# INTERNATIONAL STANDARD

# ISO 11821

First edition
1997-04-01

# Acoustics — Measurement of the *in situ* sound attenuation of a removable screen

*Acoustique — Mesurage de l'atténuation acoustique in situ d'un écran amovible*



Reference number
ISO 11821:1997(E)

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Printed in Switzerland

## 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.

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.

International Standard ISO 11821 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

Annex A of this International Standard is for information only.

## Introduction

This International Standard specifies *in situ* methods for the determination of the sound attenuation performance of removable sound-protecting screens for industrial purposes. A screen is any object (e.g. panels, flexible curtains, etc.) breaking the line of sight between source and receiver; such a screen may be flat or curved. A removable screen is a screen that can be dismantled without the other environmental conditions being changed. The purpose of such a screen is to shield a work station or a complete work area from the noise emitted by sound source(s). Such an area can be a zone where one operator is located or a zone occupied by several operators at no fixed positions. For example, screens can be used by a maintenance unit to reduce the effect of noise at a given location, from repair work, and to reduce the noise at a work station located close to a machine or process.

Related standards concern noise attenuation measurements of enclosures under *in situ* conditions (ISO 11546-2), and sound insulation measurements of cabins under *in situ* conditions (ISO 11957).

Other International Standards dealing with screens in other situations are ISO 10053 (sound attenuation of screens for open plan offices) and ISO 10847 (sound attenuation of outdoors screens).

Technical information about noise reduction in workrooms can be found in ISO 11690-2.

# Acoustics — Measurement of the *in situ* sound attenuation of a removable screen

## 1 Scope

This International Standard specifies methods for evaluating the *in situ* sound attenuation performance of a removable screen, either indoors or outdoors. This engineering grade method is based on an insertion loss measurement that can be carried out either with shielding of the actual sound source(s) or using an artificial sound source.

The sound attenuation performance achieved by such a screen, as evaluated by the present International Standard, depends on:

— diffraction around the edges of the screen;

— transmission through the components of the screen;

— absorption of the panels of the screen, as well as in its surroundings;

— the room in which the screen stands if indoors.

When a specific work station is to be shielded, the *in situ* sound attenuation value describes the effect of the screen. However, when a complete area is to be shielded, the performance of the screen will vary depending on the positions used for measurement. Therefore, it is recommended that the maximum and minimum values of sound attenuation are given. The sound attenuation performance is determined in terms of insertion loss.

When assessing the performance of a screen located indoors, the room geometry and reflections from walls, ceilings and room fittings will influence the performance. As a consequence, the comparison of screen performance can only be made if the test conditions are identical.

This International Standard is applicable to screens with height and length greater than 1,5 m. However, it may also be used for smaller screens provided that the interested parties come to an agreement on this.

As environmental conditions can affect the measurements outdoors, it is recommended that measurements should be restricted to within 25 m of the screen. However, measurements may also cover a greater distance provided that the interested parties come to an agreement on this.

Differences can occur between *in situ* test results. Therefore, comparison of the performance of different screens can be made only on the basis of data based on the same measurement method performed at the same location.

This International Standard applies to a complete screen only and not to individual components from which it is made. Sound insulation and sound absorption for screen components (such as panel elements, doors, windows) should be measured according to other relevant standards.

This International Standard is not applicable to open plan offices screens nor to outdoor barriers dealing with community noise. It is also not intended for qualification purposes.

## 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 651:1979, *Sound level meters.*

IEC 804:1985, *Integrating-averaging sound level meters.*

IEC 942:1988, *Sound calibrators.*

IEC 1260:1995, *Electroacoustics — Octave-band and fractional-octave-band filters.*

## 3 Definitions

For the purposes of this International Standard, the following definitions apply.

**3.1 screen:** Any object that is specially designed to shield one or more specified positions in a given area from the noise of specific sound source(s).

NOTE — Examples are panels and flexible curtains.

**3.2 removable screen:** A screen that can be dismantled without the other environmental conditions being changed.

**3.3 actual sound source(s):** The sound source(s) to be shielded.

**3.4 sound pressure level, $L_p$:** Ten times the logarithm to the base 10 of the ratio of the mean-square sound pressure of a sound to the square of the reference sound pressure 20 µPa. The sound pressure level is expressed in decibels.

**3.5 A-weighted sound pressure level, $L_{pA}$:** Sound pressure level weighted in accordance with IEC 651. The A-weighted sound pressure level is expressed in decibels.

**3.6 unscreened sound pressure level, $L_{p1}$:** Sound pressure level measured at one position not screened from the sound source(s) without the screen in its intended position. The unscreened sound pressure level is expressed in decibels.

**3.7 screened sound pressure level, $L_{p2}$:** Sound pressure level measured at the same position as in 3.6 but screened from the sound source(s) by the screen in its intended position. the screened sound pressure level is expressed in decibels.

**3.8 *in situ* sound attenuation, $D_p$:** Difference, in decibels, between $L_{p1}$ and $L_{p2}$ at the particular position defined in 3.6, $L_{p1}$ and $L_{p2}$ being determined in either one-third-octave or octave bands.

**3.9 A-weighted *in situ* sound attenuation, $D_{pA}$:** Difference, in decibels, between $L_{pA1}$ and $L_{pA2}$ at the position defined in 3.6 when using the actual sound source(s).

**3.10 directivity index, $DI_i$:** Difference, in decibels, between $L_{360}$ (the logarithmic mean value of the sound pressure level in 12 positions evenly distributed on a horizontal circle surrounding the sound source) and $L_{30,i}$ (the sound pressure level in position $i$ of the twelve positions).

The radius of the circle shall be approximately 1,5 m.

$$DI_i = L_{360} - L_{30,i}$$

NOTE — The definition of the directivity index stated in this International Standard is in principle equivalent to the definition given in ISO 140-3. However, the procedure in this International Standard is somewhat simplified by allowing the directivity

index to be determined in 12 discrete positions in the horizontal plane instead of using "gliding averaging" in different planes as described in ISO 140-3.

## 4 Instrumentation

The instrumentation system, including the microphones and cables, shall meet the requirements for a type 1 instrument as specified in IEC 651 or, in the case of integrating-averaging sound level meters, the requirements for a type 1 instrument as specified in IEC 804.

For measurements in octave or one-third-octave bands, the instrumentation system shall meet the requirements for a class 1 filter as specified in IEC 1260.

Before and after each series of measurements, the calibration of the entire measuring system shall be verified at one or more frequencies over the frequency range of interest, using a sound calibrator with an accuracy of ± 0,3 dB (class 1 as specified in IEC 942).

NOTE — Other calibration methods are permissible, provided that it is shown that the instrumentation system is stable during the measurements and that measurements with and without the screen are carried out using the same measurement system.

When measuring outdoors, a microphone windscreen with negligible influence on the frequency response of the microphone shall be used during the measurements.

## 5 Determination of *in situ* sound attenuation

### 5.1 General

The unscreened acoustic field can be generated using the actual sound source(s) to be shielded, provided the provisions outlined in 5.2 are met. If needed, an artificial sound source can be used instead. The use of the actual sound source(s) is the preferred method.

When performing the measurements, ensure that the same operating conditions are used for the screened and unscreened situations.

### 5.2 Sound source requirements

#### 5.2.1 Actual sound source(s): Preferred method

The generated sound shall be reproducible and the same sound shall be used for measurements with and without the screen.

The output shall be sufficiently high to give a sound pressure level behind the screen exceeding the background noise level by at least 6 dB and preferably more than 10 dB for all frequency bands of interest.

NOTE — In order to check the operating conditions, all relevant sound source(s) at the test site should be listed, together with their operating conditions (such as rotational speed, flow rate, power, etc.).

#### 5.2.2 Artificial sound source

If the requirements in 5.2.1 are not met by the actual sound source(s), the measurements shall be carried out in octave or one-third-octave bands using an artificial sound source instead of the actual sound source(s).

NOTE 1 The artificial sound source may be a loudspeaker, a pistol shot, a bursting membrane, but it can also be machinery brought in for the purpose of testing the screen.

The artificial sound source must have at least one axis of symmetry which shall be directed perpendicular to the floor during operation. The directivity index should not exceed + 8 dB in any of the twelve positions (see definition 3.10). The requirement shall be fulfilled in all one-third-octave bands in the frequency range from 100 Hz to 5 000 Hz. If the artificial sound source is a loudspeaker, the test shall be performed with a pink-noise signal either in one-third-octave bands or as a broad-band signal.

The 12 measurement positions shall be evenly distributed on a circle with a radius of approximately 1,5 m. The centre of the circle shall be at the same horizontal level as the centre of the sound source. If the centre of the sound source is situated less than 1,5 m above floor level, the centre of the circle shall be 1,5 m above floor level.

The test shall be carried out under conditions corresponding as closely as possible to a free field over a reflecting plane.

NOTE 2 The directivity requirement stated above cannot be expected to be fulfilled with a simple box loudspeaker with one or two loudspeaker units. An omnidirectional loudspeaker, e.g. a dodecahedron type, can fulfil the requirements.

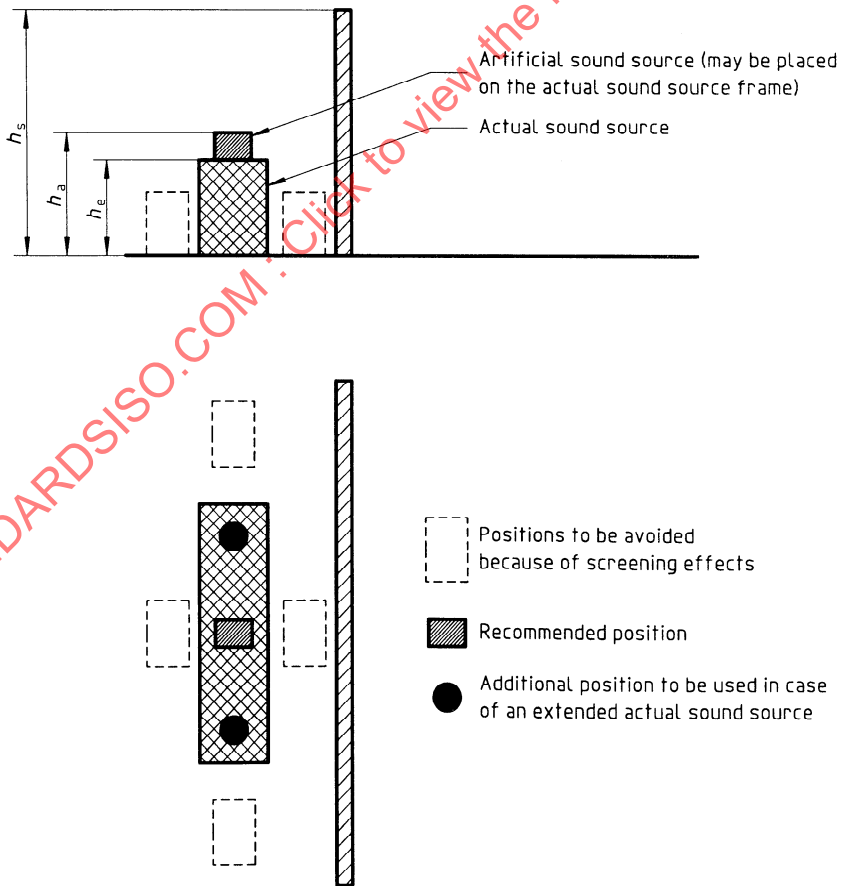
Single bursts of noise can be used to achieve a high signal-to-noise ratio. In the case of an impulsive sound source (e.g. a pistol shot or a bursting membrane), the directivity is determined and evaluated according to the method described in this subclause.

The artificial sound source shall be located as close as possible to the actual sound source(s) to be shielded. This location shall be such that it is not shielded by the actual sound source(s) itself. The height of that artificial sound source shall not be smaller than the actual sound source height. Figure 1 provides an example of such an arrangement.

The frequency range shall be at least 100 Hz to 5 000 Hz for one-third-octave bands, and at least 125 Hz to 4 000 Hz for octave bands.

NOTE 3 When dealing with extended actual sound source(s), it is recommended that several positions of the artificial sound source are used. The position(s) of the artificial sound source should be agreed upon by the interested parties.

The output shall be sufficiently high to give a sound pressure level behind the screen exceeding the background noise level by at least 6 dB and preferably more than 10 dB for all frequency bands of interest.




$h_e$ is the actual sound source height;
$h_a$ is the artificial sound source height ($h_a > h_e$);
$h_s$ is the screen height.

**Figure 1 — Positions of the artificial sound source if the actual sound source cannot be moved**

## 5.3 Acoustical environment

Measurement of unscreened and screened situations shall be carried out under the same environmental conditions. It is especially important that nearby reflective surfaces are in the same position and unchanged in both situations. In addition, the following parameters shall be checked for conformity:

— same operating conditions;
— fittings of the room or outdoor space;
— environmental conditions (e.g. wind speed and direction).

## 5.4 Screen mounting

The screen shall be installed at its specified position as intended under normal mounting conditions.

## 5.5 Microphone positions

### 5.5.1 Screen intended to protect an operator's position which is well defined

If the screen is intended to protect an operator's position which is well defined, three microphone positions shall be distributed on a sphere of 0,3 m radius, the centre of which is at the head position of the operator.

NOTE — In accordance with ISO 11200, the height of measurement positions should be 1,55 m ± 0,075 m.

### 5.5.2 Screen intended to shield an area

If the operator's position is not well defined, the microphone positions shall be located along at least one line perpendicular to the screen. These microphone positions shall be located in the area to be shielded, at typical operator's height. If no such value is defined, the height of the microphone positions shall be 1,55 ± 0,075 m. The distance from the microphone positions to the screen should, if applicable, be equal to a quarter of the height of the screen, half the height of the screen, once the height of the screen, and twice the height of the screen, unless the plant layout prevents this. The minimum distance shall be 1 m. One possible arrangement of the measurement positions is displayed as an example in figure 2.

NOTE 1 In case of a non-flat screen, the measurement line should be perpendicular to the main line of the screen.

In the case of a large screen and in the case of screens with complicated geometry, the position of measurement lines shall be agreed upon by the interested parties. If only one line is used, a line close to the geometric centre of the screen shall be chosen.

NOTE 2 Provided that there are no reflective surfaces or fittings in the area of measurements, the minimum sound attenuation value will probably be found at the most remote position from the screen, and the maximum sound attenuation value at the microphone position which is closest to the screen.

## 5.6 Measurement procedures

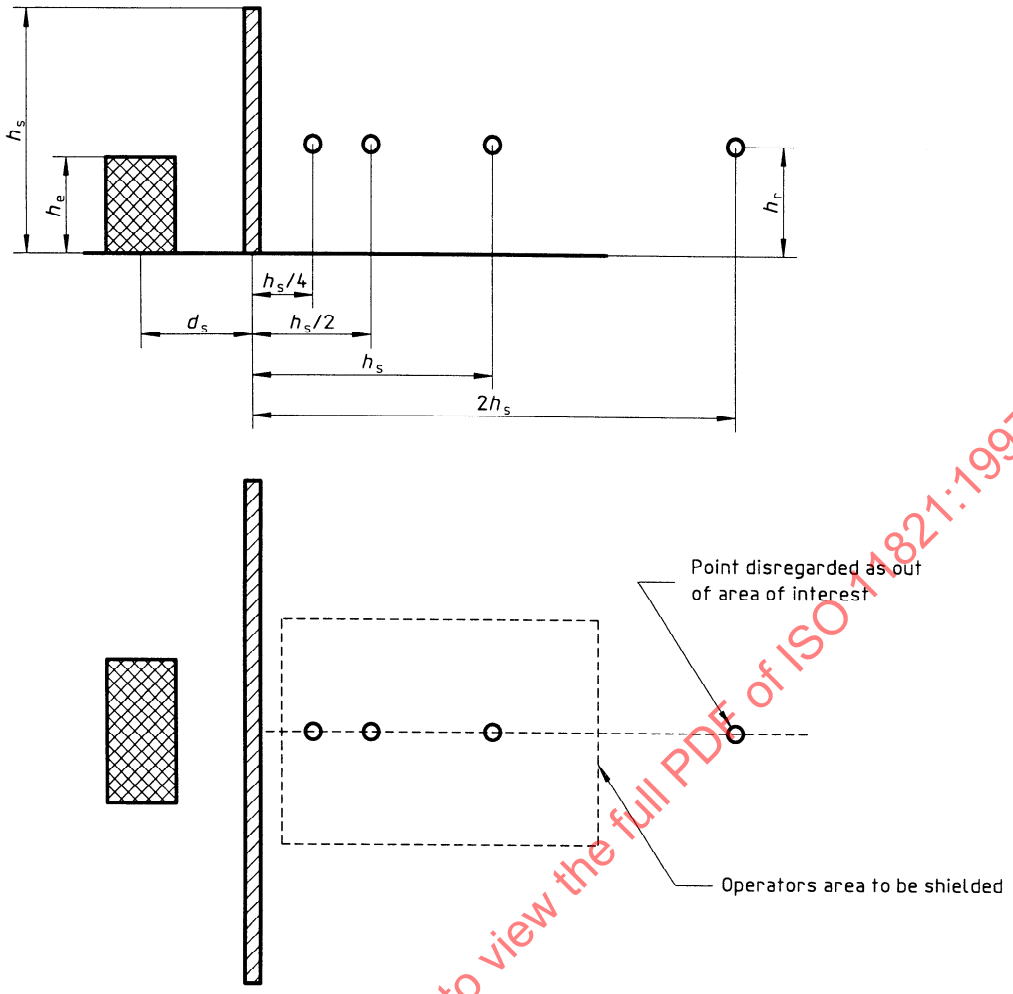
Measurements of the unscreened sound pressure level $L_{p1}$ shall be performed with the screen removed. Measurements of the screened sound pressure level $L_{p2}$ shall be performed under the same conditions with the screen in position.

Correction for the influence at background noise at each measurement position shall be carried out as indicated in 5.7.

### 5.6.1 Actual sound source

Quantities to be measured are octave or one-third-octave band levels. Both $L_{p1}$ and $L_{p2}$ shall be determined as time-averaged values.

The time-averaging period shall be sufficiently long to be representative of the actual noise.




$h_r$ is the usual operator's height (1,55 m ± 0,075 m unless otherwise specified);
$h_e$ is the sound source height (for an artificial source this shall be greater or equal than the actual source height);
$d_s$ is the distance from the centre of the sound source to the screen.

**Figure 2 — Measurement positions in the case of measurements over an area**



### 5.6.2 Artificial sound source

#### 5.6.2.1 Single-impulse sound source

Quantities to be determined are maximum octave or one-third-octave band levels, measured with time weighting S, $L_{Smax}$. Measurements with and without the screen shall be repeated at least three times. If the deviation exceeds 3 dB, then the measurements shall be repeated again three times. If the deviation exceeds 5 dB, the measurement is invalid. $L_{p1}$ and $L_{p2}$ shall be determined as the arithmetic mean values of those measured values.

#### 5.6.2.2 Any other type of sound source

Measurements shall be carried out as outlined in 5.6.1.

## 5.7 Correction for background noise

If the difference between the noise generated by the sound source(s) and the background noise (including wind-generated noise) is in the range 6 dB to 10 dB, correction is made according to the equation below.

If the difference exceeds 10 dB, no correction is required.

If the difference is less than 6 dB, the environmental conditions are not acceptable.

Correction for the influence of background noise at each measurement position shall be carried out as follows:

$$L_p = 10 \lg \left( 10^{\left(L_{ps}/10\right)} - 10^{\left(L_{pb}/10\right)} \right) \text{ dB}$$

where

$L_{ps}$ is the sound pressure level, in one-third-octave or octave bands, measured with the sound source(s) turned on;

$L_{pb}$ is the sound pressure level, in one-third-octave or octave bands, measured with the sound source(s) turned off;

$L_p$ is the sound pressure level of interest (e.g. screened or unscreened sound pressure level), in one-third-octave or octave bands.

### 5.8 *In situ* sound attenuation

The *in situ* sound attenuation $D_p$ for a microphone position in octave or one-third-octave bands, is given by:

$$D_p = L_{p1} - L_{p2}$$

where

$L_{p1}$ is the unscreened sound pressure level in one-third-octave or octave bands;

$L_{p2}$ is the screened sound pressure level in one-third-octave or octave bands.

Either $L_{p1}$ and $L_{p2}$ are both time-averaged sound pressure levels or both are the arithmetic mean values of several $L_{Smax}$ values.

### 5.9 A-weighted *in situ* sound attenuation

The A-weighted *in situ* sound attenuation $D_{pA}$ for a microphone position is given by:

$$D_{pA} = L_{pA1} - L_{pA2}$$

where

$L_{pA1}$ is the A-weighted unscreened sound pressure level;

$L_{pA2}$ is the A-weighted screened sound pressure level.

$D_{pA}$ shall not be determined when an artificial sound source is used.

## 6 Uncertainty

For A-weighted measurements carried out under similar environmental conditions and with a stable source of steady broad-band noise, the standard deviation of the mean value is estimated to be approximate to the engineering grade of accuracy (2 dB).

NOTES

1 A detailed explanation of the uncertainty of an engineering method can be found for example in ISO 3743-1 or ISO 3744.

2 The accuracy is unknown for measurements carried out under different environmental conditions, when an impulsive sound source is used and/or when the noise contains pure tones. However, the accuracy is expected to be equal to or better than corresponding to a method of survey grade.

## 7 Information to be recorded

The following information, when applicable, shall be compiled and recorded for all measurements carried out in accordance with the requirements of this International Standard.

### 7.1 Test object

a) Identification of the screen (name/trademark).

b) Detailed description, preferably including drawings, of the screen (panels, windows, doors, joints between panels).

c) Total mass or mass per unit area of the screen.

d) Area and dimensions.

e) Description of the surfaces (acoustical properties, etc.).

f) Description of the screen mounting.

### 7.2 Test conditions

a) Description of the test environment (dimensions, approximate reverberation time if applicable, absorptive, reflective or scattering objects, estimated absorption of room surfaces for indoor measurements).

b) Description of the positions of test object, microphones, sound source(s), work station.

c) Description of the test environment for outdoor test [e.g. ground conditions (hard, soft), wind speed and direction, air temperature, barometric pressure, relative humidity if relevant].

d) Checklist of the sound source(s) to be found in the test environment.

### 7.3 Instrumentation

A list of the test equipment and instruments used.

### 7.4 Acoustical data

a) Description of the sound source used.

b) Description of the measurement method used: time averaging or maximum sound pressure level.

c) For a shielded work station: $D_p$ and/or $D_{pA}$.

For a shielded area: minimum and maximum values of $D_p$ and/or $D_{pA}$ with indication of their corresponding microphone positions.

The values of $D_p$ and, if applicable, $D_{pA}$ shall be given in decibels and rounded to the nearest integer.

d) In the case of impulsive sound source(s), the arithmetic mean values of $L_{Smax}$ as well as levels of background noise in octave or one-third-octave bands and standard deviations of these levels for repeated measurements.

e) For situations in which no specified operator's position is defined, a table giving the value of $D_p$ (and $D_{pA}$ if applicable) at each microphone position.

f) The sound attenuation performance given in one-third-octave or octave bands shall be given in the form of table and, preferably, a graph (sound attenuation in decibels plotted against frequency in hertz on a logarithmic scale). For results obtained in accordance with this International Standard, it is preferred that one octave corresponds to 15 mm and 10 dB to 20 mm. A scaling of both axes by the same factor is permissible.