INTERNATIONAL STANDARD

ISO 11690-1

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Acoustics — Recommended practice for the design of low-noise workplaces containing machinery —

Part 1:
Noise control strategies

Acoustique — Pratique recommandée pour la conception de lieux de travail à bruit réduit contenant des machines —

Partie 1: Stratégie de réduction du bruit

Reference number
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Contents

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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 11690-1 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

ISO 11690 consists of the following parts, under the general title *Acoustics — Recommended practice for the design of low-noise workplaces containing machinery*:

- *Part 1: Noise control strategies*
- *Part 2: Noise control measures*
- *Part 3: Sound propagation and noise prediction in workrooms*

Part 1 is the central document in the series. Parts 2 and 3 give additional technical and explanatory information. It is therefore recommended to start with part 1.

Annex A of this part of ISO 11690 is for information only.

Introduction

Most of the existing International Standards prepared in ISO/TC 43/SC 1 specify methods for measurement and/or evaluation of noise. The final objective of ISO 11690, however, is noise reduction.

A number of noise control measures are offered. However, in order to be effective, the most appropriate noise control measure(s) should be chosen for a given situation.

It is important when non-acoustic engineers are involved in noise control practice for these engineers to have a basic knowledge of noise emission and propagation characteristics and to understand the basic principles of noise control.

To assist in the development of noise control in the workplace, it is essential that the information contained in these recommended practices is disseminated through International Standards.

In order to reduce noise as a hazard in the workplace, individual countries have produced national legislation. Generally, such national legislation requires noise control measures to be carried out in order to achieve the lowest reasonable levels of noise emission, noise immission and noise exposure, taking into account:

— known available measures;

— the state of the art regarding technical progress;

— the treatment of noise at source;

— appropriate planning, procurement and installation of machines and equipment.

This part of ISO 11690, together with the two other parts in the series, outlines procedures to be considered when dealing with noise control at workplaces, within workrooms and in the open. These recommended practices give in relatively simple terms the basic information necessary for all parties involved in noise control in workplaces and in the design of low-noise workplaces to promote the understanding of the desired noise control requirements.

The purpose of the ISO 11690 series is to bridge the gap between existing literature on noise control and the practical implementation of noise control measures. In principle, the series applies to all workplaces and its main function is:

— to provide simple, brief information on some aspects of noise control in workplaces;

— to act as a guide to help in the understanding of requirements in standards, directives, text books, manuals, reports and other specialized technical documents;

— to provide assistance in decision making when assessing the various measures available.

The ISO 11690 series should be useful to persons such as plant personnel, health and safety officers, engineers, managers, staff in planning and purchasing departments, architects and suppliers of plants, machines and equipment. However, the above-mentioned parties should keep in mind that adherence to the recommendations of the ISO 11690 series is not all that is necessary to create a safe workplace.

The effects of noise on health, well-being and human activity are many. By giving guidelines for noise control strategies and measures, the ISO 11690 series aims at a reduction of the impact of noise on human beings at workplaces. Assessment of the impact of noise on human beings is dealt with in other documents.

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Acoustics — Recommended practice for the design of low-noise workplaces containing machinery —

Part 1:
Noise control strategies

1 Scope

This part of ISO 11690 outlines strategies to be used in dealing with noise problems in existing and planned workplaces by describing basic concepts in noise control (noise reduction, noise emission, noise immission and noise exposure). It is applicable to all types of workplaces and all types of sources of sound which are met in workplaces, including human activities.

It includes those important strategies to adopt when buying a new machine or equipment.

This part of ISO 11690 deals only with audible sound.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 11690. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 11690 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.

ISO 1996-1:1982, *Acoustics — Description and measurement of environmental noise — Part 1: Basic quantities and procedures.*

ISO 1996-2:1987, *Acoustics — Description and measurement of environmental noise — Part 2: Acquisition of data pertinent to land use.*

ISO 1999:1990, *Acoustics — Determination of occupational noise exposure and estimation of noise-induced hearing impairment.*

ISO 3740:1980, *Acoustics — Determination of sound power levels of noise sources — Guidelines for the use of basic standards and for the preparation of noise test codes.*

ISO 3741:1988, *Acoustics — Determination of sound power levels of noise sources — Precision methods for broad-band sources in reverberation rooms.*

ISO 3742:1988, *Acoustics — Determination of sound power levels of noise sources — Precision methods for discrete-frequency and narrow-band sources in reverberation rooms.*

ISO 3743-1:1994, *Acoustics — Determination of sound power levels of noise sources — Engineering methods for small, movable sources in reverberant fields — Part 1: Comparison method for hard-walled test rooms.*

ISO 3743-2:1994, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering methods for small, movable sources in reverberant fields — Part 2: Methods for special reverberation test rooms.*

ISO 3744:1994, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering method in an essentially free field over a reflecting plane.*

ISO 3745:1977, *Acoustics — Determination of sound power levels of noise sources — Precision methods for anechoic and semi-anechoic rooms.*

ISO 3746:1995, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane.*

ISO 3747:1987, *Acoustics — Determination of sound power levels of noise sources — Survey method using a reference sound source.*

ISO 4871:1996, *Acoustics — Declaration and verification of noise emission values of machinery and equipment.*

ISO 9614-1:1993, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 1: Measurement at discrete points.*

ISO 9614-2:1996, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 2: Measurement by scanning.*

ISO 11200:1995, *Acoustics — Noise emitted by machinery and equipment — Guidelines for the use of basic standards for the determination of emission sound pressure levels at a work station and at other specified positions.*

ISO 11201:1995, *Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Engineering method in an essentially free field plane.*

ISO 11202:1995, *Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Survey method in situ.*

ISO 11203:1995, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions from the sound power level.*

ISO 11204:1995, *Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Method requiring environmental corrections.*

ISO/TR 11688-1:1995, *Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 1: Planning.*

ISO 11689:1996, *Acoustics — Procedure for the comparison of noise-emission data for machinery and equipment.*

ISO 11690-2:1996, *Acoustics — Recommended practice for the design of low-noise workplaces containing machinery — Part 2: Noise control measures.*

IEC 651:1979, *Sound level meters.*

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

3 Definitions

For the purposes of this part of ISO 11690, the following definitions apply.

3.1 General noise descriptors

3.1.1 sound pressure level, L_p: Ten times the logarithm to the base 10 of the ratio of the mean-square sound pressure (p, in pascals) to the square of the reference sound pressure ($p_0 = 20$ µPa).

$$L_p = 10 \lg \left(\frac{p^2}{p_0^2} \right) \text{ dB}$$

The sound pressure level is the main quantity to describe the noise at a given point. It is expressed in decibels and shall be measured with a standardized sound level meter (see IEC 651).

The frequency weighting (A or C) or the width of the frequency band and the time weighting (S, F, I or peak) used shall be indicated.

NOTES

1 For example, the C-weighted sound pressure level with time weighting peak is $L_{pC,peak}$.

2 The notation L_p is used whether the sound pressure level refers to emission (see 3.2), immission or exposure (see 3.3).

3.1.2 time-averaged sound pressure level, $L_{peq,T}$: Sound pressure level of a continuous steady sound that within a measurement time interval, T, has the same mean square sound pressure as a sound under consideration which varies with time; it is the level of the mean square sound pressure over a time interval. It is expressed in decibels.

$$L_{peq,T} = 10 \lg \left[\frac{1}{T} \int_0^T 10^{0,1 L_p(t)} \, dt \right] \text{ dB}$$

The time-averaged sound pressure level is the main quantity to assess the immission at work stations and the exposure of persons. It is then called the equivalent continuous sound pressure level.

NOTES

3 When immission or exposure is considered, impulse and tone adjustments, DL_I and DL_T, in decibels, may be used to take into account the influence of impulsive and tonal components ($L_{pAeq,T} + DL_I + DL_T$) (see ISO 1996-1, ISO 1996-2 and ISO 1999).

4 Subscript "eq,T" is often omitted because in all cases considered in this part of ISO 11690 the sound pressure is averaged over a certain measurement time interval (see IEC 804).

3.1.3 work station: A position, in the vicinity of a machine, which can be occupied by the operator or a position where a task is carried out.

3.2 Noise emission descriptors

3.2.1 noise emission: Airborne sound radiated into the environment from a defined source (machine or equipment). [See figure 1a).]

3.2.2 sound power level, L_W: Ten times the logarithm to the base 10 of the ratio of the sound power (P, in watts) radiated by the sound source under test to the reference sound power (P_0 = 1 pW).

It is expressed in decibels and is a descriptor of the emission of a sound source (see the ISO 3740 and ISO 9614 series). The frequency weighting or the width of the frequency band used shall be indicated.

NOTE 5 For example, the A-weighted sound power level is L_{WA}.

3.2.3 emission sound pressure level, L_p: The sound pressure level caused by a sound source under test at its work station or at any other specified position. It is expressed in decibels and is an additional descriptor of the emission of a sound source (see ISO 11200 to ISO 11204).

The frequency weighting and/or the time weighting or the width of the frequency band used shall be indicated.

NOTES

6 For example, the C-weighted peak emission sound pressure level is $L_{pC,peak}$.

7 The A-weighted emission sound pressure level is often averaged over an operational period of a sound source; it is denoted L_{pA}.

3.2.4 surface sound pressure level, $L_{pA,d}$: The A-weighted sound pressure level averaged on an energy basis over a measurement surface at a distance d from the sound source (see ISO 3744). When d = 1 m, it is usually noted $L_{pA,1m}$.

3.2.5 measured noise emission value, L: Any of the A-weighted sound power level, the A-weighted time-averaged emission sound pressure level, or the C-weighted peak emission sound pressure level, determined from measurements. Measured values may be determined either for a single machine or from the average of a number of machines. They are expressed in decibels and are not rounded.

3.2.6 noise emission declaration: The information on the noise emitted by the machine, given by the manufacturer or the supplier in technical documents or other literature, concerning noise emission values. The noise emission declaration may take the form of either the declared single-number noise emission value or the declared dual-number noise emission value.

3.2.7 uncertainty, K: The numerical value of the measurement uncertainty associated with a measured noise emission value.

3.2.8 declared single-number noise emission value, L_d: The sum of a measured noise emission value and the associated uncertainty, rounded to the nearest decibel:

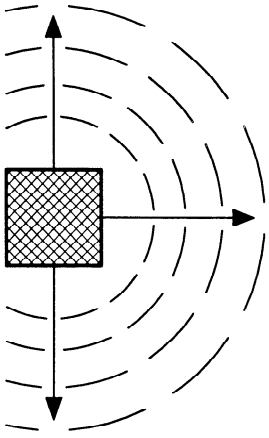
$$L_d = L + K$$

3.2.9 declared dual-number noise emission value, L and K: A measured noise emission value and its associated uncertainty, K, both rounded to the nearest decibel.

3.3 Noise immission and noise exposure

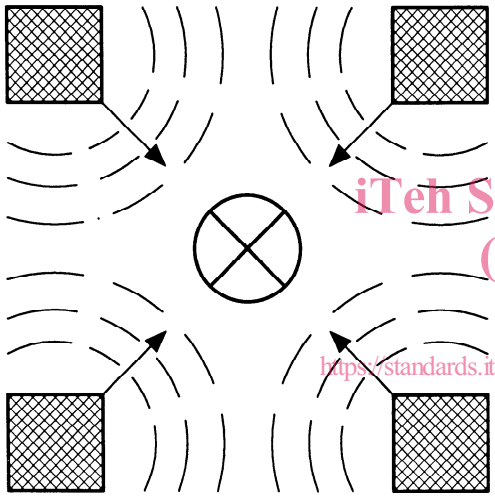
3.3.1 noise immission at a work station: All noises that arrive, whether or not a worker is present, over a specific time period T, at a measuring point (work station) in the actual situation; i.e. noise coming from the machine, noise coming from the other sound sources and noise reflected by the ceiling, the walls and any fittings. [See figure 1b).]

NOTE 8 T can be the duration of a measurement, an operating cycle of a machine, a process, the duration a worker is usually present at or near the measurement point, or the duration of the workshift.



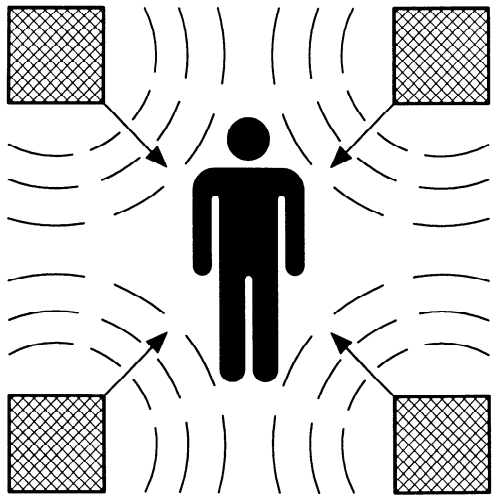
a) Noise emission; sound radiation of a machine:

- machine related
- specified operating conditions
- independent of environment



b) Noise immission; sound impact at the work station:

- work station related
- real operation
- dependendent on immission time
- contribution from all sound sources



c) Noise exposure; sound impact on human beings:

- person related [at one or several work stations or for a person moving around (see figure 2)]
- real operation
- dependent on exposure time
- contribution from all sound sources

Figure 1 — Illustration of the difference between noise emission, noise immission and noise exposure (see also figure 2)

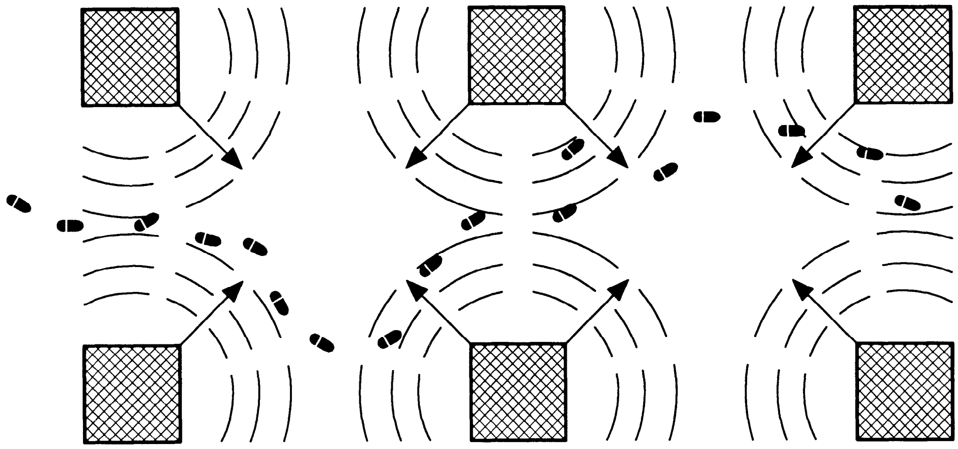


Figure 2 — Illustration of noise exposure for a person moving around

3.3.2 noise exposure of a person: All noises that arrive, over a specific time period T, at a person's ear in the actual situation. [See figure 1c) and figure 2.]

3.3.3 noise immission and noise exposure descriptors: The equivalent continuous A-weighted sound pressure level normalized to a nominal working day, $L_{p\mathrm{Aeq},T_0}$, in decibels:

$$L_{p\mathrm{Aeq},T_0} = L_{p\mathrm{Aeq},T_e} + 10\ \lg(T_e/T_0) \quad \mathrm{dB}$$

where T_0 is the reference duration (e.g. 8 h) and T_e is the duration of the workshift. Immission is measured at the work station. Exposure is measured at the ear of the person.

$L_{p\mathrm{Aeq},T_0}$ can result from the energetic summation of immission or exposure values, $L_{p\mathrm{Aeq},T_i}$, measured over individual time periods T_i, with $\sum T_i = T_e$.

In some countries, a rating level $L_{p\mathrm{Ar}}$ is used:

$$L_{p\mathrm{Ar}} = L_{p\mathrm{Aeq},T_0} + \mathrm{DL_I} + \mathrm{DL_T} \quad \mathrm{dB}$$

where $\mathrm{DL_I}$ and $\mathrm{DL_T}$ describe impulsive and tonal components.

3.4 Noise reduction

3.4.1 sound reduction index, ***R:*** A descriptor of transmission loss defined as ten times the logarithm to the base 10 of the ratio of the sound power incident on a test specimen to the sound transmitted through the test specimen. (See figure 3.) It is expressed in decibels and is frequency dependent.

NOTE 9 Methods for determining the insulation of walls, doors, ceilings and windows are described in parts 1 to 10 of ISO 140 (frequency band values) and in parts 1 and 3 of ISO 717 (single number ratings).

3.4.2 sound absorption coefficient, α**:** The fraction of the acoustic energy absorbed when sound waves strike a surface. It is frequency dependent.

NOTE 10 A single number rating is given in ISO 11654.

3.4.3 equivalent absorption area, A**:** The area, in square meters, obtained by summing the products $\alpha_i S_i$:

$$A = \alpha_1 S_1 + \alpha_2 S_2 + \ldots = \bar{\alpha} S$$

where

α_i is the absorption coefficient of a partial area, S_i, of a room surface;

S is the total room area ($= \sum S_i$);

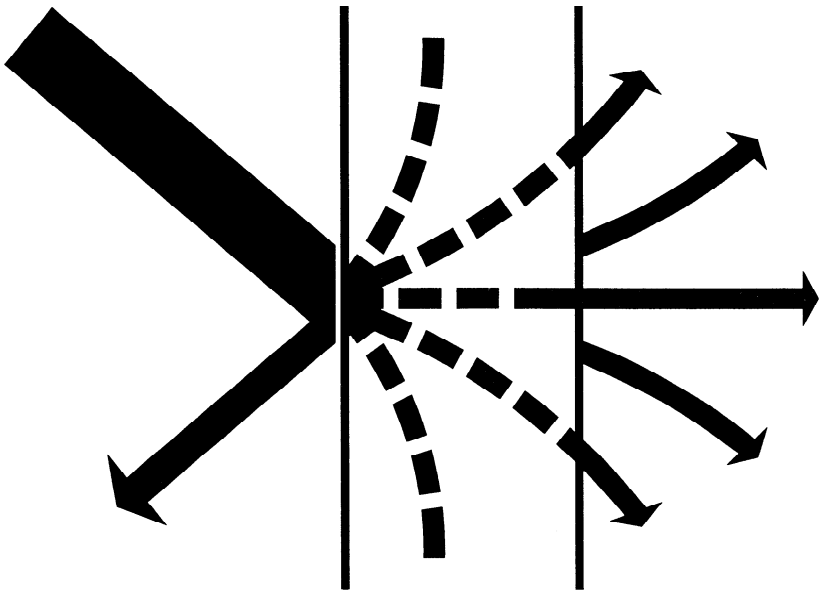
$\bar{\alpha}$ is the mean absorption coefficient of the room.

3.4.4 insertion loss, D_i**:** The difference in sound power level or emission sound pressure level with and without a noise control device applied to a sound source. D_i is frequency dependent and is expressed in decibels. The A-weighted insertion loss is always related to a given source.

NOTE 11 The insertion loss is used to assess the acoustical performance of enclosures (see ISO 11546-1 and ISO 11546-2), screens (see ISO 10053 and ISO 11821) and silencers (see ISO 7235, ISO 11691 and ISO 11820).

3.4.5 reduction of sound pressure level at a work station: The result of a set of noise reduction measures described by the difference in noise immission levels.

NOTE 12 For example, $L_{p\mathrm{Aeq,8h,1}} - L_{p\mathrm{Aeq,8h,2}}$, where numeral 1 means before and numeral 2 means after technical measures for reduction have been taken.



NOTE — A proportion of the sound which is incident on a partition or wall is reflected, a proportion is transformed into heat (i.e. is absorbed) and a proportion goes through the wall to the other side (i.e. is transmitted). The sound insulation of the wall determines what proportion of the incident sound is transmitted.

Figure 3 — Illustration of reflection, absorption and transmission at a boundary

3.4.6 direct sound: The sound which propagates directly from the source to the point of observation. No reflection of sound is involved so it is not affected by the characteristics of the room in which the source is located.

3.4.7 reflected sound: The sound at any point in a room, resulting from reflections from room surfaces and fittings. It does not include the direct sound.

3.4.8 diffuse-field conditions: Sound propagation in rooms or regions of rooms where the sound is reflected so often and uniformly from all surfaces of the room and the fittings that the sound pressure level of the reflected sound is the same at any point inside the region.

3.4.9 non-diffuse-field conditions: Sound propagation in rooms or regions of rooms where sound does not propagate uniformly in all directions. This is the case if

— the ratio of any two dimensions out of the three is more than three, or

— the absorption of the surfaces of the room is notably non-uniformly distributed (e.g. a room with hard walls and absorbent ceiling), or

— the absorption is high.

3.4.10 reverberation time, T**:** The time, in seconds, it takes for the sound pressure level in a room (originally in a steady state) to decrease 60 dB after the source is turned off. (See figure 4.) The reverberation time is frequency dependent. It is useful for describing the acoustic properties of rooms with a diffuse sound field; room volume must be taken into account.

3.4.11 spatial sound distribution curve: The curve which shows how the sound pressure level from a reference sound source decreases when the distance to the source increases. Such curves are frequency dependent and characterize the acoustic properties of rooms. In some cases, several spatial sound distribution curves are necessary to characterize a room.

From this curve and for a given range of distances from the source, two main quantities are determined (see figure 5):

— the rate of spatial decay per distance doubling (DL_2), and

— the excess of sound pressure level (DL_f).

Three distance ranges are normally of interest: near, middle and far regions. These two quantities (DL_2, DL_f) are useful for assessing the acoustic quality of a room.