

---

---

**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*



This document is a preview generated by ERS



**COPYRIGHT PROTECTED DOCUMENT**

© ISO 2019

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Fax: +41 22 749 09 47  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

Published in Switzerland

# Contents

Page

<b>Foreword</b>	<b>iv</b>
<b>Introduction</b>	<b>v</b>
<b>1 Scope</b>	<b>1</b>
<b>2 Normative references</b>	<b>1</b>
<b>3 Terms and definitions</b>	<b>1</b>
<b>4 Selection of degrees of freedom (DOFs)</b>	<b>6</b>
4.1 General	6
4.2 Source receiver interface	7
4.3 Contact DOFs	7
4.4 Indicator DOFs	8
4.4.1 General	8
4.4.2 All indicator DOFs at contact area	8
4.4.3 No indicator DOF at contact area	8
4.4.4 Some indicator DOFs at contact area	8
4.5 Validation DOFs	8
<b>5 Test arrangement</b>	<b>8</b>
5.1 General	8
5.2 Representativeness of the receiver	8
5.3 Design of test receiver	9
5.4 Avoidance of secondary noise sources	9
<b>6 Measuring equipment</b>	<b>10</b>
6.1 General	10
6.2 Multi-channel analyser	10
6.3 Vibration sensors	10
6.4 Means of excitation	10
<b>7 Test procedure</b>	<b>10</b>
7.1 General	10
7.2 Operational test	12
7.3 Frequency response function (FRF) test	12
7.3.1 General	12
7.3.2 Direct FRF measurement	12
7.3.3 Reciprocal FRF measurement	12
7.4 Preliminary test with artificial excitation	13
<b>8 Analysis procedure</b>	<b>13</b>
<b>9 Uncertainties and validation</b>	<b>14</b>
9.1 General	14
9.2 On-board validation	15
9.3 Preliminary validation using artificial excitation	15
<b>10 Test report</b>	<b>15</b>
<b>Annex A (informative) Example of a test report: Electric rear axle drive in a passenger car; transfer path analysis (TPA) and estimation of blocked forces in situ according to ISO 20270:2019</b>	<b>17</b>
<b>Annex B (informative) Tests for validity of measurement data</b>	<b>24</b>
<b>Annex C (informative) Case studies</b>	<b>26</b>
<b>Annex D (informative) Criteria for selection of indicator and validation DOFs</b>	<b>31</b>
<b>Annex E (informative) Prediction of sound and vibration</b>	<b>35</b>
<b>Bibliography</b>	<b>37</b>

## 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

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.

This document is a preview generated by EVS

# 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.