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Acoustics — Guidelines for noise control in offices and workrooms by means of acoustical screens

Acoustique — Lignes directrices pour la réduction du bruit dans les bureaux et locaux de travail au moyen d'écrans acoustiques

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Foreword

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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 17624 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

Introduction

Besides silencers and enclosures (see ISO 14163 and ISO 15667, respectively), indoor screens are used as secondary means of noise control in workrooms and offices. For workplaces containing machinery, some information on such elements is given in ISO 11690-2:1996, Annexes E and F. More detailed information can be found in the bibliographic references.

Acoustics — Guidelines for noise control in offices and workrooms by means of acoustical screens

1 Scope

This International Standard deals with the effectiveness of acoustical screens. It specifies the acoustical and operational requirements to be agreed upon between the supplier or manufacturer and the user of acoustical screens. This International Standard is applicable to the following types of acoustical screens:

a) free-standing acoustical screens for offices, service areas, exhibition areas, and similar rooms;

b) acoustical screens integrated in the furniture of such rooms;

c) portable and removable acoustical screens for workshops;

d) fixed room partitions with more than 10 % of the connecting area open and acoustically untreated.

Walls of partial acoustic enclosures and cabins which, together with the room boundary surfaces, also partition a room and provide more than 10 % open and acoustically untreated area, are also treated as acoustical screens.

NOTE Guidance on complete acoustic enclosures is given in ISO 15667.

This International Standard is not applicable to cabinet walls and similar multi-layer walls whose thickness exceeds 0,2 m, nor to banners and other types of suspended baffles.

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 140-3, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 3: Laboratory measurements of airborne sound insulation of building elements*

ISO 354, *Acoustics — Measurement of sound absorption in a reverberation room*

ISO 717-1, *Acoustics — Rating of sound insulation in buildings and of building elements — Part 1: Airborne sound insulation*

ISO 9053, *Acoustics — Materials for acoustical applications — Determination of airflow resistance*

ISO 10534-1, *Acoustics — Determination of sound absorption coefficient and impedance in impedance tubes — Part 1: Method using standing wave ratio*

ISO 10534-2, *Acoustics — Determination of sound absorption coefficient and impedance in impedance tubes — Part 2: Transfer-function method*

ISO 11654, *Acoustics — Sound absorbers for use in buildings — Rating of sound absorption*

ISO 11821:1997, *Acoustics — Measurement of the in situ sound attenuation of a removable screen*

3 Terms and definitions

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

3.1
(acoustical) screen
object that is specifically designed to shield one or several specified positions in a given area from the noise of (a) specified sound source(s)

[ISO 11821:1997]

3.2
portable or removable (acoustical) screen
(acoustical) screen that is designed to be dismantled or relocated without the other environmental conditions being changed

NOTE Adapted from ISO 11821:1997.

3.3
insertion sound pressure level difference
***in-situ* sound attenuation**
D_p
difference, in decibels, between the sound pressure levels, in octave bands or one-third-octave bands, at a specified position without and with the screen installed when one or several specified sound sources are in operation

NOTE Adapted from ISO 14163:1998.

3.4
A-weighted insertion sound pressure level difference
A-weighted (*in-situ*) sound attenuation
$D_{p\mathrm{A}}$
difference, in decibels, between the A-weighted sound pressure levels at a specified position without and with the screen installed, when one or several specified sound sources are in operation

NOTE 1 The A-weighting is specified in IEC 61672-1.

NOTE 2 Adapted from ISO 14163:1998.

3.5
insertion loss
D_i
difference, in decibels, between the levels of the sound power, in octave bands or one-third-octave bands, radiated into the room by the sound source(s) to be shielded without and with the screen installed

NOTE By definition, the sound power is to be measured on an enveloping surface enclosing the sound source(s) to be shielded and the space for positioning the screen. It mainly applies to screens placed close to the source.

3.6
sound reduction index
transmission loss
R
quantity, in decibels, characterizing the sound energy transmitted through a building element in relation to the sound energy incident upon the element as per ISO 140-3

3.7
free-field screen sound attenuation
D_z
difference, in decibels, between the sound pressure level of the sound reaching a specified position on the direct path from the sound source to be shielded when the screen is not installed, and the level of the diffracted sound when the screen is installed, calculated from

$$D_z = 10 \lg \left(3 + 40 \frac{z}{\lambda}\right) \text{ dB} \tag{1}$$

where

z is the path length difference, in metres, between the longer sound propagation path around the least effective diffracting edge of the screen and the direct path;

λ is the wavelength, in metres, of the sound with the frequency f in hertz.

NOTE 1 The screen sound attenuation is given for octave-band or one-third-octave-band centre frequencies.

NOTE 2 The reduced screen sound attenuation, $D_{z,r}$ approximately accounts for reflections from a wall close to the sound source and considers the least effective diffracting edge of the screen, for a receiver located within the reverberation radius from the source, as per

$$D_{z,r} = 10 \lg \left(1 + 20 \frac{z}{\lambda}\right) \text{ dB} \tag{2}$$

It is 3 dB to 5 dB lower than the free-field screen sound attenuation D_z.

4 Symbols

The following symbols are used in this International Standard.

A equivalent absorption area, in square metres, see 5.3;

α absorption coefficient, see 8.1;

B average room width in the vicinity of the screen, in metres;

h screen height, in metres;

H average room height in the vicinity of the screen, in metres;

l_S length, in metres, of mean free path between reflections from scattering objects, typically 10 m;

r_r reverberation radius, in metres, see 5.3;

s distance from source to receiver, in metres, see 6.1;

T reverberation time, in seconds, see 5.3;

V volume, in cubic metres, see 5.3.

5 Basic principles and conditions of application

5.1 Contributions to the sound attenuation

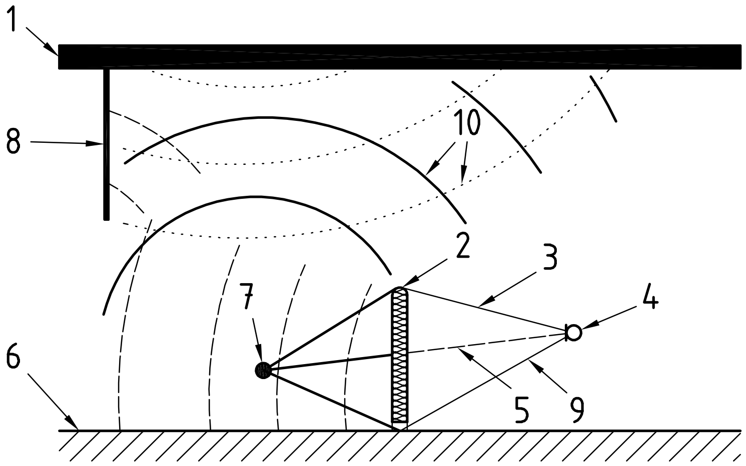
Acoustical screens typically provide an A-weighted sound attenuation of up to 10 dB in offices and workrooms. This attenuation results from (see Figure 1):

— sound absorption by the screen surface;

— blocking of the direct sound propagation path from a source to the receiver;

— partial decoupling of the sound fields on both sides of the screen.

The sound reduction index of all components forming the screen is usually sufficiently large due to structural requirements and, therefore, does not need any further consideration. Sealing joints between screen elements is only necessary to optimize the performance of screens intended to provide an insertion loss of more than 10 dB.



Key

1 ceiling
2 acoustical screen
3 diffracted sound
4 receiver
5 direct sound
6 floor
7 sound source
8 obstacle
9 transmitted sound
10 reflected and scattered sound

Figure 1 — Sound propagation indoors with screen (schematic)

5.2 Absorption close to the sound source

The sound absorption of a screen close to a sound source results in a reduction in the sound power radiated by that source into the space behind the screen, which is characterized by the insertion loss D_i. The value of D_i is greater

— the higher the absorption coefficient of the screen surface facing the sound source,

— the more pronounced the directivity of the sound radiation towards the screen, and

— the more completely the sound source is enclosed by the screen.

5.3 Screening effect

Blocking the direct sound propagation path between the sound source and the receiver results in a reduction in direct sound characterized by the reduced screen attenuation $D_\mathrm{z,r}$ as per Equation (2). The value of $D_\mathrm{z,r}$ is greater

— the larger the smallest dimension of the screen,

— the shorter the distance between the sound source and screen, and

— the shorter the distance between the receiver and screen.

The shape and absorption properties of the screen are less important for the screening effect. The screening of direct sound has less of an effect on the *in-situ* sound attenuation at a receiver lying outside the reverberation radius around the sound source. At such a point, the sound reflected from all surfaces of the room and its fittings (for further details see ISO 11690-1:1996, 3.4.7) is stronger than the direct sound field. Usually, the reverberation radius will be a few metres only.

For a sound source with an omnidirectional sound radiation characteristic, the reverberation radius can be approximated as follows.

a) For approximately cubic rooms where Sabine's formula applies:

$$r_\mathrm{r} = \sqrt{\frac{A}{16\,\pi}} = 0{,}057\sqrt{\frac{V/\mathrm{m}^3}{T/\mathrm{s}}}\ \mathrm{m} \qquad (3)$$

See ISO 11690-1:1996, 3.4.3 for A, and ISO 11690-1:1996, 3.4.10 for T.

b) For rooms with many scattering objects:

$$r_\mathrm{r} = l_\mathrm{S}/3 \qquad (4)$$

where $l_\mathrm{S} = 4V/S$ is the length, in metres (m), of mean free path between reflections from scattering objects within volume V (in cubic metres, m^3), and S (in square metres, m^2) is the enveloping-surface area of all objects within the volume V. For industrial workrooms and open concept offices, l_S is typically 10m.

c) For rooms with a low ceiling (i.e. H is less than one-third of the other room dimensions), with only few scattering objects and little absorption at the ceiling:

$$r_\mathrm{r} = 3H/2 \qquad (5)$$

d) For long rooms (i.e. B and H are less than one-third of the room length) where reflections mainly occur at the sides:

$$r_\mathrm{r} = 3B/2 \qquad (6)$$

5.4 Decoupling

Screens dividing a room into several areas are called partitions. These result in a partial decoupling of the sound field on the source side of the screen from the sound field in the rest of the room. The decoupling is the more effective and the resulting sound pressure level difference is greater

— the smaller the open area beside the screen, and

— the greater the sound absorption at the perimeter of the opening.

This International Standard deals with thin screens only. Sound absorption on the top edge of the screen is not considered. It is therefore the sound absorption of the room boundary and the screen surfaces that is relevant. A sufficiently large, highly absorbent surface area should be provided near the edge of the screen.

5.5 Absorption away from the sound source

By virtue of their sound absorption, both sides of the screen contribute to an attenuation of the reverberant field (or diffuse field; see ISO 11690-1:1996, 3.4.8 for more details). This effect will become less in rooms with high absorption. In reverberant workrooms, with low absorption, the installation of absorbent screens can result in a considerable reduction of the spatially averaged sound pressure level.

5.6 Further effects of screens

5.6.1 In addition to noise control, there are other desired effects of screens, such as

a) protection against fragments coming off the workpiece, e.g. during blasting and grinding,

b) protection of the eyes, e.g. during arc welding,

c) protection against splashes of liquids, such as chemically aggressive or hot liquids, and hot molten material,

d) protection against heat radiation,

e) protection against glare for VDU-based[1)] work stations near windows, or in zones with unfavourable lighting conditions,

f) partitioning of a room to create recreation areas or privacy areas,

g) integration of cabling and services for power or IT[2)] equipment, and

h) creating agreeable working or exhibition areas.

5.6.2 There are also undesired results, such as

a) limiting the ease of supervision in a workroom,

b) reducing access to the work station,

c) reducing lighting of the work station,

d) limiting the transport of materials or parts,

e) reducing the flexibility in specifying the dimensions of the working area,

f) effects on heating, ventilation and air-conditioning.

5.6.3 The optimum design of acoustical screens depends on the type of work station and is influenced by the choice of

a) material, i.e. sound-absorbent, opaque or transparent,

b) dimensions, and thus mass and mobility,

c) shape and surface, and

d) space between the screen and the room boundary surfaces.

6 Types of acoustical screens and special requirements

6.1 Partitioning of large rooms

Together with the furniture, large screens serve to partition a room. The following should be considered:

a) the ratio of the screen height to the height of the room, which allows for an estimation of the achievable insertion sound pressure level difference as per Table 1;

b) the sound absorption coefficient, which will mainly have an effect on the insertion sound pressure level difference in reverberant rooms;

c) a clearance of approximately 0,2 m needed for heating, ventilation and air-conditioning purposes;

d) fire protection (usually, non-combustible materials are required in production facilities, see ISO 1182, ISO/TR 11925-1, ISO 11925-2 and ISO 11925-3) and sufficient mechanical stability, oil-proofing, if required, and requirements concerning cleaning and hygiene;

e) the long-term wear resistance of textile surfaces, and their light-reflection properties in open-plan offices, teller areas, exhibition rooms, etc.

1) VDU = visual display unit

2) IT = information technology

Table 1 — Typical empirical values for the insertion sound pressure level difference of acoustical screens in rooms with low ceilings

h/H	s/H		
	$<$ 0,3	0,3 to 1	1 to 3
$<$ 0,3	7 dB	4 dB	—
0,3 to 0,5	10 dB	7 dB	4 dB
$>$ 0,5	—	9 dB	6 dB
NOTE In the octave bands from 500 Hz to 4 000 Hz, the standard deviation is approximately 1 dB.			

6.2 Noise control for individual work stations

For an industrial work station, acoustical screens serve as partial enclosures with a large percentage of open area, where the following requirements apply. There shall be

a) ease of access for machine control, supply of workpieces and maintenance, taking into account hoisting gear, industrial trucks (conveyor, fork-lift truck), etc., if needed, and, if required, ease of modification and dismantling of labelled screen elements,

b) structural stability, including windows and doors, if required, and compliance with other relevant regulations concerning safety at the workplace,

c) mechanical resistance to damage of the outer surface by cladding with bricks or sheet metal, or other damage/resistant facing, and

d) sound-absorbing surfaces on the source side, both sides being non-combustible or hardly flammable, oil-proof, splash-proof and hygienically acceptable, if necessary.

NOTE A work station lying between the source (machine, plant, hammering, grinding, etc.) and the screen is not protected from the sound from that source.

Screens shall never be installed on emergency escape routes. Also, screens should not impair the lighting. Furthermore, all relevant regulations for workplaces shall be observed.

6.3 Protection of individual work stations

Acoustical screens can be arranged to provide an open-top cabin or enclosure. There shall be

a) sufficient ventilation, particularly when installed in rooms with air conditioning,

b) optical shielding and sound absorption up to a height of approximately 1,4 m; for enhanced protection from noise, glass elements may be used above that height,

c) safety aspects according to EN 1023, particularly with respect to the structural stability of the screen, and to the danger of injury to personnel from corners or edges, as well as the tripping hazard caused by the supports of the screen, and

d) integration of cabling and services for power or IT equipment.

In offices with sound-absorbent ceilings, no particular requirements are necessary with respect to the sound absorption coefficient of screens for individual work stations. However, screen absorption may be required when higher levels of speech privacy are important.

7 Combined effect of acoustical screens and acoustical claddings

As a rule, room-acoustical measures are needed primarily for noise control in work places. These include sound-absorbent claddings of the room boundary surfaces, such as ceiling and wall claddings, carpets, and also suspended absorbent baffles and cylinders. It is the effectiveness of these measures, and the fittings of the room, which determine the amount by which the insertion sound pressure level difference of a screen in the room is less than the free-field screen sound attenuation, D_z. The fittings are characterized by a mean fitting density (the reciprocal of the length of the mean free path between sound reflections from fittings) and by the fitting absorption.

It is often effective

a) to use screens with two highly absorbent sides in rooms without any, or with only slightly sound-absorbent claddings at the ceiling,

b) to suspend absorbers relatively low above the top edge of the screen in rooms with many reflective fittings, and

c) to apply sound-absorbent claddings to walls at a relatively small lateral distance from the screen.

Claddings on walls or ceilings should have a width at least twice their distance from the edge of the screen.

8 Acoustical requirements for planning and verification purposes

8.1 Sound absorption

When a screen is to be used as a partial enclosure around a sound source, a high sound absorption on the source side should be specified. Where no knowledge about the sound source is available, sound absorption class B of ISO 11654:1997 shall apply. Otherwise, the normal-incidence sound absorption coefficient, α, shall exceed 0,8 in all one-third-octave bands or octave bands of the frequency range dominating the A-weighted sound pressure level at the receiver. Measurements of the normal-incidence sound absorption coefficient shall be as specified in ISO 10534-1 (method using standing-wave ratio) and ISO 10534-2 (transfer-function method). Samples of porous screens can be measured in front of an anechoic termination. Additionally, their flow resistance shall be measured according to ISO 9053. The airflow resistance shall not be less than 1 600 $N \cdot s/m^3$.

When the screen is used as a room partition or open cabin enclosing a work station, its equivalent absorption area (see ISO 11690-1:1996, 3.4.3) is of interest. For individual, free-standing screens, this is determined by reverberation-room measurements in accordance with ISO 354.

Estimates of the absorption provided by the room, or the room boundary surfaces, around the intended screen are needed for the evaluation of the room in which the screen is to be used. These can be obtained from reverberation-time measurements (before the installation of the screen) or measurements according to the transfer-function method.

8.2 Sound insulation

Information on the sound insulation (sound reduction index) of the screen is only needed for screens with large porous areas, or where significant leaks occur at the joints resulting in a weighted apparent sound reduction index (see definition in ISO 717-1) $R'_{\mathrm{w}} < 20$ dB. Values can be verified according to ISO 717-1.

8.3 *In-situ* sound attenuation

The principal acoustical quantity of interest to the user of a screen is the A-weighted *in-situ* sound attenuation, $D_{p\mathrm{A}}$. The supplier or an expert must predict this quantity on the basis of a calculation based on the procedures outlined in 5.3, and on ISO 11690-1, taking into account the conditions of the room and the relevant sound source(s). Compliance of a removable screen with the specified performance shall be verified according to ISO 11821.

The determination of the *in-situ* sound attenuation, D_p, of a removable screen may also be carried out in accordance with ISO 11821 using an artificial sound source. This method shall be chosen when there is substantial background noise. It is also applicable to fixed (i.e. non-removable) screens.

For fixed screens, measurements at the microphone positions specified in ISO 11821 shall be carried out in the room during the planning stage with all relevant sound sources running, when the room is finished except for the installation of the screen(s). Measurements near the sound source shall be evaluated for the overall frequency range and for one-third-octave bands or octave bands. The measurements shall be repeated at the same microphone positions after installation of the screen. If, in those frequency bands which dominate the A-weighted overall sound pressure level, the sound pressure levels near the source have not changed by more than 3 dB between the measurements before and after the installation of the screen, the data may be evaluated as specified in ISO 11821.

The effect of fixed screens in planned rooms may be verified by measurements of acoustically comparable rooms, sound sources and screens.

Laboratory measurements of office screens according to ISO 10053 will not provide reliable information on the *in-situ* sound attenuation of a screen.

9 Information for user inquiries and information to be provided by the supplier/manufacturer of a screen

9.1 Information to be provided by the user

If applicable, the user/buyer shall provide the following minimum information needed to specify the requirements to be fulfilled by an acoustical screen:

a) type and dimensions of the machine, plant or work station to be screened;

b) dimensions of the room (height, width, length), fittings and sound absorption of the room;

c) type of screen (portable, removable or fixed);

d) specified acoustical performance (see Clause 8);

e) material for the screen surface (pattern, finishing, colour and surface protection);

f) permissible absorbent materials and covers;

g) dimensions and materials for transparent areas;

h) safety and hygiene requirements;

i) ventilation and air-conditioning of the room in which the screen is to be installed;

j) lighting;

k) electrical services;

l) maximum permissible mass and dimensions of the screen elements;

m) intended use for purposes other than acoustical screening (such as display of information, anti-glare device);

n) further special information.

9.2 Information to be provided by the supplier/manufacturer

The supplier/manufacturer of a screen shall provide at least the following information, if applicable, allowing determination of the operational properties of an acoustical screen:

a) acoustical performance, in terms of

— A-weighted *in-situ* sound attenuation, and

— equivalent absorption area, in octave bands;

b) geometry of the screen (sketch);

c) materials used, type of covering of absorbent material;

d) mass, mounting and connection of screen elements;

e) further special information.

Annex A
(informative)

Case studies

A.1 Simple removable screen on supports

The room and screen have the following characteristics:

— shape of room: low ceiling;

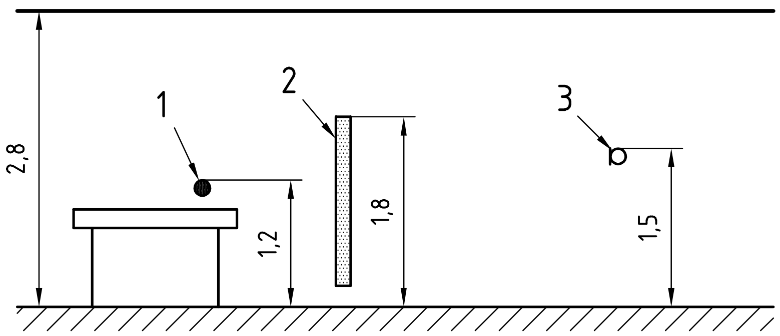
— ceiling: different areas with high and low absorption;

— screen: hard core covered with 50 mm mineral wool and textile material.

See Figures A.1 to A.3.

Figure A.1 — Photograph of removable office screen

Dimensions in metres



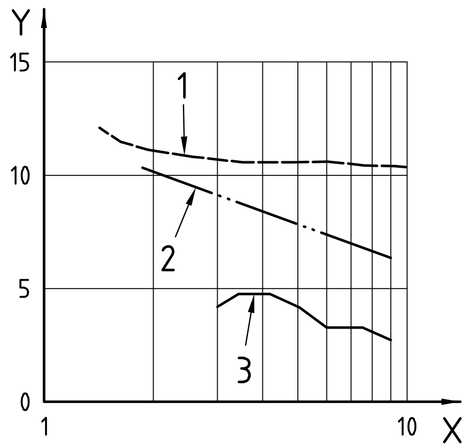
Key

1 sound source

2 screen

3 receiver (microphone)

Figure A.2 — Set-up for measurement of screen performance



Key

X distance between source and receiver, metres

Y insertion loss, D_{i}, in decibels

1 $D_{\mathrm{z,r}}$ calculated from Equation (2) for source height 1,2 m, screen height 1,8 m, receiver height 1,5 m, distance source to screen 1 m

2 measured under ceiling with high absorption

3 measured under ceiling with low absorption

Figure A.3 — Screen performance in terms of insertion loss in the octave band centred at 1 000 Hz **as a function of distance between source and receiver**

A.2 Screens enclosing a grinding workplace in a corner

The room and screen have the following characteristics:

— shape of room: low ceiling;

— ceiling: hardly absorbent;

— screen (from receiver side to source side):

  — approx. 1 mm steel sheet,

  — approx. 50 mm mineral wool,

  — approx. 1 mm perforated sheet.

See Figures A.4 to A.6.

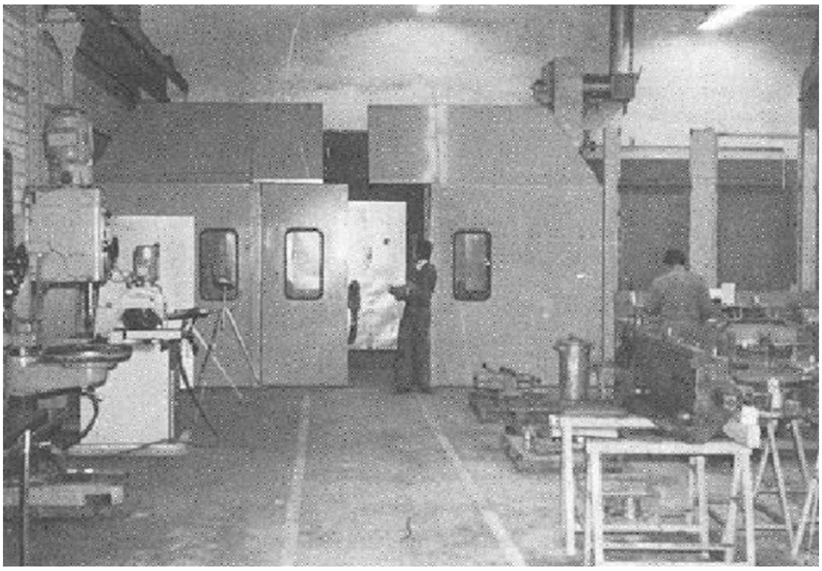
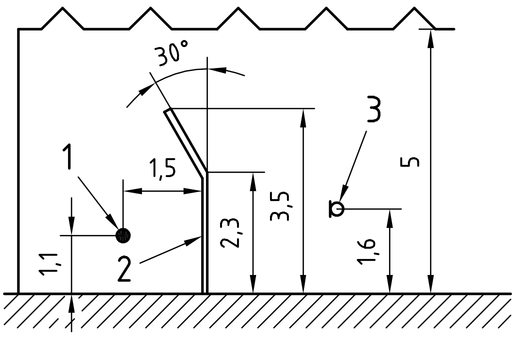


Figure A.4 — Photograph of screens enclosing a grinding workplace in a corner of a workroom

Dimensions in metres



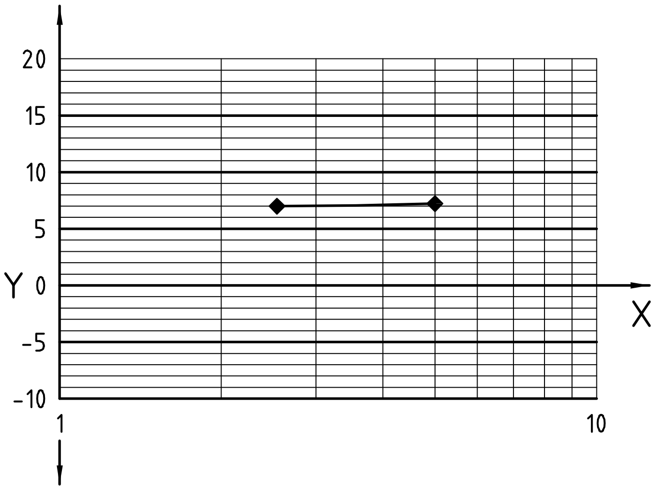
Key

1 sound source

2 screen

3 receiver (microphone)

Figure A.5 — Set-up for measurement of screen performance



Key

X distance between source and receiver, in metres

Y insertion loss, D_i, in decibels

Figure A.6 — Screen performance in terms of insertion loss in the octave band centred at 1 000 Hz as a function of the distance between source and receiver

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