r,m}(f) \end{Bmatrix}$$

where  $v_{r,j}(f)$  is the complex Fourier spectrum component of the velocity (or acceleration) at frequency  $f$  and at indicator DOFs  $j$

Note 1 to entry: Consistent quantities shall be used throughout: either velocity and mobility, or acceleration and accelerance.

## 3.12

**measured validation velocity vector**

$\mathbf{v}_v(f)$

complex velocity (or acceleration) at the *validation DOFs* (3.10), arranged into a  $p \times 1$  vector at each frequency according to:

$$\mathbf{v}_v(f) = \begin{Bmatrix} v_{v,1}(f) \\ v_{v,2}(f) \\ \vdots \\ v_{v,p}(f) \end{Bmatrix}$$

where  $v_{v,k}(f)$  is the complex Fourier spectrum component of the velocity (or acceleration) at frequency  $f$  and at indicator degree of freedom  $k$

### 3.13

#### **predicted validation velocity vector**

$\mathbf{v}_v'(f)$

complex velocity (or acceleration) vector which has the same form as the *measured validation velocity vector* (3.12) but contains predicted rather than measured data

Note 1 to entry: It is calculated according to [Clause 8](#).

### 3.14

#### **operational test**

test in which vibration responses are measured at the *indicator* (3.9) and *validation DOFs* (3.10) while the *source* (3.4) is in operation under a given set of *operational conditions* (3.16)

### 3.15

#### **operational test using artificial excitation**

test in which vibration responses are measured at the *indicator* (3.9) and *validation DOFs* (3.10) in the same way as for an *operational test* (3.16) except that the *source* (3.4) is switched off and excitation is provided by an instrumented hammer or shaker

### 3.16

#### **operational conditions**

defined set of circumstances under which the *source* (3.4) operates for the *operational test* (3.14), including speed, load and any other settings or conditions particular to the source which can affect source operation

### 3.17

#### **artificial excitation**

set of circumstances similar to *operational conditions* (3.16) except that the *source* (3.4) is switched off and the source structure is excited artificially by a controlled force from an instrumented hammer or shaker

### 3.18

#### **background noise conditions**

conditions similar to *operational conditions* (3.16) except that the *source* (3.4) is switched off while any other auxiliary equipment required to operate or load the source, e.g. hydraulic pumps, generators or actuators, and/or other secondary sources of noise, e.g. wind noise, are active

### 3.19

#### **on-board validation**

procedure used for determining the quality of the *blocked force* (3.1) data

Note 1 to entry: The on-board validation is described in [Clause 9](#).

### 3.20

#### **frequency response function test**

##### **FRF test**

test in which the response to a unit point force (mechanical mobility or accelerance) matrix is measured with the *source* (3.4) switched off, i.e. under passive conditions