
**Acoustics — Noise emitted by machinery
and equipment — Engineering method
for the determination of emission sound
pressure levels *in situ* at the work station
and at other specified positions using
sound intensity**

*Acoustique — Bruits émis par les machines et les équipements —
Méthode d'expertise pour la détermination par intensimétrie des
niveaux de pression acoustique d'émission in situ au poste de travail et
en d'autres positions spécifiées*



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Contents

Page

Foreword	iv
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Measurement uncertainty	3
5 Principle	4
6 Instrumentation	4
6.1 General	4
6.2 Calibration	4
7 Installation and operation of the source	5
7.1 General	5
7.2 Location of the machine	5
7.3 Mounting of the machine	5
7.4 Auxiliary equipment	6
7.5 Operation of the machine under test	6
8 Test procedure	7
8.1 Applicability	7
8.2 Measurement time interval	7
8.3 Measurements	8
8.4 Wind and gas flows	9
8.5 Criteria for qualification of the measurement	9
8.6 Criterion for background noise	9
8.7 Frequency range of measurements	9
8.8 Evaluation of the measurement result	9
9 Information to be recorded	10
9.1 General	10
9.2 Machine under test	10
9.3 Test conditions	10
9.4 Acoustic environment	10
9.5 Instrumentation	10
9.6 Location of specified positions	11
9.7 Noise data	11
10 Information to be reported	11
Annex A (normative) Criterion for the adequacy of the direction of the sound intensity vector	12
Annex B (normative) Procedure for frequencies higher than 5 000 Hz	14
Annex C (normative) Procedure in case the measurement fails to qualify	15
Annex D (informative) Example of a test table	16
Bibliography	17

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.

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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.

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ISO 11205 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

Acoustics — Noise emitted by machinery and equipment — Engineering method for the determination of emission sound pressure levels *in situ* at the work station and at other specified positions using sound intensity

1 Scope

This International Standard specifies an engineering method (grade 2 accuracy) to determine the emission sound pressure level of machines *in situ*, at the work station or at other specified positions, using sound intensity. It is an alternative to ISO 11201, ISO 11202 and ISO 11204 for *in situ* measurements. It is applicable to all kinds of test environments provided that the requirements on background noise and field indicators are fulfilled.

This International Standard is applicable to equipment emitting stationary broadband noise. The noise can differ between operational cycles and can be with or without discrete frequency or narrow band components.

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 7574-1, *Acoustics — Statistical methods for determining and verifying stated noise emission values of machinery and equipment — Part 1: General considerations and definitions*

ISO 12001, *Acoustics — Noise emitted by machinery and equipment — Rules for the drafting and presentation of a noise test code*

IEC 60942:2003, *Electroacoustics — Sound calibrators*

IEC 61043:2003, *Electroacoustics — Instruments for the measurement of sound intensity — Measurements with pairs of pressure sensing microphones*

3 Terms and definitions

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

3.1 sound intensity

$\bar{I}$

time-averaged instantaneous flow of sound energy per unit of area and per unit time in the direction of the local instantaneous acoustic particle velocity in a temporally stationary sound field

$$\bar{I} = \lim_{T \rightarrow \infty} \frac{1}{T} \int_0^T p(t) \bar{u}(t) dt$$

where

$p(t)$ is the instantaneous sound pressure at a point, in pascals;

$\vec{u}(t)$ is the associated instantaneous particle velocity at the same point, in metres per second;

T is the integration period, in seconds;

NOTE The sound intensity is a vectorial quantity. It is expressed in watts per square metre.

3.2 sound intensity vector

$\vec{I}_{xyz}$

vector sum of three measured orthogonal intensity components

NOTE It is expressed in watts per square metre.

3.3 level of the sound intensity vector

L_{Ixyz}

ten times the logarithm to the base 10 of the ratio of the modulus of the sound intensity vector to the reference intensity I_0 , in decibels, as given by

$$L_{Ixyz} = 10 \lg \left(\frac{|\vec{I}_{xyz}|}{I_0} \right) \text{ dB}$$

NOTE The reference sound intensity is $I_0 = 10^{-12} \text{ W/m}^2$.

3.4 sound field pressure-intensity indicator or field indicator

F_{pIxyz}

difference, in decibels, between the time-averaged measured sound pressure level, L'_p , and the level of the sound intensity vector, L_{Ixyz} , given by

$$F_{pIxyz} = L'_p - L_{Ixyz}$$

NOTE 1 When the indicator is determined for each of the Cartesian coordinates x , y and z , it is denoted F_{pIx} , F_{pIy} and F_{pIz} respectively.

NOTE 2 In ISO 9614-1 the notation F_2 is used.

3.5 pressure-residual intensity index

δ_{pI0}

difference, in decibels, between the indicated sound pressure level and the sound intensity level when the intensity probe is placed and oriented in a sound field such that the sound intensity is zero

EXAMPLE This can be achieved in an acoustic coupler, or other suitable unit that has been designed for the probe so that the microphones are transverse to the direction of propagation of plane sound waves.

3.6 emission sound pressure level

L_p

sound pressure level at a specified position near a machine, when the machine is in operation under specified operating and mounting conditions on a reflecting plane surface, excluding the effects of background noise as well as the effect of reflections other than those from the plane or planes permitted for the purpose of the test

NOTE It is expressed in decibels.

3.7

specified position

position defined in relation to a machine, including, but not limited to, an operator's position

NOTE The position can be a single, fixed point, or a combination of points along a path or on a surface located at a specified distance from the machine, as described in the relevant test code, if any. Positions located in the vicinity of a work station, or in the vicinity of an unattended machine, may be identified as "bystander positions".

3.8

dynamic capability index

L_d

difference, in decibels, between the pressure-residual intensity index and the bias error factor, K

$$L_d = \delta_{pI0} - K$$

NOTE The value of K is 10 dB in this International Standard.

3.9

hemi-free field intensity correction

K_5

correction to account for the fact that the sound intensity level is slightly smaller than the sound pressure level in a hemi-free field

NOTE 1 In this International Standard, $K_5 = 1$ dB.

NOTE 2 By introducing this correction, the risk of a small systematic underestimate of the emission sound pressure level is minimized, see references [9] to [16] in the Bibliography. K_5 is frequency independent and thus also valid for A-weighted sound pressure levels with the notation K_{5A} .

4 Measurement uncertainty

A single value of an emission sound pressure level of a noise source determined according to the procedures of this International Standard is likely to differ from the true value at a fixed position by an amount within the range of the measurement uncertainty. The uncertainty in measurements of emission sound pressure levels arises from several factors which affect the results, some associated with environmental conditions in the measurement room and others with experimental techniques. A method for the determination of the measurement uncertainty from information on the various influence parameters is specified in the GUM.

Until more specific knowledge is available, the estimation of the measurement uncertainty might be based on existing information on the standard deviations of reproducibility and repeatability according to ISO 7574-1. Extensive measurement data are necessary in order to establish standard deviations of reproducibility and repeatability of emission sound pressure levels at individual positions; in any case, these standard deviations are likely to vary considerably between the many types of different machinery and equipment to which this International Standard is applied. It is therefore not possible to provide information that is universally applicable, and reference can only be made to noise test codes for relevant data on individual types of machines.

A typical value for the standard deviation of reproducibility is given in Table 1. From this, and with additional information on the standard deviation of repeatability, the total standard deviation and an estimate of the expanded measurement uncertainty for a coverage probability of approximately 95 % corresponding to a coverage factor of two, may be derived, as indicated.

Table 1 — Measurement uncertainty of the A-weighted emission sound pressure level

Reproducibility ^a standard deviation, σ_{RA} , for a stable source dB	Repeatability ^b standard deviation, σ_{rA} , for an unstable source dB	Total standard deviation dB	Expanded uncertainty ^d dB
1,5 ^c	σ_{rA}	$\sqrt{\sigma_{RA}^2 + \sigma_{rA}^2}$	$2 \sqrt{\sigma_{RA}^2 + \sigma_{rA}^2}$
^a Found by different operators using different equipment measuring the same machine in different environments. This value includes a small repeatability standard deviation ($\sigma_r \approx 0,5$ dB). ^b Found by the same operator measuring the same machine in the same environment using the same equipment (only to be used if $\sigma_r > 0,5$ dB). ^c If frequencies above 5 000 Hz dominate the A-weighted level, σ_{RA} may be greater, see Annex B. ^d 95 % confidence under the assumption of a Gaussian distribution.			

NOTE The value of the measurement uncertainty has been taken from References [11], [12], [15], [16] and [17] in the Bibliography.

5 Principle

The basic principle of the test method is that the sound intensity in a diffuse sound field is small (theoretically it should be zero) and that the sound pressure level equals the sound intensity level in a free progressive wave. The test method assumes that sound which has been reflected will add up to a diffuse sound field. The direct sound from the machine under test will not be part of the diffuse sound field but constitute the free progressive wave.

These assumptions will not be fulfilled if sound intensities from different parts of the machine with similar magnitude will meet at the probe and, to some extent, cancel each other. In such cases, the sound intensity will become smaller and, assuming uncorrelated summation, the sound pressure will become greater. In such cases, the level of the sound intensity vector will underestimate the emission sound pressure level. By adding K_5 to deal with the underestimate of the floor reflection and, for large machines, by requiring that the sound field pressure-intensity indicator meets the criterion specified in 8.5 the underestimate will be negligible.

6 Instrumentation

6.1 General

The intensity-measuring instrumentation shall be able to measure intensity levels re 10^{-12} W/m² in decibels in octave or one-third-octave bands. The instrument, including the probe, shall comply with a Class 1 instrument in accordance with IEC 61043:2003. If the probe does not have a flat frequency response above 5 000 Hz, see Annex B.

The residual pressure-intensity index δ_{pI0} of the microphone probe and analyser shall be higher than $F_{pI} + 10$ dB in each octave or one-third-octave band.

6.2 Calibration

The compliance of the instrumentation system with the requirements of IEC 61043 shall be verified periodically in a manner that is traceable to appropriate standards.

During each series of measurements, the instrument and the probe shall be calibrated at least at one frequency in the range from 200 Hz to 1 000 Hz in accordance with the calibration procedure.