PCD 454 - 1:2023
ICS: 13.140

DRAFT ZANZIBAR NATIONAL STANDARD

Acoustics — Recommended practice for the design of low-noise workplaces containing machinery — Part 1: Noise control strategies

ZANZIBAR BUREAU OF STANDARDS

First edition

Foreword

This draft Zanzibar National standard has been developed by Environmental and Risk Management Standards Technical Committee (TCE3). In accordance with ZBS general procedures, this draft standard is presented to the public in order to receive any technical and editorial comment concerns.

Technical Committee Representatives

This Draft Zanzibar National Standard was prepared by Soil and Air Quality Standards Technical Committee which consist of representatives from the following organizations:

Zanzibar Environmental Management Authority (ZEMA)
Department of Environment (DoE)
Tanzania Atomic Energy Commission (TAEC)
Zanzibar Upstream Regulatory Authority (ZPRA)
Ministry of Health (MoH)
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Introduction

Several standards specify methods for measurement and/or evaluation of noise. The final objective of the PCD 454 - 1:2023 series 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 experts are involved in noise control practice for these experts 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:

a) known available measures;

b) the state of the art regarding technical progress;

c) the treatment of noise at source;

d) appropriate planning, procurement and installation of machines and equipment.

This part of PCD 454 - 1:2023, 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 PCD 454 - 1:2023 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 workplacesand its main function is:

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

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

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

The PCD 454 - 1:2023 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 PCD 454 - 1:2023 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 PCD 454 - 1:2023 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.

Acoustics — Recommended practice for the design of low-noise workplaces containing machinery — Part 1: Noise control strategies

1 Scope

This document 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 document deals only with audible sound.

2 Normative references

The following referenced documents are indispensable for the application of this Zanzibar National Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61672-1, *Electroacoustics - Sound level meters - Part 1: Specifications*

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

ISO 3740, Acoustics — Determination of sound power levels of noise sources — Guidelines for the use of basic standards

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

ISO 7235, Acoustics Laboratory Measurement Procedures for Ducted Silencers and Air-terminal Units Insertion Loss, Flow Noise and Total Pressure Loss

ISO 9614, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 3: Precision method for measurement by scanning*

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

ISO 1996-2, *Acoustics — Description, measurement and assessment of environmental noise — Part 2: Determination of environmental noise levels*

ISO 1999, *Acoustics — Estimation of noise-induced hearing loss*

ISO 10053, Acoustics — Measurement of office screen sound attenuation under specific laboratory conditions

ISO 10140, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 2: Measurement of airborne sound insulation*

ISO 11200, *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 11204, *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 11546-1, *Acoustics — Determination of sound insulation performances of enclosures — Part 1: Measurements under laboratory conditions (for declaration purposes)*

ISO 11546-2, *Acoustics — Determination of sound insulation performances of enclosures — Part 2: Measurements in situ (for acceptance and verification purposes)*

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

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

ISO 11691*, Acoustics — Measurement of insertion loss of ducted silencers without flow — Laboratory survey method*

ISO 11820, *Acoustics — Measurements on silencers in situ*

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

3 Terms and definitions

For the purposes of this standard, the following (terms and) definitions shall apply.

3.1 General noise descriptors

3.1.1
sound pressure level Lp
ten times the logarithm to the base 10 of the ratio of the mean-square sound pressure p, in pascals, to the square of a reference value, P_0

$$Lp = 10lg\left[\frac{p^2}{p_0^2}\right]dB$$

where the reference value, p_0, is 20 µPa

NOTE 1: The sound pressure level is the main quantity to describe the noise at a given point. It is expressed in decibels and should be measured with a standardized sound level meter (see IEC 61672-1).

NOTE 2: The frequency weighting (A or C) or the width of the frequency band and the time weighting (S [slow], F [fast], I [impulse] or peak) used should be indicated.

NOTE 3 : For example, the C-weighted sound pressure level with time weighting peak is LpC, peak.

NOTE 4: The notation Lp is used whether the sound pressure level refers to emission (see 3.2), immission or exposure (see 3.3).

3.1.2
equivalent continuous sound pressure level Lpeq,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, and is the level of the mean square sound pressure over a time interval

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

NOTE 1: Equivalent continuous sound pressure level is expressed in decibels.

NOTE 2: The equivalent continuous sound pressure level is the main quantity to assess the immission at work stations and the exposure of persons.

NOTE 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 ($L_{pA,\,eq,T} + DL_I + DL_T$) (see ISO 1996-1, ISO 1996-2 and ISO 1999).

NOTE 4: Subscript “eq, *T*” is often omitted because in all cases considered in this document the sound pressure is determined over a certain measurement time interval (see IEC 61672-1).

3.1.3
work station
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 1 a)]

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

NOTE 1: Sound power level 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 should be indicated.

NOTE 2: For example, the A-weighted sound power level is L_{WA}.

3.2.3
emission sound pressure level L_p
sound pressure level caused by a sound source under test at its work station or at any other specified position

NOTE 1: Emission sound pressure level is expressed in decibels (dB) and is an additional descriptor of the emission of a sound source (see ISO 11200 to ISO 11204).

NOTE 2: The frequency weighting and/or the time weighting or the width of the frequency band used shall be indicated.

NOTE 3 : For example, the C-weighted peak emission sound pressure level is $L_{pC,peak}$.

NOTE 4 : 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 $L_{pA,d}$
A-weighted sound pressure level averaged on an energy basis over a measurement surface at a distance d from the sound source

NOTE: 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

NOTE 1: Measured values may be determined either for a single machine or from the average of a number of machines.

NOTE 2: Measured noise emission value is expressed in decibels and is not rounded.

3.2.6
noise emission declaration
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

NOTE: 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*
value of the measured uncertainty associated with a measured noise emission value

NOTE: Uncertainty is expressed in decibels and is not rounded.

3.2.8
declared single-number noise emission value L_d
sum of a measured noise emission value, *L*, and the associated uncertainty, *K*, rounded to the nearest decibel (dB)

$$L_d = L + K$$

3.2.9
declared dual-number noise emission value *L* and *K*
measured noise emission value, *L*, 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 1 b)]

NOTE: *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.

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 1 c) and Figure 2]

3.3.3
noise immission and noise exposure descriptors
equivalent continuous A-weighted sound pressure level normalized to a nominal working day, L_{PA,eq,T_0} in decibels

$$L_{p_A,e_qT_0} = L_{p_A,e_q,T_e} + 10lg(T_e/T_0)dB$$

where T_0 is the reference duration (e.g., 8 h) and T_e is the duration of the workshift

NOTE 1: Immission is measured at the work station. Exposure is measured at the ear of the person.

NOTE 2: L_{pA,eq,T_0} can result from the energetic summation of immission or exposure values, $L_{pA,eq,T_{i'}}$, measured over individual time periods $T_{i'}$ with $\sum T_i = T_e$.

NOTE 3: In some countries, a rating level $L_{pA,r}$ is used:

$$L_{pA,r} = L_{p_A,e_q,T_0} + DL_I + DL_T dB$$

where DL_I and DL_T describe impulsive and tonal components.

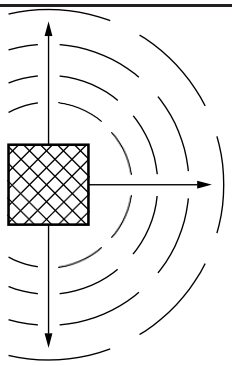
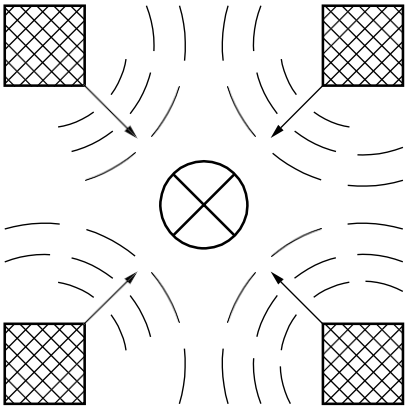
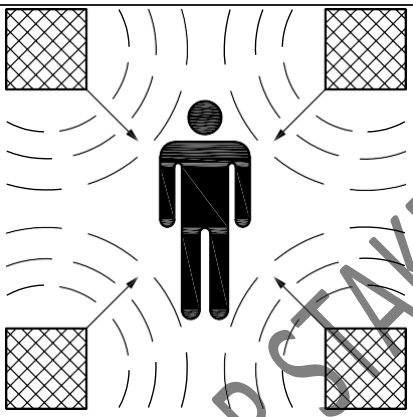
	a) Noise emission; sound radiation of a machine: — machine related — specified operating conditions — independent of environment
	b) Noise immission: sound impact at the work station: — work station related — real operation — dependent on immission time — contribution from all sound sources
	c) Noise 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)

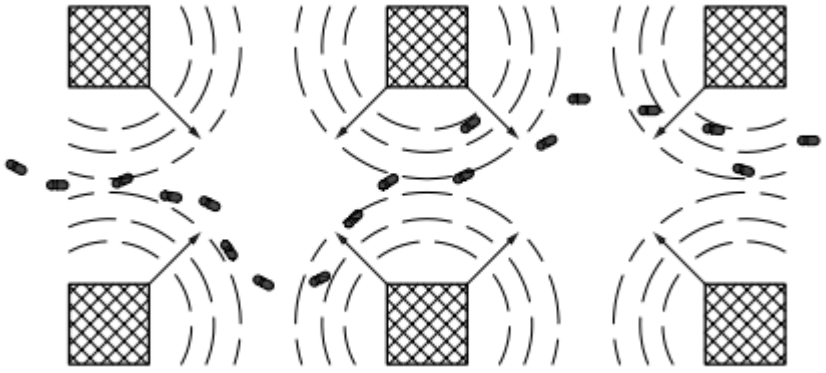


Figure 2: Illustration of noise exposure for a person moving around

3.4 Noise reduction

3.4.1
sound reduction index R
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.)

NOTE 1: It is expressed in decibels and is frequency dependent.

NOTE 2: Methods for determining the insulation of walls, doors, ceilings and windows are described in ISO 10140 (all parts) and in ISO 717-1.

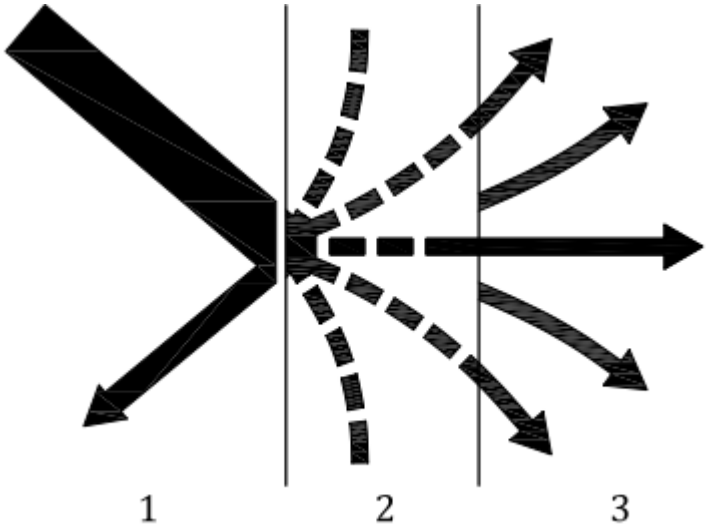


Figure 3: Illustration of reflection, absorption and transmission at a boundary

Key

1 reflection
2 absorption
3 transmission

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.

3.4.2
sound absorption coefficient α
fraction of the acoustic energy absorbed when sound waves strike a surface

NOTE 1: The sound absorption coefficient is frequency dependent.

NOTE 2: A single number rating is given in ISO 11654.

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

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

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 Di
difference in sound power level or emission sound pressure level with and without a noise control device applied to a sound source

NOTE 1: Insertion loss is frequency dependent and is expressed in decibels.

NOTE 2: The A-weighted insertion loss is always related to a given source.

NOTE 3: 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
result of a set of noise reduction measures described by the difference in noise immission levels

NOTE: For example, $L_{pA,eq,8h,1} - L_{pA,eq,8h,2}$, where numeral 1 means before and numeral 2 means after technical measures for reduction have been taken.

3.4.6
direct sound
sound which propagates directly from the source to the point of observation

NOTE: 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
sound at any point in a room, resulting from reflections from room surfaces and fittings, and excluding 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

NOTE: Non-diffuse-field conditions are the case if

a) the ratio of any two dimensions out of the three is more than three, or
b) the absorption of the surfaces of the room is notably non-uniformly distributed (e.g. a room with hard walls and absorbent ceiling), or
c) the absorption is high.

3.4.10

reverberation time T_{60}

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)

NOTE 1: The reverberation time is frequency dependent.

NOTE 2: 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

curve which shows how the sound pressure level from a reference sound source decreases when thedistance to the source increases

NOTE 1: Spatial sound distribution 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.

NOTE 2: From this curve and for a given range of distances from the source, two main quantities are determined (see Figure 5):

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

b) 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.

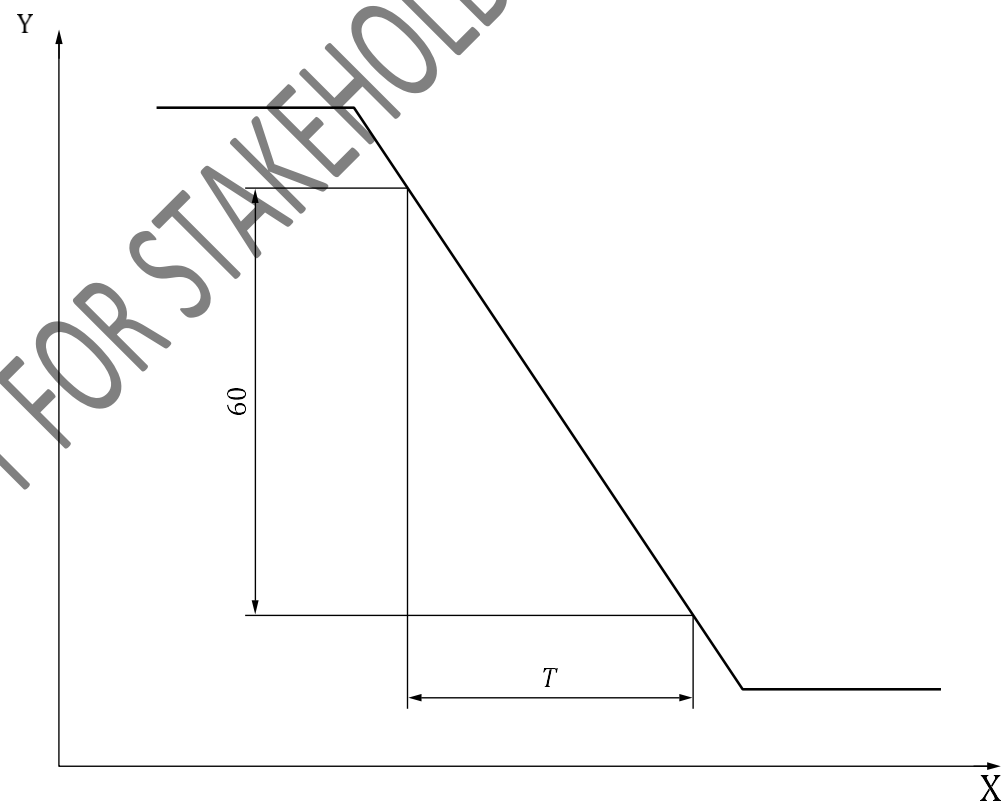


Figure 4: Idealized time history of sound pressure level after the sound source is turned off

Key

X time, in s

Y sound pressure level, in Db
T reverberation time

3.4.12
rate of spatial decay of sound pressure levels per distance doubling DL_2
amount, in decibels, by which the sound pressure level decreases over a given range of distances, when the distance from the source is doubled (see Figure 5)

3.4.13
excess of sound pressure level DL_f
average difference, in decibels, over a given distance range, between the spatial sound distribution curve of the room and the spatial sound distribution curve for a free field (6 dB per distance doubling) (see Figure 5)

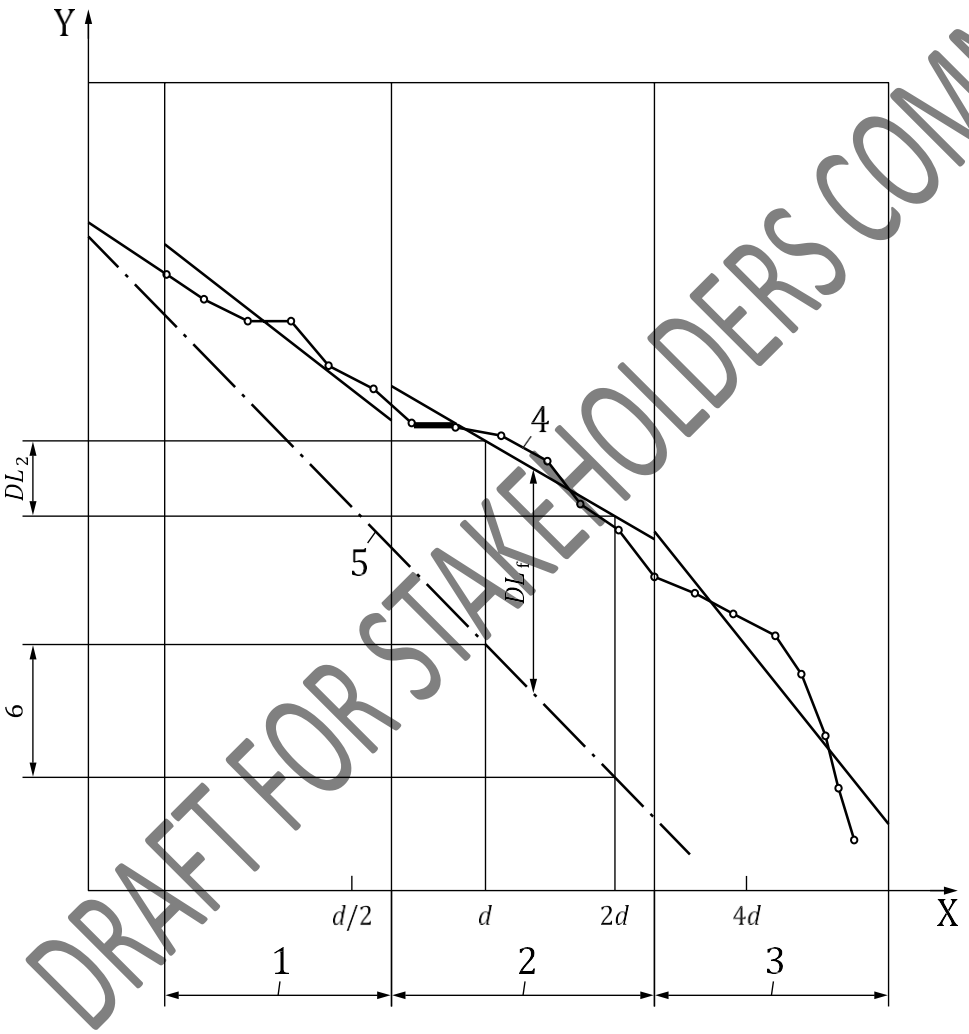


Figure 5 — Example of:
i) a spatial sound distribution curve for a room and for the free field;
ii) the three ranges of distances;
iii) the determination of the spatial decay (DL_2); and
iv) the excess (DL_f) of sound pressure level

4 Basic concepts in noise control

4.1 Basic noise control strategy

Effective noise reduction will only be achieved by dealing with the problem in a systematic manner. Listed below is a series of steps that should be considered when formulating a noise control strategyand implementing noise control measures for new and existing workplaces.

a) Determine objectives and establish criteria.

b) Carry out noise assessment by identifying:

i) the areas concerned,

ii) the immission at work stations,

iii) the contributions of different noise sources to the immission at work stations,

iv) the exposure of persons,

v) the emission of sources in order to rank them.

c) Consider noise control measures such as:

i) noise control at source,

ii) noise control on the transmission path in the workplace,

iii) noise control at work stations.

d) Formulate a noise control programme.

e) Implement the appropriate measures.

f) Verify the noise reduction attained.

4.2 Concept of noise reduction

Noise control can be implemented using various technical measures (see ISO 11690-2) and there maybe several ways to solve a noise problem. These measures are noise reduction at source (e.g., machines, working processes), noise reduction by increasing the attenuation of sound during its propagation (e.g. using enclosures, screens, absorbing linings), noise reduction at specific positions (e.g. using cabins).

Technical measures for noise control should be applied in order to implement the state of the art with regard to noise control. For this purpose, it is necessary to compare and determine the effectiveness of these measures. Acoustical quantities are used for this purpose. They describe the acoustical features of the sound sources, the noise reduction attained in workplaces, and especially at work stations, when sound sources are operating and some noise control measures have been implemented.

The connection between regulations, standards and the use of acoustical quantities to assess noise control measures offered by the market is illustrated in Figure 6.

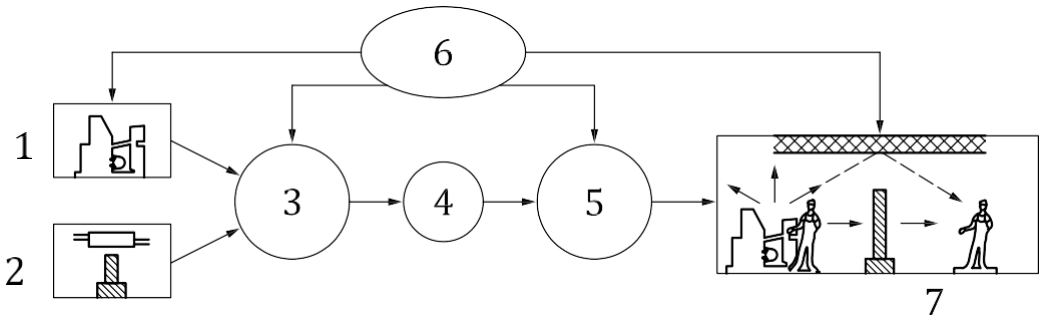


Figure 6: Factors affecting noise control

Key

1 machinery
2 additional noise reduction measures
3 characteristic acoustic quantities
4 market
5 purchase, assessment, planning, design
6 regulations, standards
7 user of technical equipment

If noise immission and noise exposure levels are low, all possible effects of noise on man are reduced. Such effects include hazards to health and safety, for example impairment of hearing capacity, stress, disturbance of speech communication and recognition of warning signals, disturbance of tasks requiring high concentration and attentiveness.

5 Assessment of the noise situation

5.1 Quantities for noise emission, noise immission and noise exposure

5.1.1 Noise emission quantities [see 3.2 and Figure 1 a)]

An important characteristic emission quantity which is normally used is the A-weighted sound power level (L_{WA}) under defined mounting and operating conditions.

Another characteristic emission quantity is the A-weighted emission sound pressure level (L_{pA}) at a specified position for defined mounting and operating conditions and due to the machine only.

There are further noise emission quantities such as frequency band levels, the C-weighted peak emission sound pressure level at the work station and the time history.

Basic methods for measuring and declaring noise emission values are given in the ISO 3740 series, the ISO 9614 series, the ISO 11200 series and ISO 4871. Noise test codes specify, for families of machines and equipment, mounting and operating conditions during the determination of noise emission quantities.

5.1.2 Noise immission and noise exposure quantities [see 3.3 and Figures 1 b), 1 c) and 2]

In contrast to the emission quantities which are intrinsic descriptors of machines as sound sources, noise immission quantities describe the total sound impact on the work station, and noise exposure quantities describe the impact on human beings.

Noise immission quantities are evaluated at a given work station and over a time period representative of the daily (or weekly) activity at this work station. If several activities follow one another at a work station, it may be necessary to evaluate a set of noise immission values at this work station.

Since they are specific to a person who may daily (or weekly) occupy different work stations, noise exposure quantities can be evaluated from the noise immission or exposure quantities and the time spent at each of the work stations concerned.

Noise exposure quantities for a person who occupies a single work station are identical to the noise immission quantities of that work station.

In general, values of $L_{pA,eq,8h}$, $L_{pA,r}$ and $L_{pC,peak}$ are compared to noise immission and exposure limits. The measurement uncertainty should be added to these values prior to the comparison with limits.

5.2 Description of the noise situation

In order to describe the noise situation in defined areas of a workplace, indoors or outdoors, the following steps are normally carried out:

a) determination of work stations and related immission quantities;

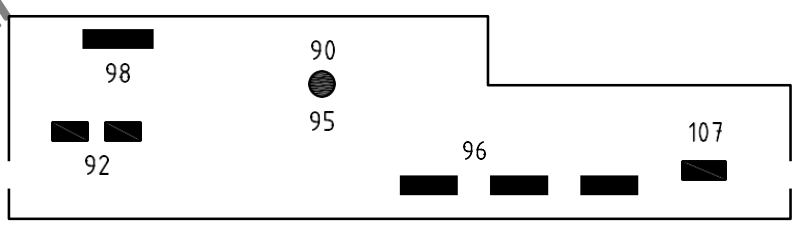
b) determination, for each person, of the work stations involved and the corresponding exposures;

c) determination of sound sources and related noise emission quantities.

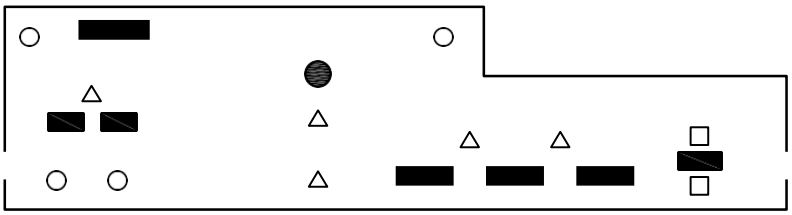
These data can be listed on a noise information sheet such as that shown in Table 1 for industrial workplaces. Noise maps can also be useful (see Figure 7).

Table 1: An example of noise description of a workplace

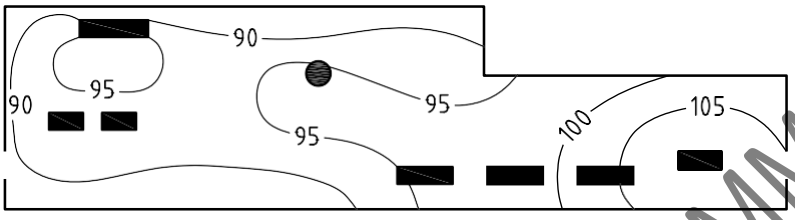
A) List of work stations				
Work station No.	Description of work station (task, job function, machine operation, process, etc.)	Machine No. (No. from C)	Noise Immission values	Additional values (e.g., $L_{pC,\ peak}$, DL_I)
1 2 3 …				
B) List of persons				
Person No.		Work station 1(No. from A) Duration	Work station 2[a] (No. from A) Duration	Noise exposure values
1 2 3 …				
C) List of equipment/machines				
Machine No.	Description of machine	Sound power level	Emission sound pressure level	Operating condition
1 2 3 …				
[a] More columns can be added if there are more work stations.				



a) Indication of noise levels at work stations



b) Indication of region of noise levels (colours are often used for such noise maps)



c) Equal noise level curves (here with 5 dB increments)

Figure 7: Different illustrations of noise maps for a given workplace

Key

○ up to 90 dB

△ from 90 dB to 100 dB

□ above 100 dB

5.3 Use of noise information sheets and noise maps

Noise information sheets and noise maps can be used for a variety of purposes:

a) to assess noise immission at work stations;
b) to identify the location of high-noise areas and dominant sound sources;
c) to identify noisy areas where noise immission levels exceed relevant noise limits;
d) to show the actual noise situation at a specified time;
e) as important tools at the planning stage of a new workplace;
f) as an aid to assess the effect of changing a machine, a working process or a working layout;
g) to verify the effectiveness of measures taken or planned;
h) as an aid to setting up a long-term noise control programme;
i) as a tool for dialogue and coordination between the parties involved;
j) to inform the persons exposed about the noise situation;
k) as an aid in the performing of audiometric programmes and to motivate workers to wear personal hearing protectors.

6 Parties involved

Noise control measures may modify substantially the machine/operator environment. It is therefore recommended that all interested parties be involved in any proposed control measures.

Representatives of various functions in the company may be involved: i.e., management, planners, purchase department, health and safety committees, medical orderlies, maintenance, process and production departments, technical staff, unions and, obviously, the workers involved. To ensure effective participation by all parties concerned, prior and appropriate information and training are often necessary.

The diagnosis of the noise problem, its study and the definition and implementation of noise control measures are normally performed in collaboration with the parties concerned. In many situations, the involvement of external parties such as health and safety and labour protection authorities, specialists in acoustics and ergonomics, etc. is recommended. Such collaboration between the company representatives and external parties ensures that all constraints specific to the project under study are taken into account when choosing the noise control measures.

The success of noise control planning is dependent on active and committed involvement of company management representatives.

7 How to tackle noise problems in workplaces

7.1 Noise control objectives

Objectives should be based on general knowledge on how noise affects people's health and interferes with their activities. When setting objectives in relation to the acoustical quality of a work station or workroom, the required noise levels, reverberation time and sound propagation parameters should be set.

NOTE: Details are given in ISO/TR 11690-3.

Noise control objectives should be based on the fact that noise should be reduced to the lowest levels feasible, taking into account technical progress, production processes, tasks and noise control measures. The main objectives can be expressed in terms of noise immission and/or noise exposure levels. Commonly considered A-weighted values that should not be exceeded for noise immission and/ or noise exposure are the following:

a) in industrial workplaces, 75 dB to 80 dB;

b) for routine office work, 45 dB to 55 dB;

c) for meeting rooms or tasks involving concentration, 35 dB to 45 dB.

NOTE 1: The above values are recommended target values. National regulations should be consulted for noise immission and/or exposure limit values.

NOTE 2: Impulsive and tonal noise can be more dangerous and annoying than continuous broadband noise. Therefore, the control of such types of noise should have high priority.

A convenient way to set noise control objectives for workplaces is to link noise levels to the type of task and the acoustical properties of the workroom.

Recommended background noise levels in different workrooms are given in Table 2. Recommended values for reverberation times, equivalent absorption areas and spatial sound pressure decays are given in Table 3.

Table 2: Maximum recommended background noise levels

Type of room	L_{pA}eq dB
Conference rooms	30 to 35
Classrooms	30 to 40
Individual offices	30 to 40
Multi-person offices	35 to 45
Industrial laboratories	35 to 50
Control rooms in industry	35 to 55
Industrial workplaces	65 to 70
NOTE: Background noise is noise arising from indoor technical equipment (e.g. ventilation systems) or noise coming from the outside, with production machines off in the case of a workplace in industry.	

Table 3: Recommended acoustical properties of workrooms

Room volume m^3	Reverberation time s	Rate of spatial sound pressure decay per distance doubling, DL_2 dB
Less than 200	Lower than 0.5 to 0.8	—
Between 200 and 1 000	Between 0.8 and 1.3	
Greater than 1 000	—	Greater than 3 to 4
NOTE 1: These recommendations are usually fulfilled if the mean absorption coefficient of the room is higher than 03 or if the equivalent absorption area is higher than 06 to 09 times the floor area, in square meters.		
NOTE 2: When the room is flat (room without diffuse-field conditions, see 3.4.9 and ISO/TR 11690-3), the use of the equivalent absorption area or the spatial decay is preferred.		

7.2 Principles of noise control planning for new and existing workplaces

7.2.1 General

The acoustical planning of new workplaces and the design and implementation of required noise control measures in existing workplaces should be combined with the overall design of a whole new plant or the modification of existing ones. In this way, acoustical design and noise control can be carried out in the most effective manner in close relation to the construction of the plant or modification of the production process or building structure. If noise control is the only target, there is freedom to concentrate on noise control at the initial design stage.

With existing workplaces, retrospective noise control measures can be more difficult to achieve.

In every acoustical design and noise control task, it is useful to draw up a plan of operations for different action stages. Whatever the task, there are some basic stages which follow the progress of the work. These stages are

a) preliminary planning and design,

b) planning and design,

c) implementation of measures, and

d) assessment and acceptance.

The importance of these stages varies with the task. In the acoustical design of totally new

premises, the preliminary planning and design stage and the planning and design stage play very important roles since, in this case, it is possible to influence all factors related to a good acoustical environment.

In the modification of existing workplaces (because of the likely effects on production/processes), there are more constraints on noise control actions, and more emphasis should be put on planning and implementation stages.

There should be a system for organizing and controlling the work. This can be best achieved by establishing a project group. This group should have the necessary authority and influence at the planning and implementation stages and should ideally include a representative from each involved section of the company plus an acoustical consultant. A representative of health and safety and/or labour protection authorities may also be included.

7.2.2 Preliminary planning and design stage

At the preliminary planning and design stage, all the acoustical and noise control design features should be considered; i.e. objectives, effects of production solutions, effects of basic layout of production and general procedures related to noise control planning. The organization of the work (formation of a planning group and introduction of the required professionals in the group) should be decided at this stage.

Noise control objectives should be decided at this stage (see 7.1 and Tables 2 and 3). The upper limits for the immission noise levels in different parts of the plant are usually set by regulations. Possible noise emission limits for the machines to be used are also to be considered. However, when designing new plants or modifying existing ones, the objectives should generally be more stringent (lower emission and immission noise levels) than those given in the relevant regulation. Objectives regarding the acoustical quality of the room (reverberation time, spatial sound distribution) can also be set (see Table 3).

An important aspect in noise control is the location of work stations in relation to the position of noisy machines and equipment. If the production is mainly automatic, only the maintenance personnel are exposed to possible high noise levels caused by machines and equipment. In this case, low noise exposure of workers is much easier to achieve but should, however, be considered at this stage. In some situations, automation or remote control of the process, the machine or the equipment may be the only feasible measure.

The choice of the production layout is generally based on production efficiency. Efficient material flow is often the key point when choosing the basic layout. Unfortunately, this is often in conflict with a good acoustical design. Efficient material flow demands large open spaces with as few walls, screens and fittings as possible. A good acoustical design is often possible only in small spaces which are separated from noisy machines.

At the preliminary planning stage, each activity should be identified and its location considered in relation to the effects of noise. Proper planning should consider locating noisy machines away from work stations or isolating machines from work stations. Offices should be sited such that they are not affected by airborne and structure-borne sound (see ISO 11690-2).

For construction companies or companies participating in the erection of large technical facilities, it is necessary to meet the *in-situ* noise control requirements of the client, designer and other contractors and to consider the possible consequences of project costs.

7.2.3 Planning and design stage

At the planning and design stage, effective noise control by design needs to consider three phases:

a) determination of noise emission values of machines,

b) estimation of sound propagation parameters of the room and of noise immission levels, and

c) selection of noise control measures

Because this stage has the most influence on the outcome, the assistance of an acoustical

consultant is often useful.

7.2.3.1 Determination of noise emission values

An acoustical environment can be designed and an appropriate noise control plan be drawn up only if the noise emission values of the machines are known. The determination of noise emission values is described in Clause 8. If these emission values are not known, estimation may be helpful.

7.2.3.2 Estimation of sound propagation parameters of the room and of noise immission levels

The most efficient way to estimate noise immission levels and sound propagation parameters of the room is to use computer-based noise prediction techniques developed for the acoustical design of workplaces, in conjunction with experienced interpretation (see Clause 9 and ISO/TR 11690-3).

In addition to the prediction of noise levels in production areas, the transmission of noise from one room into another should be examined (see ISO 11690-2:2020, Clause 6).

7.2.3.3 Selection of noise control measures

It is necessary, when deciding which noise control measure(s) to adopt, to establish the noise emission levels of machines, the noise immission levels and the sound propagation parameters and to compare these with the objectives. The following steps should then be considered:

a) consideration of the relevant noise control measures,

b) evaluation of their effects on noise levels (see Clause 9 and ISO/TR 11690-3), production process and other aspects.

Based on these evaluations, the most appropriate set of noise control measures should be selected and the detailed plans with necessary drawings and descriptions of the work to be done should be made (see ISO 11690-2).

7.2.4 Implementation stage

When deciding the time schedule for the implementation of the measures chosen, the following items should be considered:

a) priority of the task involved,

b) relationship to other tasks, and

c) planning of each step.

The following general principles apply.

a) The tasks related to building a new plant are carried out in this stage; for example, structural joints, vibration isolation (e.g., floating floors), structures for airborne sound insulation and absorbent lining of surfaces are accomplished (see ISO 11690-2).

b) The tasks related to machine structures are carried out by the machine manufacturer in close collaboration with the buyer (see ISO/TR 11688-1 and ISO/TR 11688-2).

c) Silencers, isolators and enclosures are considered in relation to the installation of the machines andequipment (see ISO 11690-2).

In 7.3 is given information specific to the case of existing workplaces that are too noisy.

7.2.5 Assessment and acceptance stage

After the completion of the new plant or the modification of the existing one, the acceptance inspection is carried out. This includes the following tasks (see ISO 11690-2:2020, Clause 8):

a) measurement of noise immission levels (and, if necessary, of noise emission values and sound propagation parameters) in relation to the objectives;

b) verification of the performance of noise control devices, if any;

c) identification of possible installation faults and their repair;

d) identification of possible manufacturing errors in machines and their repair;

e) statement of possible additional tasks to reach the objectives.

7.3 Dealing with existing noise problems

Noise problems in existing workplaces can be due to many things such as

a) lack of basic knowledge of noise generation/control,

b) insufficient care in design and installation of machines, and

c) lack of maintenance of machines and equipment.

The strategy for dealing with such problems should at least always follow five steps, as follows.

Step 1: Avoid noise (turn off machines that are not used, avoid impacts and falling parts, etc.).
Step 2: “Do things right” (shut doors in buildings and enclosures, fix loose shutters and other components, etc.).

Step 3: Substitute a noisy process with a quiet one (see ISO 11690-2:2020, Annexes A and B).

Step 4: Plan quiet areas.
Step 5: Implement noise control measures (see ISO 11690-2).

The identification of noise problems, and the planning, implementation and verification of noise control measures are described in 4.2, 5.2 and 7.2.

In many cases, noise problems can be solved without specialized acoustical knowledge. This applies mostly to steps 1 and 2, but can also be true for steps 3, 4 and 5. In all cases, a strong motivation is necessary and the assistance and advice from persons with experience in noise control will help.

8 What to do before buying a new machine

8.1 Questions that a potential buyer should consider

Before purchasing a new machine, a potential buyer should always consider the following basic questions.

a) Is information (noise declaration) available about the noise emission of that family of machines and about the lowest noise emission level achievable?
b) Has a specific request for information or guarantee on noise emission been included in the tenderto potential suppliers, and is the request properly formulated?
c) What will be the noise impact of the new machine on the workroom where it will operate?

In order to answer these questions, the potential buyer should do the following.

d) Study the noise immission information available for the workplace where the machine will operate, or, if it does not exist yet (planning stage), for another workplace with similar industrial activity.
e) Study the noise emission information that may already be available in the company for similar machines.
f) Consider the noise immission limits applicable to the workplace concerned and, if any, the noise emission limits for the machines.
g) Examine the long-term noise reduction programme of the company, if any.
h) Determine what noise emission information and, optionally, what compliance with a noise immission requirement the purchaser can reasonably request from potential suppliers, taking into account technical usefulness and practicability. This may imply an interaction between several parties inside and outside the company and a dialogue with potential suppliers.
i) Consider what this noise emission information means, how it can be used and for what

purposes.

8.2 What information to request from potential suppliers

The basic information to be requested from potential suppliers includes the following noise emission data:

a) declared single-number A-weighted sound power level, $L_{WA,d}$, or dual-number value (see Table 4 and ISO 4871);

b) emission sound pressure levels at the work station(s):

i) declared single-number A-weighted sound pressure level, $L_{pA,d}$, or dual-number value (see Table 4 and ISO 4871),

ii) declared C-weighted peak emission sound pressure level, $L_{pC,peak,d}$, if relevant;

c) reference to the standardized noise test code used or, if there is no such code for the machine concerned, a full description of the noise emission measurement method, the work station position, the mounting and operating conditions and the workcycle of the machine that have been used.

It is recommended to request:

i) emission sound pressure levels at the work station(s) in frequency bands,

ii) sound power levels in frequency bands, and

iii) information on the directivity of the sound emission, if relevant.

Table 4 gives an example of a typical noise emission data sheet to be supplied by machine manufacturers at the request of the potential buyer. The technical data and description of the machine should be given in other data sheets for the supply specification.

If a noise test code exists for the family of machines concerned, the above noise emission quantities should comply with the requirements of this test code. Explicit reference in the noise emission declaration to the applicable standardized noise test code, if any, should be given. If the noise test code offers alternatives (regarding operating and mounting conditions, workcycles, work station positions, noise measurement methods) or if no noise test code exists, the noise emission declaration should yield all information necessary to make the noise declaration clear.

Additionally and following a private agreement between the buyer and a potential supplier, noise emission data for workcycles, mounting and operating conditions different from those specified in the relevant noise test code, if any, and those that correspond to conditions of operation of special interest to the buyer, may also be provided by the supplier.

Table 4: Noise emission data sheet

1	**Machine**								
1.1	Type:	**1.6**	Noise-related machine parameters						
1.2	Model:		Rated electrical power:						
1.3	Manufacturer:		Rated mechanical power:						
1.4	Machine No.:		Rated speed:(as examples)						
1.5	Year of manufacture:		Max. speed:						
			etc.						
2	**Measured noise emission values**								
	Noise emission measurements according to ISO... and ISO...	Operating conditions according to ISO...			Other agreed operating conditions				
		No load See 2.6.1			Load See 2.6.2		Planned use See 2.6.3		
2.1	Sound power level L_{WA}, (dB, ref. 1 pW)	dB			dB		dB		
2.2	Measurement uncertainty	dB			dB		dB		
2.3	A-weighted emission sound pressure level at workstation, L_{pA}	dB			dB		dB		
2.3.1	Alternatively, 1 m-surface sound pressure level, $L_{pA,1m}$, or	dB			dB		dB		
2.3.2	Maximum value of sound pressure level at 1 m distance from machine surface and 1,60 m above the floor, $L_{PA,1m,max}$	dB			dB		dB		
2.4	C-weighted peak emission sound pressure level at work station,$L_{pC,}$	dB			dB		dB		
2.5	Optionally, sound level L_W or L_p in octave bands for operating conditions according to ISO ...								
	f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
	L_W □ L_P at work station □ in dB								
2.6	Information on operating conditions								
2.6.1									
2.6.2									
2.6.3									
3	**Noise abatement**								
3.1	Are noise reduction measures included in the design of the machine? Yes □ No □ If yes, what noise reduction measures have been applied?.....								
3.2	Is there a low-noise version for this model of machine? Yes □ No □								
	If yes, which noise reduction has been achieved?								
		No load			Load		Planned use		
	Reduction of L_{WA}	dB			dB		dB		
	Reduction of L_{pA}	dB			dB		dB		

4	**Declared values** Alternatively: declared single-number (4.1) □	dual-number (4.2) □		
		No load	Load	Planned use
4.1	Declared single-number noise emission value			
4.1.1	Sound power level, $L_{WA,d}$	dB	dB	dB
4.1.2	Emission sound pressure level at work station, $L_{PA,d}$	dB	dB	dB
4.2	Declared dual-number noise emission value	dB	dB	dB
4.2.1	Sound power level, L_{WA}	dB	dB	dB
	Uncertainty, K_{WA}	dB	dB	dB
4.2.2	Emission sound pressure level at work station, L_{pA}	dB	dB	dB
	Uncertainty, K_{PA}	dB	dB	dB
4.3	C-weighted peak emission sound pressure level at work station, $L_{PC,peak}$	dB	dB	dB

8.3 Declared and additional noise emission values

Values of noise emission are given by the manufacturer in the noise declaration. The method and procedure to verify these values are defined in ISO 4871.

Additional noise emission data may also be provided in the noise declaration. This may be information that has been estimated, calculated or measured under various operating conditions, test environments, etc. The noise declaration should make a clear distinction between declared and additional noise emission values.

8.4 Meaning and use of noise emission values

Noise emission values are intrinsic characteristics of a machine. There is no unique and simple relationship between the noise emission values of a machine and the noise immission values that will be encountered when the machine is finally in operation in a workroom. Noise emission information is not meant to provide information directly usable for assessing noise immission levels. Generally, noise immission sound pressure levels at the work station(s) of a machine are higher than the noise emission sound pressure levels at the same work station(s) given in the noise emission declaration because of sound reflection by walls, contributions from other sound sources, and operating conditions different from those for which the noise declaration is given.

Noise emission values may be used for the following purposes:

a) selection of the machine with the lowest noise emission;

b) assessment of the state of noise reduction technology;

c) to allow a technical dialogue between buyers and suppliers;

d) prediction of likely noise immission levels in the workroom where the machine (and others) will operate (see Clause 9 and ISO/TR 11690-3);

e) evaluation of compliance by the buyer with specified or guaranteed noise emission levels.

The user of machines shall follow legal requirements laid down by national regulations in the field of noise abatement at the workplace and its vicinity. The machine user shall therefore ensure that legal obligations regarding noise immission are considered in the planning, purchasing and acceptance of new machines. In addition to other technical requirements, the machine with the lowest noise

emission should then be searched for, identified, and selected if feasible.

The availability of noise emission values prior to purchase allows a potential buyer to consider at the planning stage all possible noise reduction measures.

From the noise emission data of a machine, noise immission levels in the workroom where it is to operate can be estimated (see Clause 9 and ISO/TR 11690-3). From predicted noise immission levels, it is possible to estimate whether noise immission targets are achieved. If the prediction shows that these target levels are likely to be exceeded, then the potential buyer should discuss with the potential supplier possible technical noise reduction measures that may be taken on the machine (see ISO 11690-2:2020, Clause 5). If such measures are expected to be insufficient, the potential buyer should envisage technical and/or organizational changes within the workroom (see ISO 11690-2:2020, Clause 6).

8.5 Requirements for noise immission levels

Additionally to the declared noise emission values, a potential buyer may ask a supplier to guarantee that a given noise immission level at defined positions in a given workroom and for defined operating conditions of the machine shall not be exceeded once the machine is in operation. In practice, this implies close collaboration and a technical dialogue between the various parties involved inside and outside the company, because the noise impact of a new machine depends largely on the initial noise situation of the workroom concerned.

A-weighted immission sound pressure levels at the work stations(s) of a machine can be about 5 dB to

15 dB higher than the declared emission sound pressure levels, due to noise from similar neighbouring machines, workroom reverberation and operating conditions different from those for which noise declaration was made. Consequently, one can only be sure without any calculation that the installation of a machine in a workroom will not cause an A-weighted noise immission target of 85 dB to be exceeded if the declared A-weighted immission sound pressure level of the machine at its work station(s) does not exceed 70 dB. In all other situations, proper estimations or, preferably, noise predictions are necessary to determine whether compliance with noise immission objectives is likely to be obtained or not.

8.6 Verification of declared noise emission and/or noise immission levels

The buyer of a machine may wish to determine whether or not the noise emission values given in the noise emission declaration of the supplier are exceeded and/or that a specific noise immission requirement is met.

Verification of declared noise emission values shall be made in accordance with the methods and procedures given in ISO 4871.

Verification of noise immission values should be conducted in accordance with a noise measurement protocol agreed between the buyer and the supplier (see Clause 5 and also ISO 11690-2:2020, Clause 8).

8.7 Developments

Noise emission declaration by machine suppliers is made compulsory by some national regulations. The ongoing standardization work will make updated methods for noise emission measurement and noise test codes for families of machines available as International Standards. Through the proper application of these standards, comparable noise emission data will be available for most machinery on the market. For each family of machines, these data indicate clearly and objectively the range of noise emission levels (see ISO 11689). The noise emission value of a machine relative to the values of the family to which it belongs allows potential buyers to consider quieter options.

An example illustrating the range of noise emission values for two specific families of machines is given in Figure 8. An international noise data bank storing declared noise emission values appears to

be the appropriate tool for this purpose.

9 Noise prediction as a planning tool

There are many technical measures for reducing noise immission levels in workrooms. The calculation of sound pressure levels and the choice of the most appropriate measures are key issues if reliable indoor noise prediction techniques are to be used.

These techniques can be applied most usefully at the design stage of a new workroom. They are also a very useful tool in the case of existing workrooms with an unsatisfactory noise situation or in the case of workrooms that have to be modified due to the starting of a new activity and/or to some work reorganization.

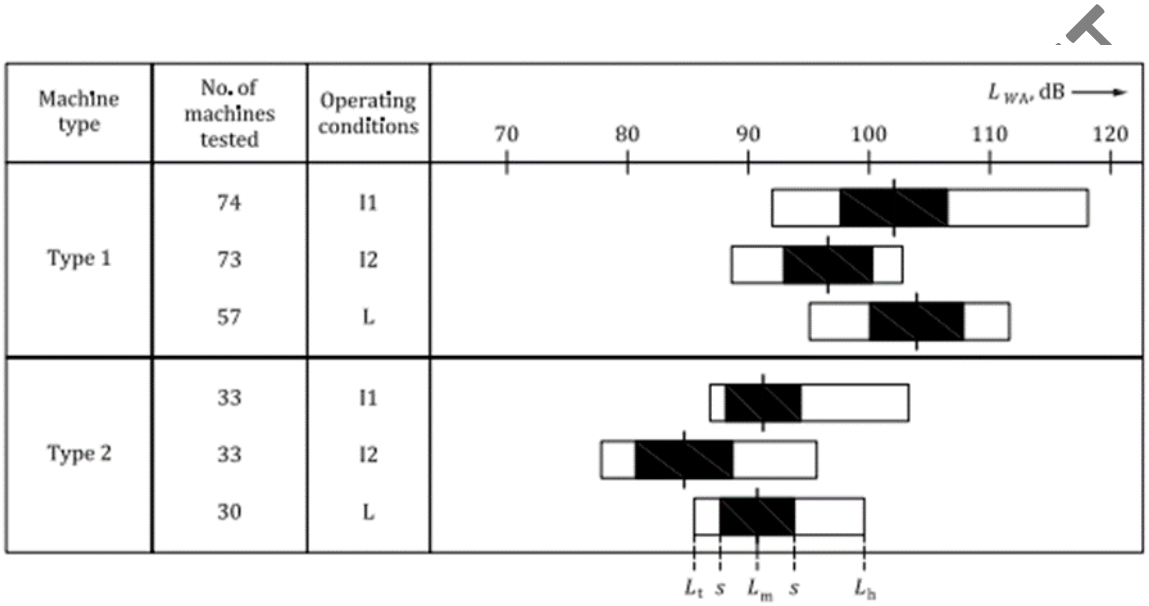


Figure 8 — Illustration of the range of noise emission values (A-weighted sound power level, L_{WA}) for two families of electric hand-held tools

Key

I1 means idle at the maximum speed

I2 means idle at nominal speed

L is the load with tool operating under specified conditions

S is the standard deviation

L_t is the lowest, L_h is the highest, and L_m is the mean value

Several possible designs of a projected workroom or several possible noise control measures to reduce noise immission in an existing workroom can be simulated and their individual efficacies compared using indoor noise prediction techniques. This makes such techniques a powerful decision-aid tool.

Practical implementation of indoor noise prediction techniques to a given situation implies the appropriate modelling of machines and equipment as sources of sound, and of workroom internal architecture and fittings as elements influencing sound propagation. This modelling together with the choice of the indoor noise prediction technique which is the most appropriate to the case under study is a matter for an expert acoustician. ISO/TR 11690-3 gives a brief description of indoor noise prediction techniques available today and a general methodology for the practice of indoor noise prediction by parties such as acoustical consultants and health and safety and/or labour protection officers with good expertise in noise control.

10 Long-term noise control programme

Companies are on occasion forced to use noisy production means in their working processes. Controlling noise gradually is more feasible than trying to do it at one go. It is therefore in the interest of the company to have an official long- term noise control programme. This programme is intended to fulfil the requirements of various relevant regulations and to anticipate their potential changes. Its content is different for projected and existing workplaces.

In the case of projected workplaces, the purchasing department requests from suppliers all data on the acoustical performance of the various machines and equipment in writing. The specified performances are then normally verified and a comprehensive reliable data bank on machine noise emission data can be developed step by step. On this basis, a prediction methodology can be used to forecast the noise im- mission and exposure levels in workplaces.

In the case of existing workplaces, the noise situation is periodically verified by means of on-site measurements. The measured data are recorded together with the measuring and operating conditions and the date. This practice allows one to determine the less noisy configurations by comparing various workplaces. It also allows comparison or possible changes in the noise situation during a given time period.

One of the main actions in the noise control strategy is to identify the sound sources and to rank them. This ranking takes into account the sound power levels, the duration of operation of the machines and the number of machines. Joined to a prediction methodology, it enables one to define the most effective noise control actions.

The agreement between the effectiveness of the implemented noise control measures and their initial specifications should always be verified and registered in writing.

The success of the long-term noise control programme depends, among other things, on the company staff (engineers, management) becoming responsive to noise reduction and technically trained in noise control.

The long-term noise control programme should specify that:

a) noise immission at work stations shall be determined and recorded;

b) noise emission shall be determined for each source (machines, equipment, devices including transport systems, working processes, etc.) under the usual mounting and operating conditions;

c) if possible, relevant noise emission data shall be obtained from the manufacturers and/or the suppliers of machines and equipment (noise emission declaration, see Clause 8);

d) it must be proved whether or not any noise immission, noise exposure or noise emission limits laid down in national regulations are exceeded;

e) sound power levels or sound pressure levels at work stations should additionally be determined in octave bands; sound pressure levels should also be determined as a function of time;

f) major sound sources shall be identified and their influence on noise immission at each work station determined;

g) this document (and possible other national or international standards or guidelines and technical literature on noise control) shall be considered as a source of information on technical measures [see ISO 11690-2 for noise control (emission and immission)];

h) noise control measures shall be in agreement with the current state of noise control technology;

i) each noisy area shall receive an adapted noise control treatment.

The long-term programme should specify for each noisy area:

j) the desired objectives;

k) the time schedule for the implementation of noise control measures;

l) the noise emission reduction achievable for each source (in terms of sound power or emission sound pressure levels);

m) the noise control devices used (in terms of their insertion loss);

n) the sound propagation parameters of each workroom (in terms of reverberation time and/or spatial sound pressure distribution);

o) the noise immission reduction achievable at each work station;

p) the immission at each work station and the noise exposure of workers.

The implementation of the long-term noise control programme should be monitored. The achieved noise level reductions should be determined and reported. The programme should be periodically updated.

Care should also be taken to ensure that reduction in noise emission is always achieved when feasible, even if it has little influence on immission or exposure levels at a given time. Indeed, in the long run, noise reduction may only become fully effective when all noise control measures planned have been implemented.

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