NON-BINDING GUIDE TO GOOD PRACTICE FOR THE APPLICATION OF DIRECTIVE 2003/10/EC "NOISE AT WORK"

European Commission

HOW TO AVOID OR REDUCE THE EXPOSURE OF WORKERS TO NOISE AT WORK

Non-binding guide to good practice for the application of Directive 2003/10/EC of the European Parliament and of the Council on the minimum safety and health requirements regarding the exposure of workers to the risks arising from physical agents (Noise)

European Commission

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Foreword

Hearing loss problems caused by noise are one of the 10 most common occupational diseases encountered in the European Union (EU). Hypoacusis (hearing loss) or deafness caused by damaging noise is one of the diseases which are identified on the European list of occupational diseases[1]. Data collected by Eurostat as part of the 'European Occupational Diseases Statistics' (EODS), show that approximately 14,300 cases of hearing loss due to noise were identified in Europe (EU-15) during 2005, equivalent to 9.5 cases per 100,000 employed people. It is appropriate to point out that amongst the cases identified, approximately 98 % are men, and that 73 % work in the manufacturing, mining and construction industries.

The last European Working Conditions Survey (ESWC) carried out by the Dublin Foundation in 2005, shows that approximately 20 % of European workers are exposed, for at least half of their working hours, to noise levels so high that they need to shout in order to be heard by their colleagues.

Although noise is currently a problem common in all economic activities, especially in manufacturing, mining and construction industries, where approximately 35 % to 40 % of workers are exposed, it is also present in all other sectors of industry.

Persistent exposure results in a series of restrictions and incapacities affecting workers suffering from hearing loss. It limits their potential for mobility, re-employment or a simple change in activity, not to mention the negative aspects of the quality of their private lives and attendant social exclusion.

As well as the hearing loss for those workers already affected, general noise presents additional accident risks in the workplace, as a result of communication difficulties arising from the activity itself. Also, in addition to hearing loss problems, noise causes psychosocial problems such as stress and anxiety.

This situation can contribute to a devaluation in the public perception of the sectors concerned, making it more difficult to recruit young workers. This is because this type of work or activity is less attractive and it is thus difficult to retain more experienced workers who could pass on their knowledge to future generations.

Europe has declared quality of employment as an objective. To reduce cases of hearing loss due to noise is an essential objective and, for this aim to be achieved, all players concerned must be involved: employers in every sector (especially those in the noisiest sectors), workers, public authorities, insurance companies or national health services, work inspection services and of course the SMEs.

The European Parliament and Council adopted Directive 2003/10/EC[2] 'Workers exposed to risks due to noise' in February 2003, which replaced the former 86/188/EEC[3], thereby providing a real and effective means to fulfil this commitment.

Moreover, it should be remembered that the 'Community strategy for health and safety 2002-2006'[4] supported by the Council[5] and the European Parliament[6], has for its part called for the risk prevention culture to be strengthened; the effective application of community legislation through trained players fully aware of the stakes involved; use of the different mechanisms available, in order to promote real

1. COM(2003) 3297 final adopted 19 September 2003, O.J. No L 238 of 25.09.2003, page 28.
2. Directive 2003/10/CE of the European Parliament and of the Council, of 6 February 2003, on the minimum health and safety requirements regarding the exposure of workers to risks arising from physical agents (noise), O.J. No L 42 of 15.02.2003, page 38.
3. Directive 86/188/EEC of the Council, of 12 May 1986, concerning the protection of workers against risks arising from exposure to noise in the workplace, O.J. No L 137 of 24.05.1986, page 28.
4. Commission communication: adapting to changes in the workplace and in society: a new community health and safety strategy 2002-2006, [COM(2002) 118 final] of 11.03.2002.
5. Resolution of Council of 3 June 2002 concerning a new community strategy for occupational health and safety 2002-2006, O.J. No C 161 of 05.07.2002, page 1.
6. European Parliament resolution on the Commission communication: 'Adapting to change in work and society: a new Community strategy on health and safety at work 2002-2006' [COM(2002) 118 final], O.J. C 300 E of 11.12.2003, page 290.

improvement procedures, not just straightforward respect for the standards. To this end, objectives for the continuous reduction of occupational accidents and diseases have been established at national level; the present guide can contribute to their achievement.

Directive 2003/10/EC provides for the establishment of a non-binding code of conduct, in consultation with both sides of industry, in order to help employers and workers in the music and entertainment sectors to respect the obligations provided for in this Directive. In this context, this guide contains a specific chapter with practical and specific provisions to help workers and employers in the music and entertainment sectors, where workers are particularly exposed to very high noise levels.

The present non-binding guide, drawn up according to Directive 2003/10/EC, is intended to assist companies, especially SMEs, and all individuals concerned with preventing occupational risks, to implement the provisions of this Directive.

Finally, this non-binding guide must be used in the practical implementation of the provisions of Directive 2003/10/EC in respect of measures to be taken to prevent risks due to exposure to occupational noise, especially by tackling noise at source, and by encouraging collective protective measures over personal protection. This guide can also help companies choose the most suitable solutions to achieve effective and efficient improvements in the health and safety of its workers. Indeed, an ambitious noise prevention policy is a competitivity factor. Conversely, the non-application of this policy generates costs which weigh heavily on economies and companies, not to mention human suffering.

Nikolaus G. van der Pas
Director General

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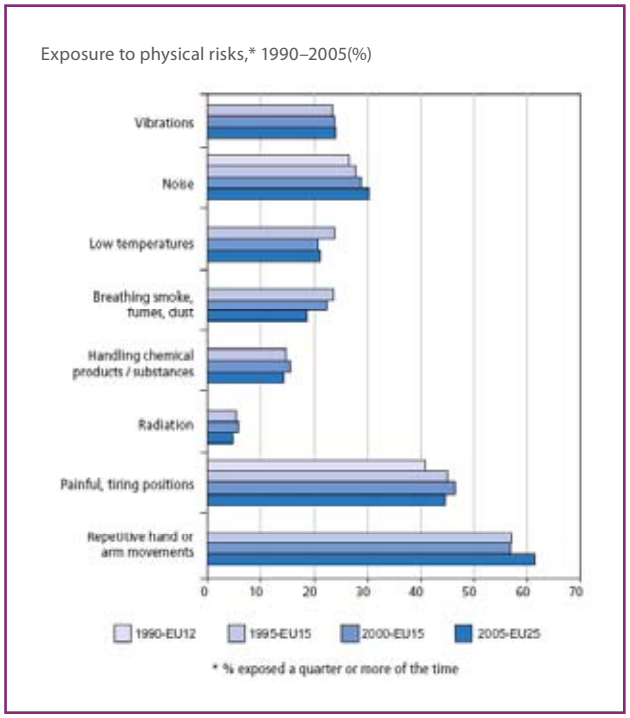
Introduction

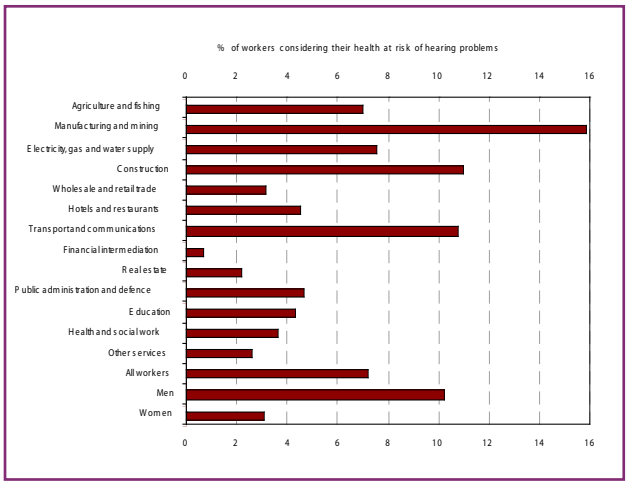
Directive 2003/10/EC[7] adopted on 6 February 2003 by the European Parliament and Council concerns the minimum health and safety regulations relating to workers' exposure to risks due to noise and is the result of considerations made during analysis of 10 years of implementation of the Council Directive 86/188/EEC[8].

Directive 86/188/EEC in fact made provision for these regulations to be reassessed by the Council (article 10), as proposed by the Commission, in order to take into account experience gained during application of the Directive, technical advances and scientific knowledge in the field.



In addition, the Commission in its Communication[9] on its programme in the field of safety, hygiene and health in the workplace, had envisaged adopting measures to strengthen safety in the workplace, extending the scope of Directive 89/188/EEC, as well as reassessing threshold values. In its resolution of 21 December 1987[10], the Council warmly welcomed the programme of the Commission and shared its views by underlining the need to improve health and safety protection of workers in the workplace. In September 1990, the European Parliament adopted a resolution inviting the Commission to draw up a specific directive in the field of risks linked to noise and vibration and any other physical agent in the workplace.

After adoption by the European Parliament and Council of the 'Vibrations' Directive (2002/44/EC[11]), the European Parliament and Council considered it an opportune moment to introduce measures protecting workers from risks due to noise, given the effects on the health and safety of workers, especially hearing damage.



7. Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003, on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise), O.J. No L 42 of 15.02.2003, page 38.

8. 86/188/EEC Council Directive of 12 May 1986 on the protection of workers from the risks related to exposure to noise at work, O.J. No L 137 of 24.05.1986, page 28.

9. O.J. No C 28 of 03.02.1988, page 3.

10. O.J. No C 28 of 03.02.1988, page 1.

11. Directive 2002/44/CE of the European Parliament and Council, of 25 June 2002, concerning minimum health and safety requirements regarding the exposure of workers to risks arising from physical agents (vibrations), J.O. No L 177 of 06.07.2002, page 13.

The fourth ESWC[12] carried out by the Dublin Foundation in 2005, showed that approximately 30 % of European workers are exposed to noise for at least a quarter of their time at work. This exposure to noise is currently a problem common in all economic activities, especially in manufacturing, mining, construction, agriculture, fishing and transport where between 25 % and 46 % of workers are exposed to this risk. Amongst all workers, twice as many men as women are exposed to noise.

The ESWC survey also shows that approximately 7 % of European workers think that their work affects their health in the form of hearing problems. This risk is particularly noticeable in manufacturing, mining, construction and transport, whereas it is practically non-existent in the financial sector.

Moreover, and according to the results of the ad hoc module 'Accidents at work and health problems linked to work' in the Labour Force Survey (LFS) carried out in 1999, approximately 0.1 % of the replies show that workers have suffered from a hearing problem, which in their own opinion had started or been made worse by their work. This would indicate that approximately 200 000 European workers (at work or retired) have hearing problems. Finally, each year, these figures are increased by thousands of new cases of hearing loss identified as an occupational disease.

According to data within the EODS project for the reference year 2005, amongst the 10 most numerous occupational diseases identified in the European Union, hearing loss due to noise is in fourth place with 10 590 identified cases in the 12 Member States who supplied data (i.e. approximately 14 300 cases when extrapolated to the EU-15 Member States). This represents a rate of incidence[13] of 9.5 per 100 000 people in employment.

Based on these data, the latest scientific knowledge, the need to include all activity sectors – since Directive 86/188/EEC does not apply to maritime or air navigation – and in compliance with the main principles of prevention announced in Directive 89/391/EEC[14] (Framework Directive), namely that the collective protection measures must take priority over individual protection measures and the existence of international legislation on noise levels, the Commission presented a new Directive which was finally adopted by the European Parliament and Council on 6 February 2003.

Finally, it should be noted that based on the requirements of Directive 2003/10/EC, whereby the levels of noise at which employers must undertake various actions for the reduction and control of noise at work have been lowered, all employers should be aware that their premises or worksites could now come within the scope of this Directive. The traditionally noisy sectors will be aware of the risk from noise but in effect offices, kindergartens, schools, recreational establishments, crèches, print rooms in buildings, post office sorting rooms, small manufacturing units, etc. could come within the lower action level of 80 dB(A) and so be required to actively protect their workers from the risk to noise in line with this Directive for the first time.

It is essential, therefore, that all employers consider the risks from noise at their workplaces knowing that the responsibility rests solely with employers (no matter how small the company, how few the number of workers employed or what sector of employment) in that they must protect their workers against the risks from exposure to noise where noise exists at a workplace or is generated by a work activity.

12. ESWC means European Survey of Working Conditions.

13. Eurostat – Data – Population and social conditions – Health – Health and safety at work. http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1090,30070682,1090_33076576&_dad=portal&_schema=PORTAL

14. 89/391/EEC Council Directive of 12 June 1989, on the introduction of measures to encourage improvements in the safety and health of workers at work, O.J. No L 183, of 29.06.1989, page 1.

MAIN DIFFERENCES BETWEEN DIRECTIVE 2003/10/EC AND THE EARLIER DIRECTIVE 86/188/EEC

Structure of the Directive

The new Directive 2003/10/EC, based on Article 137 of the treaty instituting the European Union, is much clearer in structure, since it follows the preventive approach of Directive 89/391/EEC (Framework Directive) as the 17th individual Directive.

However, Directive 86/188/EEC, which was based on a different legal base (Article 100 of the treaty instituting the European Economic Community), did not follow this preventive approach. Consequently, the Directive did not allow clear objectives to be established: risk prevention, assessment of unavoidable risks, or tackling risks at source by preferring collective measures to individual protection measures.

Directive 89/391/EEC establishes the main principles of prevention and in particular the obligations and responsibilities of employers. These principles are to be applied *mutatis mutandis*, especially for risk assessment measures to prevent or reduce the exposure of workers to noise, restricting exposure, health surveillance, as well as personnel information, training, consultation and participation of workers in this process.

Objective

Article 1 of the new Directive 2003/10/EC sets minimum regulations for protecting workers from risks to their health and safety which result from, or might result from, exposure to noise and especially risks to hearing. These provisions apply to activities in the exercise of which workers are or could be exposed to risks due to noise, as a consequence of their work.

Directive 2003/10/EC aims to combat risks due to exposure of workers to noise

(Article 1)

Scope

The new Directive 2003/10/EC applies to all activity sectors without exception (Article 1, paragraph 2). The only exceptions can be those included in Article 2 paragraph 2 of Directive 89/391/EEC, namely 'where characteristics peculiar to certain specific public service activities, such as the armed forces or the police, or to certain specific activities in the civil protection services inevitably conflict with the Directive'. On the other hand, Directive 86/188/EEC excludes air and maritime navigation and, therefore, all workers involved in these transport sectors.

Directive 2003/10/EC applies to all activity sectors without exception

(Article 1, paragraph 2)

Definitions

The new Directive 2003/10/EC simplifies in a clear manner (without recourse to complicated mathematical formulae) the different physical parameters used as risk predictors. In this respect, it is a return to the ISO 1999/1990 international standard, with its simplified wording.

Definitions

- Peak sound pressure 'p_{peak}'
- Daily noise exposure level '$L_{EX,8h}$ dB(A)'
- Weekly noise exposure level '$L_{EX,8h'}$'

Exposure limit value and exposure action values

Directive 2003/10/EC introduces the concepts of 'Exposure limit values' and 'Exposure action values'. These allow employers to optimise the implementation of the Directive, especially the assessment of risks to which workers are or could be exposed when working.

The new exposure limit value established by Directive 2003/10/EC is set at a lower level than that established by Directive 86/188/EEC and constitutes, for a company, the acceptable noise level with no consequence for the health and safety of the workers. In terms of noise exposure, the risk increases with higher exposure values and therefore it is necessary to apply proportional measures to tackle this risk, without the limit value ever being exceeded.

The new limit value is set at $L_{EX,8h}$ = 87dB(A) for daily exposure level (weighted average of the exposure level

and duration over an eight hour working day) and at ρ_{peak} = 200 Pa for peak sound pressure.

Directive 86/188/EEC established values of $L_{EX,8h}$ = 90dB(A) for the personal daily exposure and ρ_{peak} = 200 Pa for the sound pressure value.

Exposure limit values

$L_{EX,8h}$ = 87 dB(A) and ρ_{peak} = 200 Pa

This value must in no circumstances be exceeded!!!

(Article 3)

In the application of exposure limit value, determination of the effective exposure of the worker to noise takes account of the attenuation provided by individual hearing protectors worn by the workers.

The innovation in Directive 2003/10/EC, compared to Directive 86/188/EEC, is that it establishes two exposure values which trigger action: one higher [$L_{EX,8h}$ = 85 dB(A) and ρ_{peak} = 140 Pa] and one lower [$L_{EX,8h}$ = 80 dB(A) and ρ_{peak} = 112 Pa]. These values, which can be exceeded, trigger action without, however, exceeding the exposure limit value under any circumstances. This allows employers to manage the preventive actions to be taken in tackling the risk due to workers exposed to noise, in an appropriate and flexible manner. If the upper exposure action value is exceeded, the Directive obliges the employer to establish and maintain a programme of technical or organisational measures to reduce exposure to noise such as providing medical checks of the workers' hearing.

If the upper exposure action values is exceeded

$L_{EX,8h} \geq$ 85 dB(A) and $\rho_{peak} \geq$ 140 Pa

The employer must

- Establish and implement a programme of technical and/or organisational measures intended to reduce exposure to noise (Article 5, § 2)
- Ensure that workers who are exposed to noise at work receive information and training relating to risks resulting from exposure to noise (Article 8)
- Mark, with appropriate signs, workplaces where workers are likely to be exposed to noise exceeding the upper exposure action values (Article 5, § 3)
- Provide for workers' entitlement to receive hearing checks by doctors or by another suitably qualified person under the responsibility of a doctor, in accordance with national law and/ or practice (Article 10, § 2)

The workers shall use

- Individual hearing protectors, where noise exposure matches or exceeds the upper exposure action values (Article 6, § 1(b))

Moreover, when workplaces or workers are liable to be exposed to a noise level exceeding the upper action value, $LE_{X,8h} \geq$ 85 dB(A) and $\rho_{peak} \geq$ 140 Pa, the employer must provide training and information to the workers on the risks to which they are exposed and work areas must incorporate appropriate signs to restrict access, where this is feasible and when justified by the risk, and offer workers a preventive audiometric examination.

Where exposure is between

$L_{EX,8h}$ = 80 and 85 dB(A) and ρ_{peak} = 112 and 140 Pa

The employer shall ensure that:

- Workers who are exposed to noise at work receive information and training relating to risks resulting from exposure to noise (Article 8)
- Individual hearing protectors shall be made available to workers (Article 6, § 1 (a))
- A preventive audiometric test is offered to those workers identified as being at risk (Article 10, § 2)

Finally, and when workers are exposed in the workplace to a noise level equal to or greater than the lower action value, $L_{EX,8h} \geq 80$ dB(A), and $\rho_{peak} \geq 112$ Pa, the employer must provide information and training appropriate to the risks arising from exposure to the noise, such as offering workers a preventive audiometric examination.

If the lower exposure action values is exceeded

$L_{EX,8h} \geq 80$ dB(A) and $\rho_{peak} \geq 112$ Pa

The employer must:

- Inform the workers (Article 8)
- Train the workers (Article 8)
- Make available individual hearing protectors to workers (Article 6, § 1 (a))
- Offer the workers a preventive audiometric examination (Article 10, § 2)

Determination and assessment of risks

The new Directive 2003/10/EC envisages specific provisions on the determination and assessment of risks by the employers. However, Directive 86/188/EEC was not sufficiently clear on these aspects, especially on exposure level and type, limit values, direct and indirect effects on workers' health, advice from equipment manufacturers on noise emissions, the existence of replacement equipment, health surveillance, problems of interaction between noise and ototoxic substances, or between noise and vibration, or between noise and alarm signals intended to prevent accidents, etc.

Risk assessment

(Article 4)

The employer assesses and, if necessary, measures the noise level.

Methods can include taking representative samples.

Factors to be considered:

- Level, type and duration of exposure
- Exposure limit values
- Exposure action values
- Particular sensitive risk groups
- Interactions with ototoxic substances and vibration
- Interaction between noise and alarm signals
- Information on equipment noise emission levels

Provisions aimed at avoiding or reducing exposure to noise

Directive 2003/10/EC is much more precise in this field because it gives the employer some indications to be taken into account in preventing or reducing exposure. It always gives preference to collective measures over individual protective measures. Similarly, Directive 2003/10/EC envisages provisions so that the employer can take immediate measures in the case where exposure limit values have been exceeded.

Provision aimed at avoiding or reducing exposure to noise

(Article 5)

The employer must take account of technical developments and shall establish and implement a programme of technical and/or organisational measures

Elements to be taken into consideration

- Alternative working methods
- Choice of appropriate work equipment
- Design of workplace
- Information and training for workers
- Technical means to reduce airborne and structural noise
- Maintenance programmes for the work equipment
- Work organisation
- Signage
- Provision of personal protective equipment (PPE)

Personal protective equipment (PPE)

Directive 2003/10/EC is very clear on this aspect. 'If other means cannot be used to prevent risks due to exposure to noise', the Directive permits the use of personal hearing protectors as a last resort in order to observe the exposure limit value. These must be made available by the employer to the workers and must comply with the provisions of Directive 89/656/EEC[15] and Directive 89/391/EEC, without prejudice to Directive 89/686/EEC[16] relating to the essential manufacturing conditions of PPE.

Personal protective equipment

(Article 6)

If other means cannot be used to prevent risks due to exposure to noise, the employer must provide his workers individual hearing protectors

Conditions:

- When exposure exceeds the lower action values the employer provides his workers with ear protectors
- When exposure is equal to or greater than the upper actions values workers must wear individual hearing protectors
- Must be capable of eliminating the risk or reducing it as far as possible

Health surveillance

This aspect is fundamental since noise is a risk which progressively harms the health of the exposed workers. In cases where exposure exceeds the action values, the legislator has made provision for checks on individuals, designed to provide health surveillance and an early diagnosis of any hearing loss due to noise.

Directive 2003/10/EC allows workers to benefit from hearing tests carried out by a doctor or other suitably qualified person, when the upper exposure action value is exceeded [$L_{EX,8h}$ > 85dB(A) and ρ_{peak} > 140 Pa], and that a preventive audiometric examination must be offered to workers when the lower exposure action value is exceeded [$L_{EX,8h}$ > 80dB(A) and ρ_{peak} > 112 Pa].

When an identifiable case of deterioration is detected, workers are informed and the employer must reassess the risks and measures to eliminate or reduce risks.

By contrast, Directive 86/188/EEC was less stringent, especially with regard to the type of examinations and the exposure levels, as well as the reassessment of risks and measures to be taken.

Health surveillance

(Article 10)

- Workers can benefit from a hearing check if exposure exceeds 85 dB(A) and/or ρ_{peak} = 140 Pa
- Workers can benefit from a preventive audiometric examination if exposure exceeds 80 dB(A) and/or ρ_{peak} = 112 Pa

Derogations

Directive 2003/10/EC applies to all activity sectors without exception. Nonetheless, in exceptional circumstances, Member States can grant waivers on provisions relating to the use of personal protective equipment. These waivers could be granted on condition that the risks are reduced to the minimum and that the workers affected are subject to additional health surveillance. These waivers will be re-examined every four years and Member States must send the Commission the list of waivers granted.

Derogations

(Article 11)

- In exceptional circumstances
- Assurance that risks be reduced to a minimum
- Additional medical surveillance
- Re-examined every four years
- Revocation upon disappearance of circumstances

Workers' information, training, consultation and participation

Based on Framework Directive 89/391/EEC, the new Directive is very clear and detailed in these chapters. It obliges employers to provide information and appropriate training to workers when they are exposed to noise levels equal to or exceeding exposure action values. It also provides for consultation with and participation of the workers and/or their representatives in assessing risks, determining the measures to be taken to eliminate these risks and choosing personal hearing

15. 89/656/EEC Council Directive of 30 November 1989, on the minimum health and safety requirements for the use by workers of personal protective equipment, O.J. No L 393 of 30.12.1989, page 18.

16. 89/686/EEC Council Directive of 21 December 1989, on the approximation of the laws of the Member States relating to personal protective equipment, O.J. No L 399 of 30.12.1989, page 18.

protectors. By contrast, Directive 86/188/EEC makes no reference to these questions.

Training is essential in order for implementation and compliance with this legislation and to ensure adequate protection of workers while at work. Also it is extremely important that workers appreciate the reasons and understand the need for specific controls and why certain measures have been selected. Regarding PPE it is essential that not only is the correct and appropriate PPE provided and worn but that workers know the reasons and how to wear the PPE to achieve the best protection. Training in the use and wearing of PPE for individuals is essential and if not undertaken can lead to complacency and/or the assumption that a level of protection is being afforded which in reality may not be the case (e.g. if the PPE is not worn or used correctly).

Workers' information, training, consultation and participation

(Articles 8 and 9)

- On the nature of noise
- On the measures taken
- On the exposure limit values and exposure action values
- On the results of risk assessment
- On the proper use of hearing protectors
- On the medical surveillance conditions
- On the choice of hearing protectors, etc.

Code of conduct

Compared to Directive 86/188/EEC, and taking into account the specific nature of the music and entertainment sectors, Directive 2003/10/EC requires the Member States to establish a code of conduct to help the workers and employers in these sectors to respect the obligations which concern them. In order to allow this code of conduct to be established for this particular sector, Member States have recourse to a transitional period of two years, i.e. until 15 February 2008.

Code of conduct

(Article 14)

'Help workers and employers in the music and entertainment sector to respect their obligations'

Implementation delayed by two years

15.2.2008

Transposition

Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive 2003/10/EC before 15 February 2006.

In order to take account of particular circumstances, Directive 2003/10/EC accepts that in the application of the provisions of Article 7 'Limiting exposure' for personnel on board seagoing ships, Member States can delay transposition by an additional five years, i.e., until 15 February 2011.

Transposition

(Article 17)

15.2.2006

2. In order to take account of particular conditions, Member States may, if necessary, have an additional period of five years from 15 February 2006, that is to say a total of eight years, to implement the provisions of Article 7 with regard to the personnel on board seagoing vessels.

15.2.2011

Provision	86/188/EEC Noise Directive	2003/10/EC New Noise Directive
Reduce risk	To lowest level reasonably practicable	Eliminated at source or reduced to a minimum
Assess and where necessary measure exposure	Where noise experienced	Where workers are, or are likely to be, exposed to risk
Assessment period	Working day	Working day or one week
Information and training to workers and representatives	Above 85 dB(A) daily exposure and 140 dB peak level	Above 80 dB(A) daily/ weekly exposure and 135 dB(C) peak level
Health surveillance	Good practice at and above 90 dB(A)	Regularly exposed at or above 85 dB(A) daily exposure or 137 dB(C) peak
Workers' right to hearing checks / audiometric testing	Above 85 dB(A) daily exposure and 140 dB peak level	Above 85 dB(A) daily/ weekly exposure and 137 dB(C) peak level. To be available at 80 dB(A) and 112 Pa where risk indicated
Make hearing protection available	Above 85 dB(A) daily exposure and 140 dB peak	Above 80 dB(A) daily/ weekly exposure and 135 dB(C) peak level
Hearing protection to be worn	Above 90 dB(A) daily exposure and 140 dB peak	At or above 85 dB(A) daily/ weekly exposure and 137 dB(C) peak; protectors to eliminate risk or reduce to a minimum
Limit on exposure	———	87 dB(A) daily/ weekly exposure and 140 dB(C) peak at the ear
Programme of control measures	Above 90 dB(A) daily exposure and 140 dB peak	Above 85 dB(A) daily exposure and 137 dB(C) peak
Delimit areas, put up signs and control access	Where reasonably practicable above 90 dB(A) daily exposure and 140 dB peak	Above 85 dB(A) daily/ weekly exposure and 137 dB(C) peak
Workers' representatives to receive information	>85 dB(A) daily exposure and 140 dB peak (assessments) >90 dB(A) daily exposure and 140 dB peak (programmes of measures)	Refers back to Directive 89/391/EEC
Derogations	Weekly exposure averaging; From use of hearing protection where health and safety risk	From use of hearing protection where health and safety risk
Transitional periods	———	Additional transitional period for shipping and for music and entertainment sectors
Non-application	Sea and air transport	Conflict with public service activities

Table 0.1 Comparison of the previous Noise Directive with the Physical Agents Noise Directive

HOW TO READ THE GUIDE ?

- The Guide is divided into nine chapters which you may consult separately, according to your topic of interest.
- Each chapter is divided into numbered paragraphs covering a single item so you can easily access each item of information.
- In each paragraph the main points are printed in bold and are followed by a list of comments and advice. These are illustrated by industrial examples. Drawings follow most of paragraphs.
-  If you want more detailed information you will find at the end of the paragraph, text written in italics giving additional technical details introduced by the logo.
- The chapters are introduced by a summary of the relevant Directives requirements.
- You will find specific information about noise reduction techniques in Chapter 4.
  These techniques are given with the following details:
  - Technique and explanation: how does it work?
  - Precautions necessary to obtain a successful outcome;
- It is possible to find information on specific topics using two word lists:
  - a list of keywords, with the corresponding Guide chapters in which they are explained
  - a glossary, which gives short and simple definitions of the common technical terms.

A list of abbreviations is given at the end of the Guide.

WHY REDUCE NOISE EXPOSURE ?

Even without considering the regulatory aspect, it would seem obvious to try to avoid noise risk as with any other health risk, especially since noise-induced deafness is one of the most widespread occupational illnesses in Europe. However, in the workplace noise reduction not only needs effort, it also requires some modification of working practices and attitudes, so we encounter reluctance. Furthermore, the risk is not so obvious as deafness generally develops slowly and even the workers who are most at risk are reluctant to change their habits. That's the reason why it is important to reiterate the dangers of noise exposure in the workplace to managers as well as workers affected.

Exposure to high noise levels

- Induces irreversible deafness. How will this affect a workers' professional life; how will they manage the consequences in their private life?
- Prevents concentration, thus reducing performance:
- Creates stress, thus reducing ability;
- Threatens safety, because of the difficulty in hearing warnings;
- Presents a poor image of the company, especially to potential employees and the public;
- Hinders communication between employees.

In respect of these points, Table 0.2 gives some responses to frequent worker reactions.

In dealing with this problem, employees and their representatives must be informed, and involved in finding the solution.

Closely linked to the question of noise protection is the question of **exposure limits**; whatever measures are taken, some noise will always remain. What is an acceptable level for this noise?

The European Directive 2003/10/EC gives obligations linked to action and limit values (see Chapter 9 on 'Summary of the EU Noise Regulation'). These action and limit values may be reduced when transposed into national regulations.

The exposure action and limit values are defined in relation to the risk of injury and the employer should seek to achieve lower levels. In specific cases there will be situations where the type of work requires lower levels to enable concentration, reduce stress and increase efficiency, e.g. offices, precision workshops, clinical laboratories, research centres.

As mentioned above, noise can create stress and prevent concentration, thus reducing workers' ability and performance. So the employer's noise reduction efforts are in his own interest.

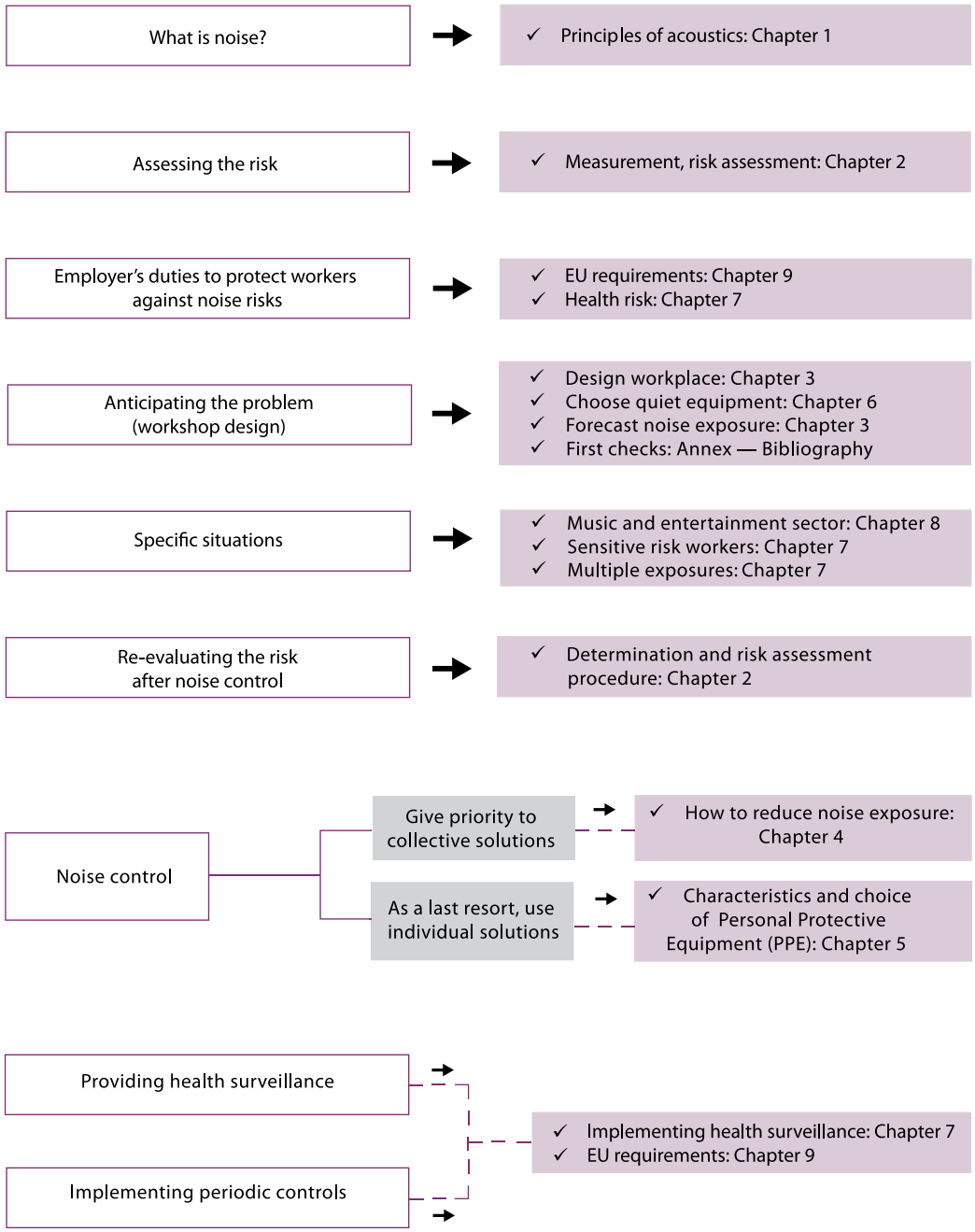
'Noise control is so important because a human being is not able to switch off his hearing, as he can close his eyes.'

Reluctance	Answer
I don't need any protection, I'm used to noise	Are you 'used to noise' or are you becoming deaf and thus less sensitive to noise?
When noise is reduced I cannot tell how my equipment is running	It's just a question of habit: you will 'learn' the new sounds of your equipment
Wearing personal hearing protectors (PHP) bothers me: it's claustrophobic and it makes me too hot, it interferes with other protective equipment	Many kinds of PHP exist; try to find the most appropriate and comfortable
Noise reduction equipment gets in the way of operating my machinery	This equipment is for your own protection. However, do you have any ideas on how to improve the machine operation?
I have been working here for a long time, I am not deaf yet	Deafness is progressive and it's hard to realise that we are losing hearing. Do you have regular audiometry tests?
Anyway, if I become deaf I will wear hearing aids	Don't forget that deafness is irreversible, and that hearing aids only emphases the hearing you have left

Table 0.2 Some reactions and answers concerning the reluctance towards noise protection

HOW TO FIND INFORMATION IN THE GUIDE ?

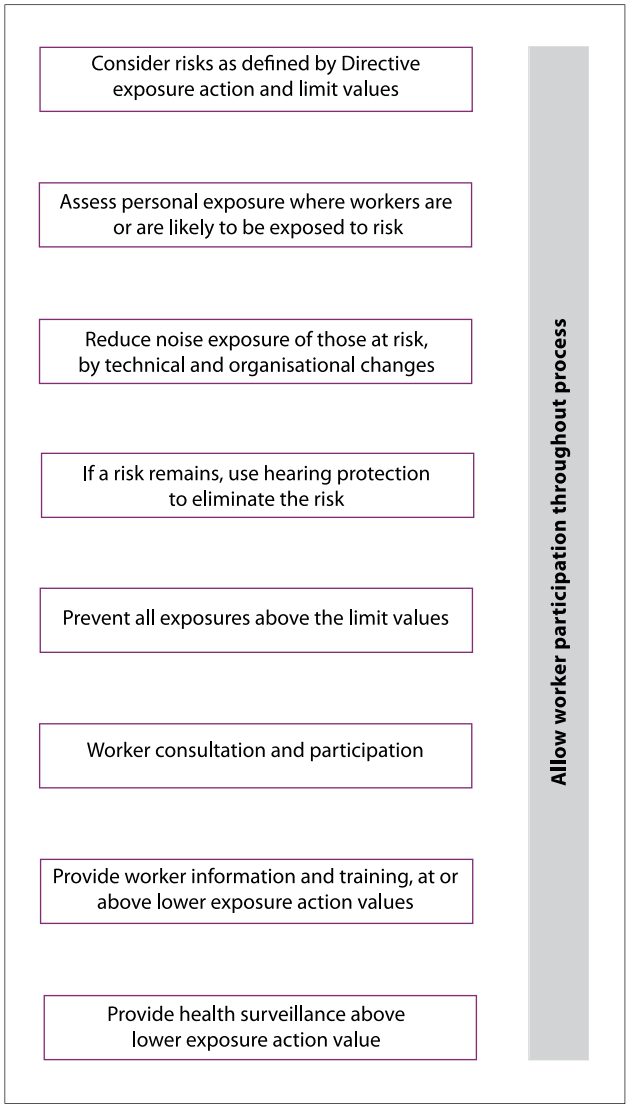
Method 1: Information on how to reduce noise exposure



Method 2: Information on how to follow Directive requirements

Chart summarises the actions required by the Directive 2003/10/EC.

The following chart summarises the actions required by the Directive to reduce the risk from noise and illustrates how each action leads to the next. The information on the opposite page gives the corresponding Articles in the Directive and the Guide chapters where further information is given.



Method 3: Information on how to follow Directive requirements

Directive 2003/10/EC, Articles and corresponding Guide references
Refer to Chapter 9 for a summary of the main requirements of the Directive and related Regulations, and to Chapter 1 for basic guidance on understanding the terms and science of acoustics and noise control.

For specific guidance for the music and entertainment sector go to Chapter 8.

Article and guidance	Guide Chapter	
Article 3: Exposure limit values and exposure action values		Article 9 Consultation and participation of workers – see Ch. 2.8
• Directive – daily and peak exposure action and limit values • Basics – terms to describe the risk of hearing loss	Ch. 2.0 Ch. 1.6 & 7.5	
Article 4: Determination and assessment of risks		
• Directive – noise assessment requirements • Basics – parameters to describe sound • Basics – terms for assessing the risk of hearing loss • Determination and risk assessment procedure – Estimates of sound level exposure – Planning and making measurements of sound level exposure – Calculation of noise exposure	Ch. 2.0 & 2.1 Ch. 1.3 Ch. 1.6 Ch. 2 Ch. 2.3 Ch. 2.4 & 2.5 Ch. 2.7	
Article 5: Provisions aimed at avoiding or reducing exposure		
• Directive – obligations of employers and workers • Basics – sound production and propagation – Noise reduction techniques – Avoiding excessive noise – Reducing noise at the source – Reducing air transmission – Reducing solid transmission – Specifying a purchased solution • Design of work spaces • Selection of quiet equipment	Ch. 4.1 Ch. 1.5 Ch. 4 Ch 4.2 , 4.3 & 4.4 Ch. 4.5 Ch. 4.6 Ch. 4.7 Ch 4.8 Ch. 3 Ch. 6	
Article 6: Personal protection		
• Directive on the use of Personal Protective Equipment (PPE) • Characteristics and choice of Personal Protective Equipment (PPE) – Information for employers and employees	Ch. 5.1 Ch. 5 Ch. 5.7	
Article 7: Limitation of exposure		
• Directive – obligations of employers	Introduction	
Article 8: Worker information and training		
• Directive – worker information, training and consultation	Introduction	
Article 10: Health surveillance		
• Directive – health surveillance • Hearing damage – Hearing damage from noise – Hearing damage from chemical agents – Symptoms of hearing damage – Audiometric testing	Ch. 7.1 Ch. 7 Ch. 7.3 Ch. 7.4 Ch. 7.5 & 7.6 Ch. 7.7	

CHAPTER 1
Principles of acoustics

1. INTRODUCTION

Acoustics is the science of sound

- Sound is one of the basic elements making up a person's living environment.
- Noise is a specific type of sound and is most commonly associated with industrial processes; it is one of the main hazards present in the work environment.
- Sounds and noises are what we hear, so we can name them intuitively without thinking of their physical nature.

The following chapter includes explanations of some terminology, which are used to describe acoustic phenomena, as well as answers to the following questions.

- What is sound really?
- Which parameters describe it?
- What is the difference between sound and noise?

2. SOUND AND NOISE

2.1. Sound

Sound is a vibration of air particles propagated as a sound (or acoustic) wave through the air. The space in which the sound wave spreads is called as a sound field.

- Sound arises when the air particles are set into vibration.
- Sources of these vibrations, i.e. sound sources, may be vibrating objects, machines, airflows or impacts.

The sound creation process may be demonstrated by the example of a gong (Figure 1.1).

- The surface of a gong, which has been struck, starts to vibrate by moving forwards and backwards (components or covers of various industrial machines can vibrate in a similar way).

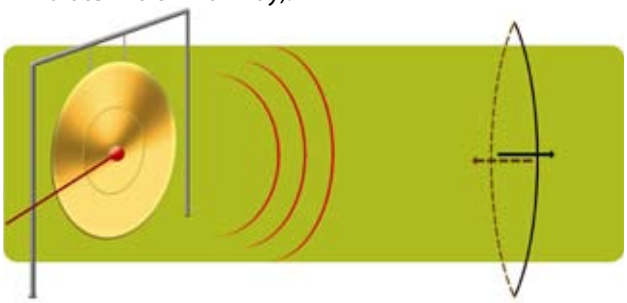


Figure 1.1 The gong and its surface vibration

- When the gong surface moves forwards, it pushes air particles forward and increases locally the density of the air (Figure 1.2).
- When it moves backwards, it pulls air particles with it and decreases locally the density of (rarefies) the air (Figure 1.2).
- Air particles in motion start vibrating to and fro in the same way as the surface. These vibrations spread to increasingly distant air particles and this is how sound is produced. This is a phenomenon similar to the one we may observe on the surface of still water, when an object is thrown into it. The object sets the water particles into motion and generates a wave.
- The spreading vibrations of air particles are called a sound wave.
- The speed at which air particle vibrations travel through the air is called the 'speed of sound' and this is equal to 340 m/s (metres per second). It means that, in 1 second, sound covers a distance of 340 metres, when passing through air.

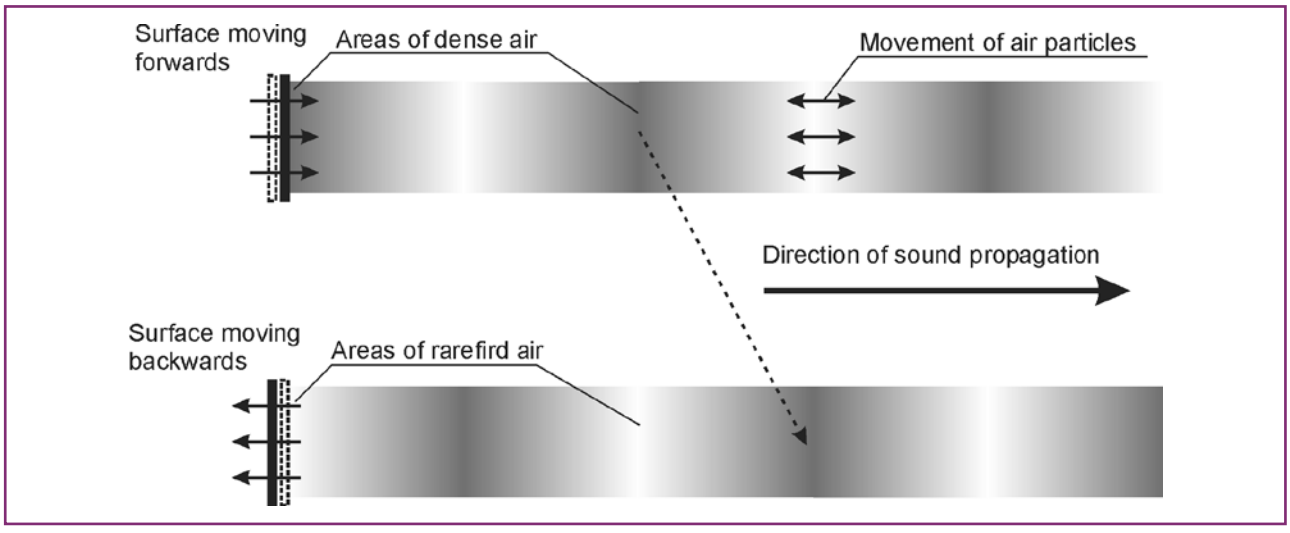


Figure 1.2 Sound production

Examples:

If we stand 340 metres away from equipment producing sound, we can hear the equipment one second after switching it on.

The most common phenomenon allowing easy observation of the speed of sound is an electrical discharge. Light moves almost a million times faster than sound, so we first see lightning and then hear thunder some time after. If we hear thunder three seconds after seeing lightning, it is easy to calculate that the electrical discharge occurred about 1 kilometre away (3 x 340 m).

2.2. Noise

Noise is unwanted sound

- Frequently, people associate noise with loud sounds that can damage their hearing so, if we consider its possible health effects, we can define noise as a loud sound able to cause hearing damage.
- Loud sounds are not always perceived as noise although they can affect a person's health, for example loud music during a concert. Conversely, in some situations, even not very loud or not potentially damaging sounds may be perceived as noise. Such sounds may hamper concentration during work requiring mental commitment, such as reading, writing and verbal communication.
- Noise is largely a subjective concept and can be defined as any undesirable sound at a particular moment.
- Each type of noise is sound, whereas not every sound is noise. However, these two terms will be used interchangeably later in this chapter.

Figure 1.3 Noise is a subjective term. Sounds that are music for some can be noise for others, even when they are not too loud

Impulse or impact noise is a loud noise occurring suddenly

- Impulse or impact noises do not last longer than one second and are followed by a period of quiet.
- Various types of impacts or explosions cause impulse noises.
- Impact noises are impulse noises produced by colliding objects.

Examples:

A bursting balloon, hammer blows, noise generated by a punch press and gunshots.

Figure 1.4 Impulse noises

2.3. Propagation in air, fluid and other media

Sounds, which are acoustic waves, propagate not only through air but also through other elastic media, such as water, concrete or steel.

- Sound travelling through air is called airborne sound.
- Sound transmitted through a solid body is called structure-borne sound.
- Sound travelling through fluid is called fluid-borne sound.

Sound sources may therefore be of different natures (air, fluid or solid) and noise reduction actions will be different depending on the nature of the sound source.

- Air sources may be gas exhausts, explosions, etc.
- Fluid sources are generated by fluid flows inside pipes, waterfalls, etc.
- Solid sources are mainly embodied by mechanical contacts: gears, rods, hammers, etc.

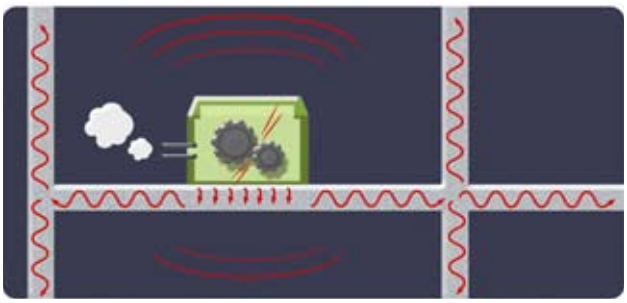


Figure 1.5 Various kinds of noise

The speed of sound travelling through a solid object is higher than the speed of sound travelling through air.

Example:

The speed of sound through concrete is 3,800 m/s; through steel it is 5,100 m/s.

3. BASIC PARAMETERS USED TO DESCRIBE SOUND

3.1. Frequency

Frequency is the number of cycles of a periodic motion per second.

- Vibrations of objects and air motion may occur at different numbers of cycles per second.
- Frequency expresses the number of vibration cycles completed in one second. Frequency, denoted by the symbol **'f'**, is measured in hertz (Hz).
- The faster particles vibrate, the higher the frequency of these vibrations measured in Hz.
- The unit of frequency a thousand times greater than hertz is the kHz (kilohertz), 1,000 Hz = 1 kHz.

Example:

A frequency of one hertz (f = 1 Hz) means that the vibration of an object completes one to-and-fro movement in a one-second period; a frequency of 100 Hz means that the vibration of a molecule completes one hundred back-and-forth movements in one second.

Sounds, which can be heard by humans, are called audible sounds.

- Audible sounds have frequencies in the 20 Hz – 20 kHz range.
- Audible sounds can be divided into:
  - Sounds of low frequency heard as bass (Figure 1.6).
  - Sounds of high frequency heard as soprano (Figure 1.7).

Example:

A male bass voice, the sound emitted by a diesel engine or a transformer are low frequency sounds. A female soprano voice, the buzz of a mosquito or the whistle of a boiling kettle are all high frequency sounds.

Figure 1.6 Low frequency sounds

Figure 1.7 High frequency sounds

3.2. Infrasound and Ultrasound

Sound in the frequency range below 20 Hz is called infrasound. Sound in the frequency range above 20,000 Hz is called ultrasound (Figure 1.8).

- Infrasound and ultrasound are inaudible.
- Despite being inaudible to the human ear, sounds in these frequency ranges may adversely affect the human body, causing headaches, tiredness, etc.

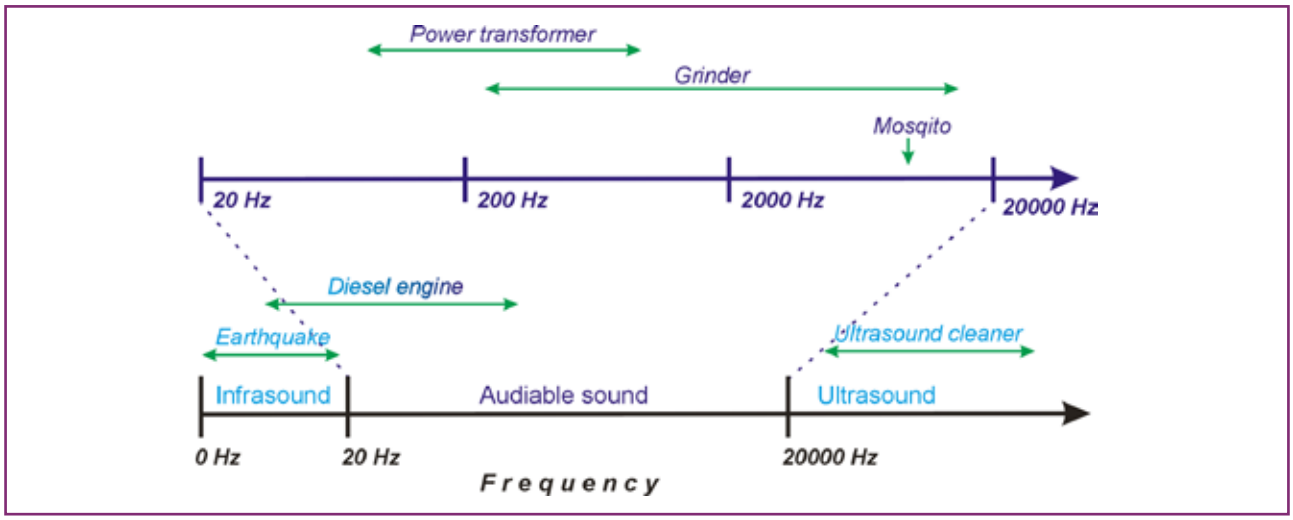


Figure 1.8 Sound ranges on the frequency scale

3.3. Sound Pressure

Sound Pressure 'p' (or acoustic pressure) is a pressure change from atmospheric pressure, which spreads through the air as a wave.

- There is a certain pressure in the surrounding air, known as the atmospheric pressure. Its value is given daily in broadcasted weather forecasts.
- When sound travels through air (Figure 1.9), it creates areas of high and low air density. This means that in places where the air density is high, the air pressure will be slightly higher than atmospheric pressure, whereas, in places where the air density is low (where the air is locally rarefied), the pressure will be slightly lower than atmospheric pressure. Thus, minor pressure changes occur in the air, as the sound travels through.
- A minor change in air pressure caused by spreading sound is known as sound pressure and is denoted by the symbol ***'p'***.
- The unit of acoustic pressure is the pascal [Pa].
- The human ear reacts to sound pressure and we therefore hear sounds.
- Larger vibrations from a sound source create higher sound pressure. Sounds with a higher sound pressure are louder.

Examples:

Sound pressure of some sounds: whisper – 0.0003 Pa; refrigerator – 0.005 Pa; conversation – 0.01 Pa; vacuum cleaner – 0.05 Pa; circular saw – 5 Pa; pneumatic drill – 10 Pa; aircraft taking off (nearby) – 30 Pa. Atmospheric pressure – 101.300 Pa.

3.4. Sound Pressure Level and the decibel

Sound pressure level (SPL) is a logarithmic measure of sound pressure for a particular sound with respect to a reference sound pressure. It is denoted 'L_p' and is expressed in decibels [dB]. The reference pressure equals 20 µPa (micropascal).

- At a frequency of 1,000 Hz, the quietest sound audible to a human with good hearing has a sound pressure of

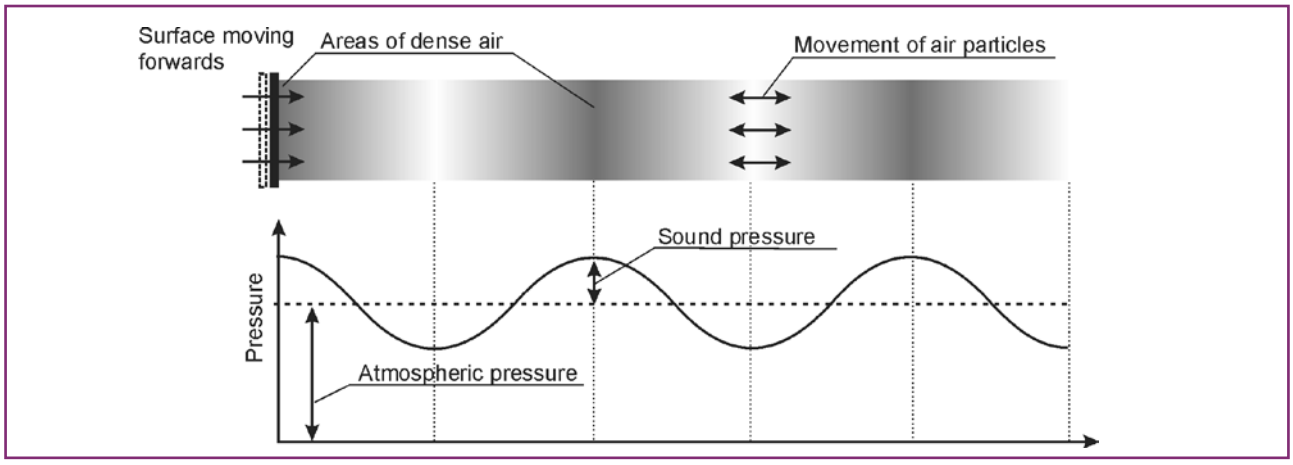


Figure 1.9 Sound pressure

20 μPa, i.e. 0.00002 Pa. Conversely, the loudest sound a human can hear has a pressure of approximately 20 Pa (a sound with such a high sound pressure is perceived as painful to the ear).

- Sound pressures of the loudest sounds audible to humans are a million times greater than those of the quietest audible sounds (Figure 1.10). Noise produced by some equipment has a sound pressure, which exceeds significantly the value at which hearing damage occurs in humans, e.g. firing of a large gun – 1,000 Pa.
- This large range of sound pressure led to introduction of a suitable measure of sound pressure. Expressed in decibels [dB], this is a logarithmic quantity called the Sound pressure level (SPL) and it tells us how by many times the sound pressure exceeds the reference value of 20 μPa.
- For a sound pressure of 20 μPa, the sound pressure level is 0 dB.
- Sound Pressure Level is related to sound energy. When the sound energy or exposure duration doubles, the sound pressure level increases by 3 dB and vice versa.

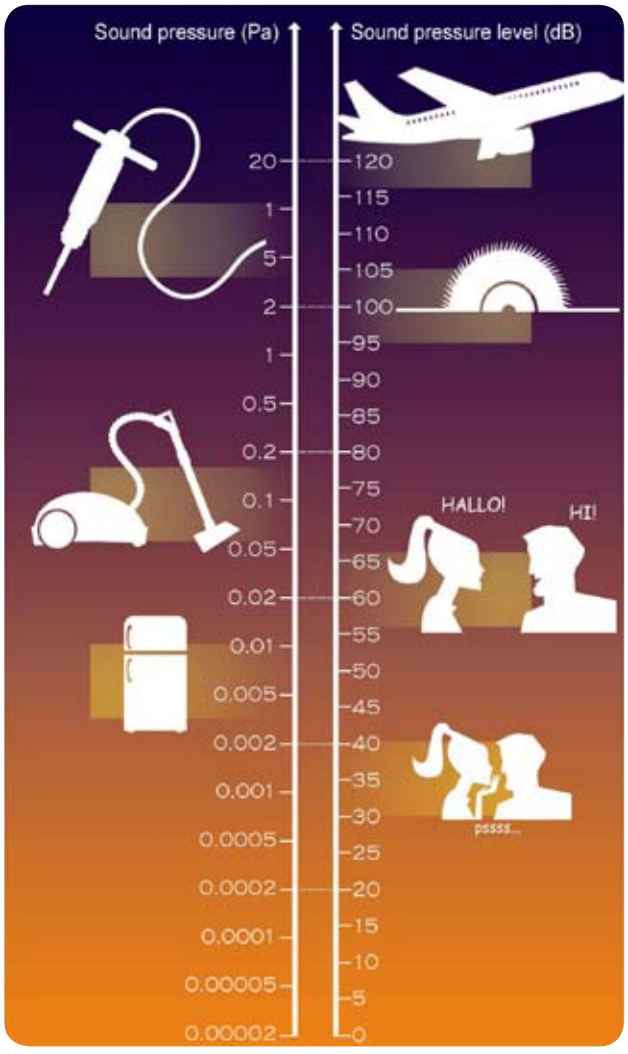


Figure 1.10 Comparison of the sound pressures and sound pressure levels of different sounds

- When sound pressure level increases or decreases by 10 dB, the sound is usually perceived as twice or half as loud respectively, but +/- 10 dB means a 10-fold increase or decrease in danger to the ear!
- A person with a good hearing can recognise approximately a 1 – 3 dB change in sound pressure level (depending on the sound frequency and pressure level).

3.5. Sound Power and Sound Power Level

Sound Power (P) is the amount of energy emitted by a sound source in a period of time (i.e. during one second). Sound Power is expressed in watts (W).

- Sound Power is one of the basic parameters used to describe a sound source because it does not change in relation to the sound source environment.
- Based on Sound Power, it is usually possible to establish a sound pressure level at a selected location near a noise source.

Examples:

Sound sources and their sound powers: whispering man – 0.0000001 W; musical band – 5 W; jet aircraft – 100,000 W.

Due to the wide range of Sound Power values emitted by sound sources, a sound power level (L_w) is generally quoted in decibels (like sound pressure level).

- The reference value of Sound power level is P0 = 10 – 12 W = 0.000000000001 W.

According to Directive 98/37/EC provisions, manufacturers of machines or equipment are required in some cases to determine the Sound Power and provide this information in their instructions.*

*Directive 98/37/EC of the European Parliament and of the Council of 22 June 1998, on the approximation of the laws of the Member States relating to machinery, O.J. n° L 207 of 23.07.1998, page 1.

3.6. Addition of Sound Pressure Levels

A decibel is a logarithmic quantity, so the sound pressure level resulting from noise produced by many different sound sources cannot be calculated by simply adding the sound pressure levels of the noises produced individually by each source (Figure 1.11a).

Examples:

A machine generates noise at a sound pressure level of 80 dB. If we place another similar machine next to it, what will be the sound pressure level of the noise generated simultaneously by both machines?

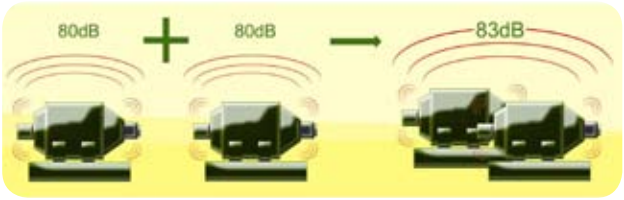


Figure 1.11a Addition of Sound Pressure Levels

What will be the sound pressure level of the noise generated by 10 such machines operating simultaneously? (Figure 1.11b)

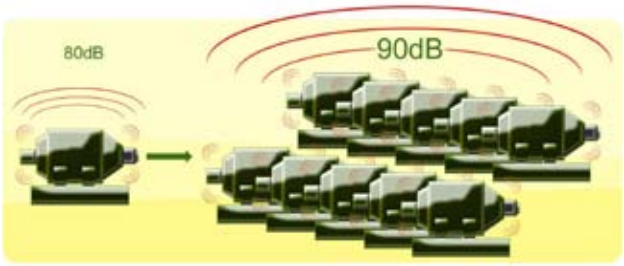


Figure 1.11b Addition of sound pressure levels

Next to the machine generating noise at a sound pressure level of 80 dB, we place a machine that generates noise at a sound pressure level of 60 dB. What is the sound pressure level of the combined noise generated? (Figure 1.11.c)

Figure 1.11c Addition of sound pressure levels

The louder machine in fact determines the Sound Pressure Level of the resulting noise generated by the two machines. If the difference in machine Sound Pressure Level exceeds 10 dB, we reckon that the resulting sound pressure level is equal to that of the louder machine.

The simplified method shown below can be used to calculate the combined sound pressure level of two sources.

- Step 1 – Calculate the difference between the two individual machine levels.
- Step 2 – Add the assigned value to the higher of the two-decibel levels.

Numerical difference between two noise levels [dB(A)]	Value to be added to the higher of the two noise levels [dB or dB(A)]
0	3.0
1	2.5
2	2.1
3	1.8
4	1.5
5	1.2
6	1.0
7	0.8
8	0.6
9	0.5
10	0.4

Table 1.1 Data for calculating combined sound pressure levels

- When the difference in sound pressure level exceeds 10 dB, combined addition can be ignored and the higher of the two noise levels is taken as the combined sound pressure level.

4. SOUND FREQUENCY ANALYSIS

4.1. Tone and acoustic spectrum

Sound created by sinusoidal vibration is called a pure tone or simply a tone. An acoustic spectrum is a distribution of sound pressures or intensities measured as a function of frequency.

- Pure tones can be shown in a graph, in which the horizontal axis represents frequency and the vertical axis represents acoustic pressure level (Figure 1.12). This type of graph is called a sound spectrum.
- Pure tones are rarely found in real conditions. The sounds that surround us usually consist of many different mixed tones.

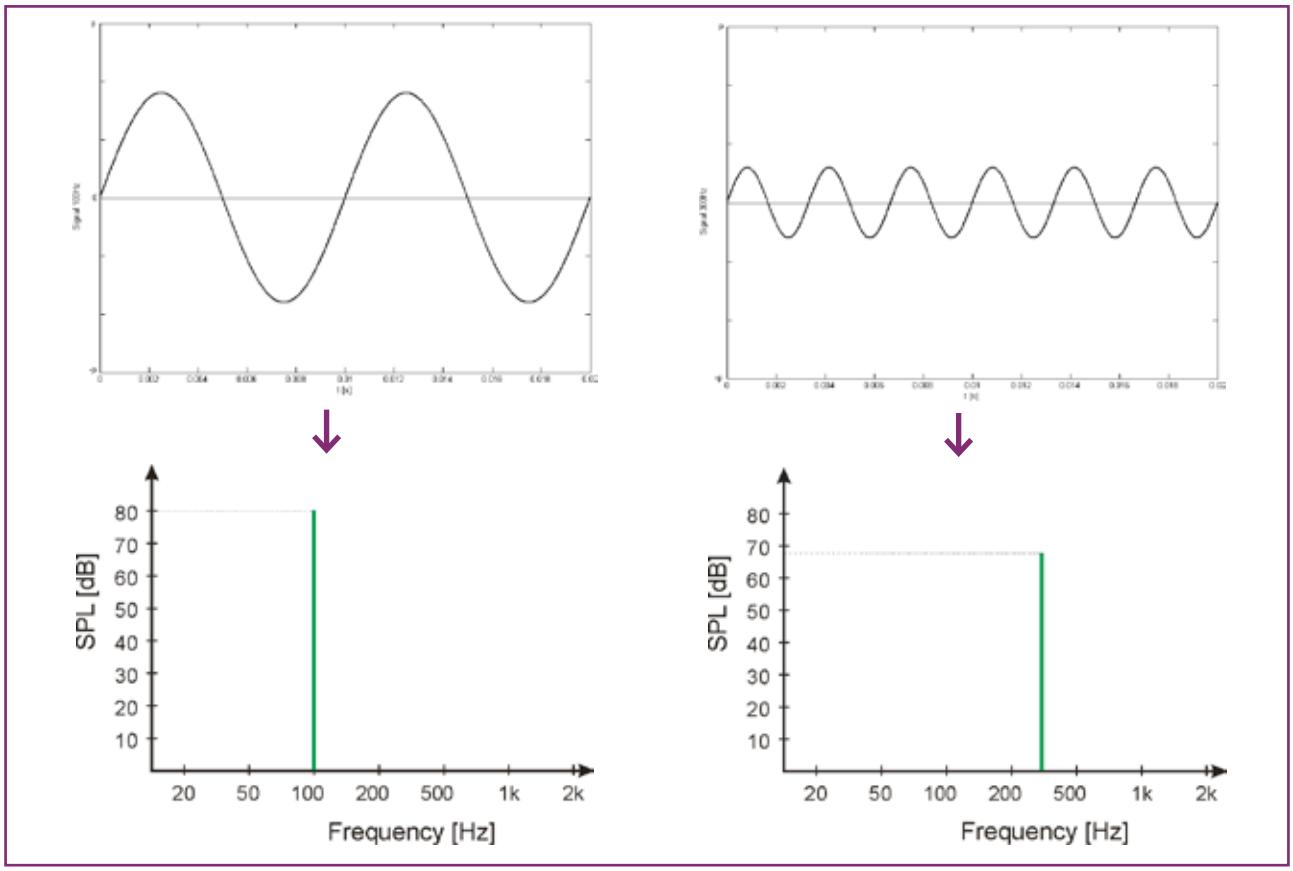
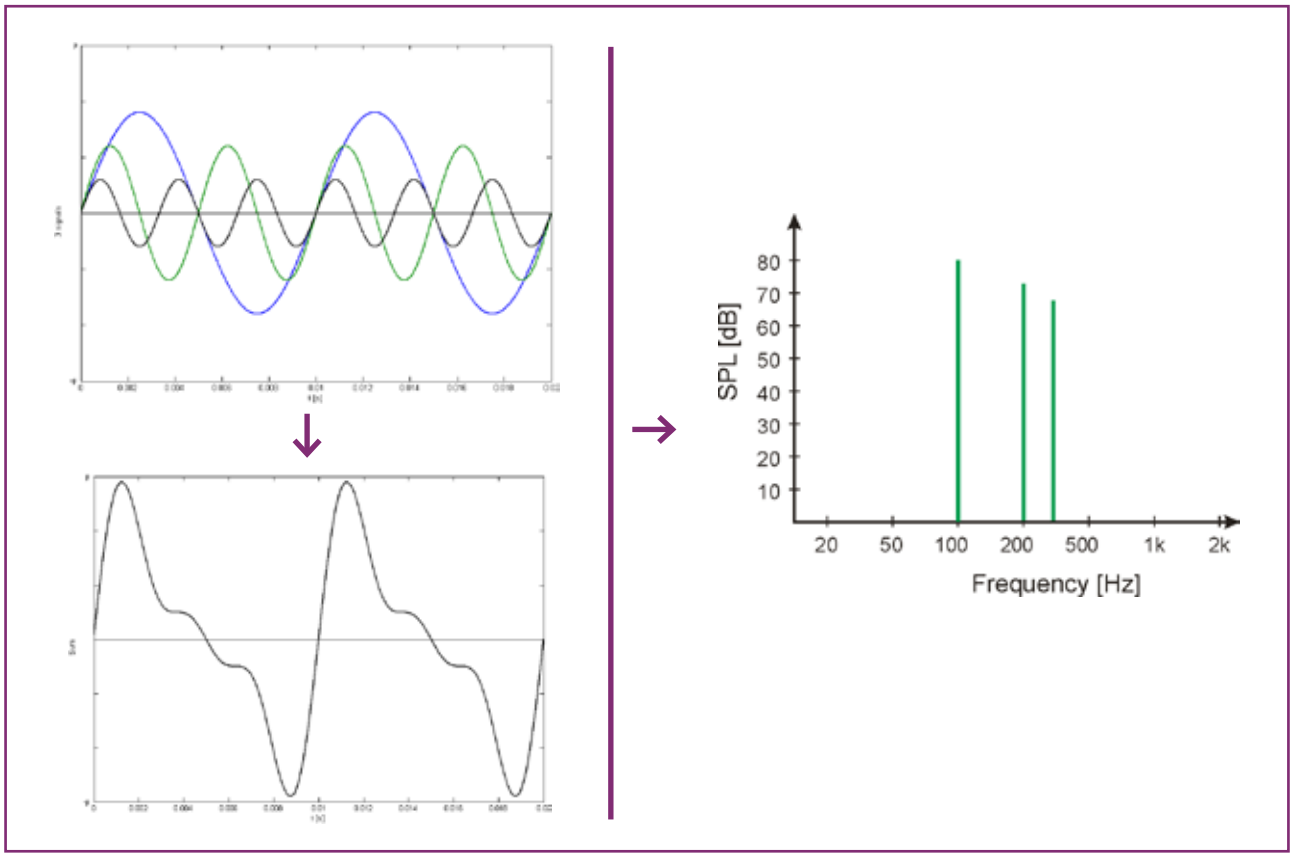
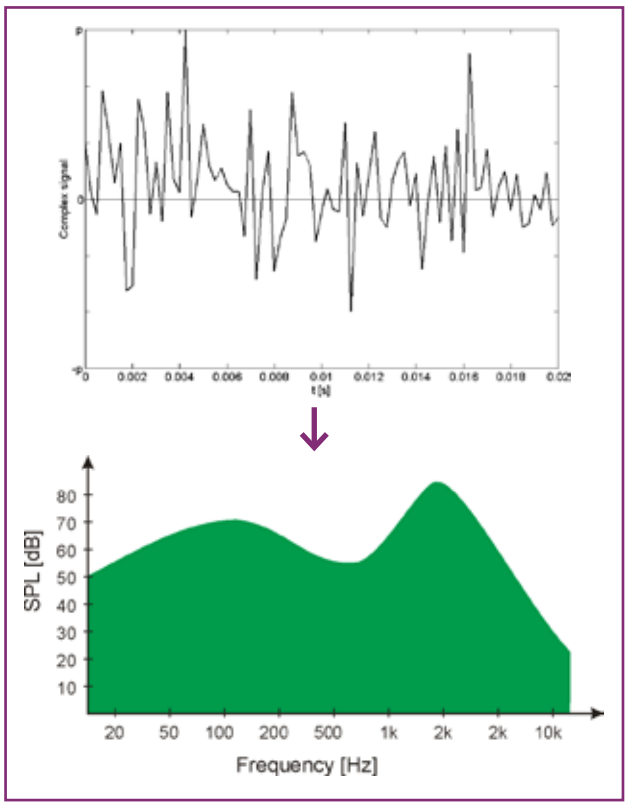


Figure 1.12 Tonal signals and their spectra

Examples:



Time signal of sound comprising three tones (100Hz, 200Hz and 300Hz) and sound spectrum.



Time signal of noise and its continuous frequency spectrum:

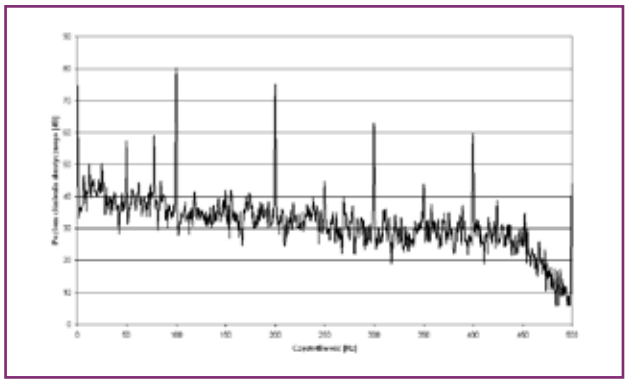


Figure 1.13 Noise spectrum of a large power transformer

Sound physical properties of materials and structures (insulation, absorption, damping, etc, – refer to Chapter 4: How do we reduce noise exposure?) depend on noise frequency. The first step to reducing noise is therefore to measure and evaluate its frequency spectrum.

- Frequency spectrum familiarity permits selection of solutions, which will be most effective for a specific noise.
- Noise spectrum analysis can be conducted at different levels of accuracy.
- It is not usually necessary to measure separately the sound pressure level for every frequency. Sound pressure level measurement in certain frequency bands is sufficient.

4.2. Octave and 1/3 octave bands

An octave band is a band for which the upper frequency is twice that of the lower frequency. Every octave band is divided into three one-third octave (1/3-octave) bands.

- According to accepted international standards, the frequency range of audible sounds can be divided into 10 octave bands.
- Octave and 1/3-octave bands are most often denoted by their centre frequencies (see EN ISO 266:2003 – Acoustics – Preferred frequencies). The following octave band centre frequencies are preferred:
  31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz and 16 kHz.

Example:

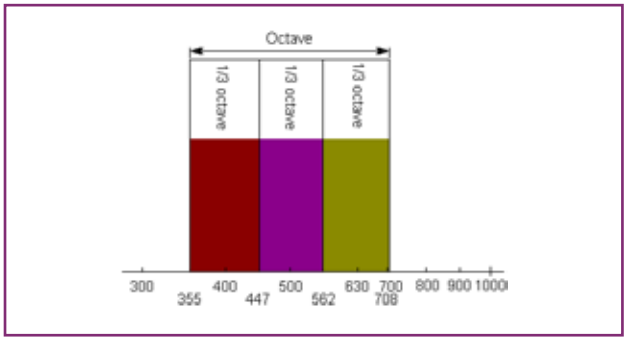


Figure 1.14 An octave with a 500 Hz centre frequency and three 1/3 octave bands with 400 Hz, 500 Hz and 630 Hz centre frequencies

- An octave band-based sound spectrum is called an octave spectrum and a 1/3-octave band-based spectrum is called a 1/3-octave band spectrum.
- Noise spectrum analysis can also be conducted using frequency bands narrower than 1/3 octave.

Example:

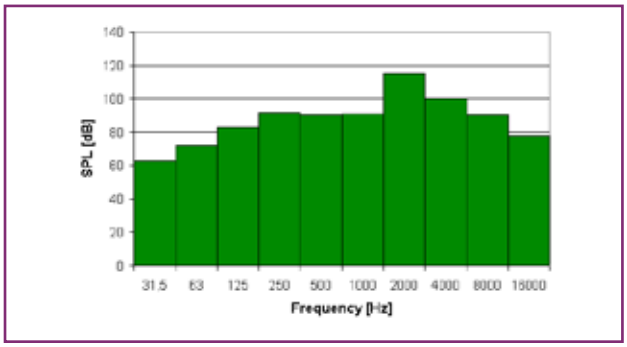


Figure 1.15 Octave spectrum

5. SOUND PRODUCTION AND PROPAGATION

5.1. Radiation, Emission and Immission

When noisy equipment produces sound, we say that it radiates sound energy. Sound radiated in this way is called emission.

- Radiation is conversion of a sound source's vibration energy into sound energy.
- Emission is the amount of sound radiated solely from a given source.
- Noise emission can be quantified either by sound power level or by sound pressure level.

Figure 1.16 Radiation and emission

Sound Power Level is one of two complementary quantities used to describe the sound emission of machinery or equipment. The other quantity is emission Sound Pressure Level at a specified position. Methods of determining emission sound pressure levels at work stations and other specified positions are given in the international standard series ISO 11200 to ISO 11204. These standards define emission as an airborne sound radiated by a well-defined noise source (e.g. a machine undergoing testing) under specified operating and assembly conditions.

Immission is the amount of sound arriving at a specific measuring point (e.g. a workplace, a microphone or a human ear – Figure 1.17), including various sound sources and room reflections.

- Immission is usually quantified by sound pressure level.

Examples:

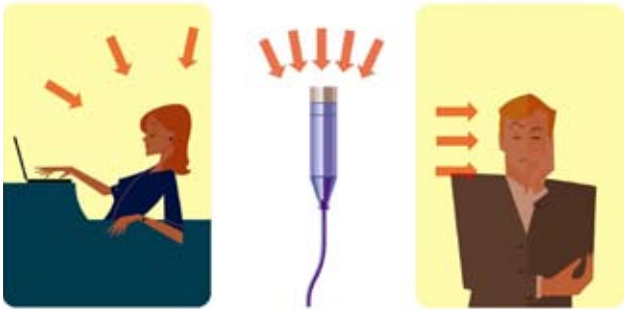


Figure 1.17 Sound immission

5.2. Directivity

Directivity is the capacity to radiate sound in defined directions.

- The amount of sound energy radiated by a sound source may vary in different directions.
- When noisy equipment radiates more sound energy in a particular direction, this means that the sound pressure level will be higher in this direction than in other directions.

Example:

When walking around a radio, music is heard to be louder in front of it than to the side of it and much louder in front of it than behind it.

- The directivity pattern of a sound source can be established by measuring sound pressure levels around it.
- The sound source directivity pattern shows the direction, in which the source radiates sound at the highest sound pressure level and how much this differs from sound pressure levels radiated in other directions.
- A sound source radiating sound energy equally in all directions is called an omnidirectional source.
- Sound source directivity depends on the generated sound frequency.
- Low frequency sound sources are often omnidirectional.
  (see Figure 1.18)

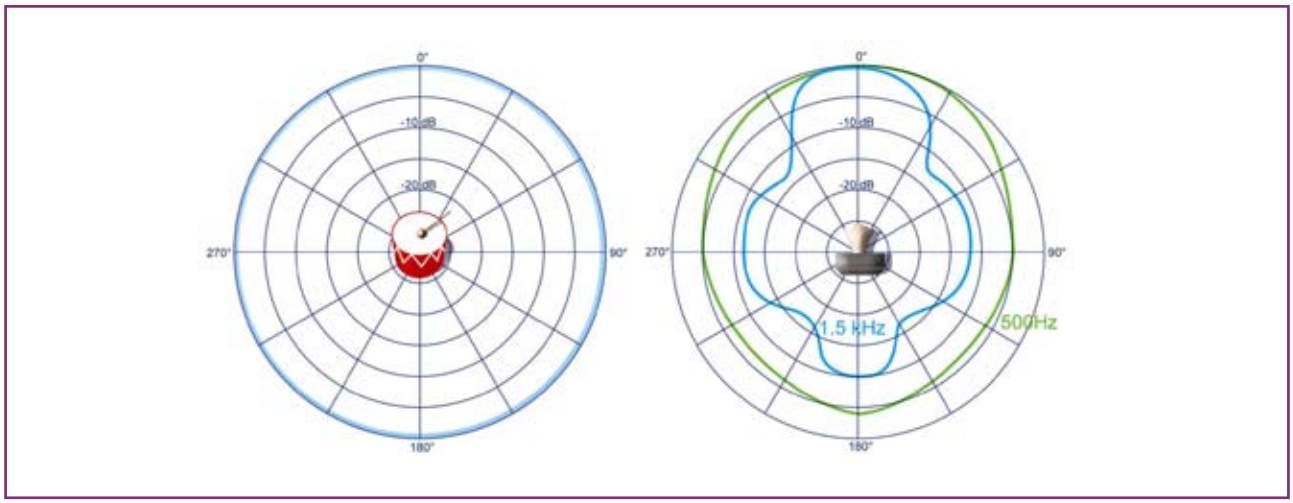


Figure 1.18 Directivity patterns – omnidirectional (large drum) and directional (horn loudspeaker)

5.3. Sound propagation and room influence

An open space, in which sound travels freely, is called a free field.

- The sound pressure level in a free field decreases by 6 dB each time the distance from the sound source doubles.

Example:

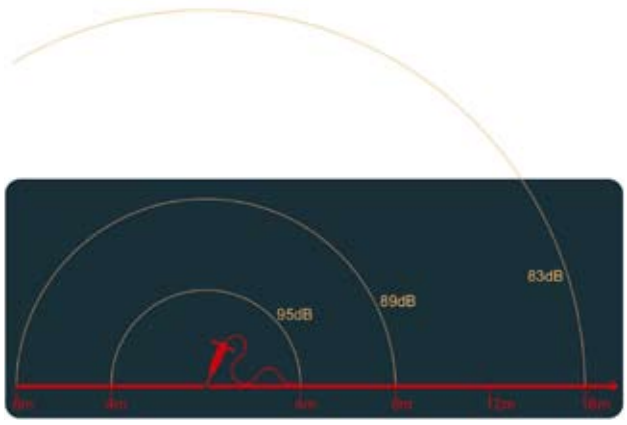


Figure 1.19 Sound propagation in a free field, from an individual source

When sound waves encounter an obstacle, a proportion of the sound energy is reflected, a proportion is absorbed and a proportion is transmitted through the obstacle.

- Reflection is a phenomenon involving rebounding of a sound wave from a surface. Absorption is a conversion of sound energy into heat.
- Transmission is the passing of sound energy through an obstacle.
- The reflected, absorbed or transmitted proportion of sound depends on the obstacle physical properties and dimensions as well as the sound frequency.

Example:

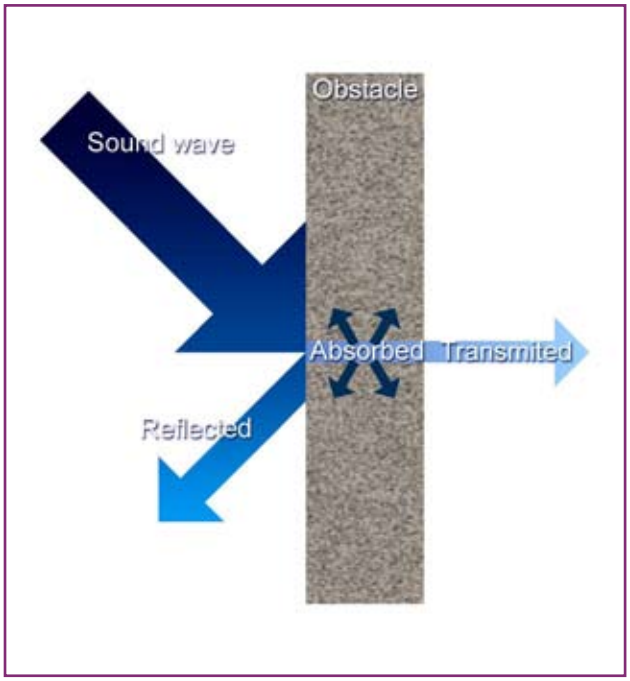


Figure 1.20 Reflection, absorption and transmission

6. TERMS AND EXPRESSIONS USED TO ASSESS HEARING LOSS RISK

6.1. Physical parameters used as risk indicators

For the purposes of the Directive, three physical parameters are defined for use as risk indicators: peak sound pressure, daily noise exposure level and weekly noise exposure level.

- Peak sound pressure is expressed in dB(C), whilst daily and weekly exposure levels are expressed in dB(A).
- We can say that:
  - Noise exposure level allows assessment of the effects of prolonged exposure to noise.
  - Peak sound pressure allows assessment of the effects of exposure to short, very loud sounds (impulse noise).

6.2. Threshold of hearing

The minimum sound pressure level of a defined audible frequency is called the threshold of hearing. It is defined as the level of sound at which, under specific conditions, a person gives 50% of correct detection responses during repeated trials (see ISO 226:2003).

- Sensitivity to sound depends on two factors:
  - Sound Pressure Level
  - Sound frequency.
- Human hearing is most sensitive to sounds with frequencies around 4 kHz.
- For young people with good hearing, the threshold of hearing within this frequency range is about – 3 dB SPL. Sounds of higher and lower frequencies are not so easily heard.

Humans can sense sounds of different frequencies and levels as equally loud. In the sound pressure level/frequency plane, a curve connecting points representing tones, which are considered equally loud, is called an equal-loudness level contour.

- Differences in sound reception cause a 1 kHz frequency sound with a 30 dB sound pressure level to seem as loud as a 100 Hz frequency sound with a 45 dB sound pressure level or an 8 kHz frequency sound with a 40 dB sound pressure level.
- At very high sound pressure levels (approximately 130 dB), loudness perception differences at various frequencies are less significant. Sound pressure levels of different frequency sounds, which are painful to the ears, differ less from each other than sound pressure levels of sounds, which are barely audible.

Example:

Sound frequencies and levels sensed as equally loud: 20 Hz – 75 dB; 60 Hz – 35 dB; 100 Hz – 25 dB; 300 Hz – 10 dB; 600 Hz – 5 dB; 1 kHz – 0 dB; 6 kHz – 5 dB; 10 kHz – 15 dB.

6.3. Frequency weighting

Differences in sound reception according to frequency and level mean that weighted sound pressure levels are used for assessing hearing loss risk.

- An A-weighted sound pressure level, expressed in dB(A), corresponds best to the subjective reception of sounds at low sound pressure level.
- A C-weighted sound pressure level, expressed in dB(C), corresponds best to the subjective reception of sounds at high sound pressure level.
- In simple terms, weighting represents an adjustment or correction of sound pressure levels and is applied to each frequency band.

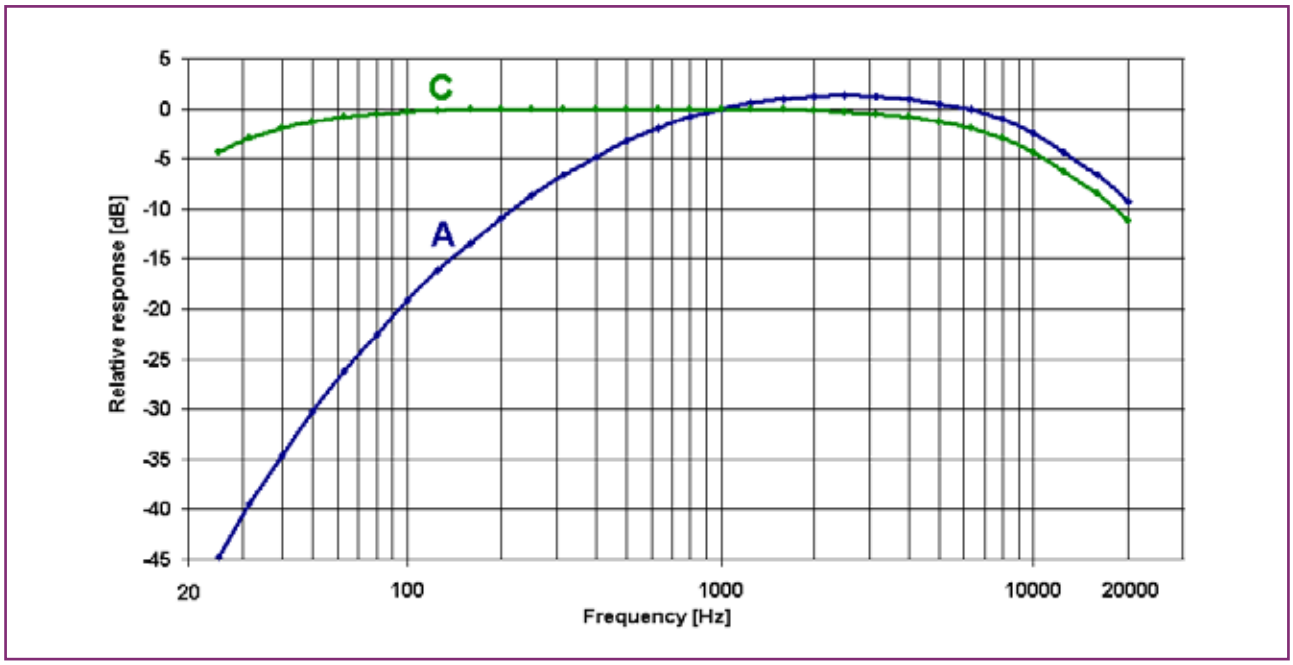


Figure 1.21 Weighting curves

- Table 1.2 below shows adjustments to octave band centre frequencies.

Octave Band Centre Frequencies, Hz	A-weighting adjustment, dB	C-weighting adjustment, dB
31.5	-39	-3
63	-26	-1
125	-16	0
250	-9	0
500	-3	0
1000	0	0
2000	+1	0
4000	+1	-1
8000	-1	-3
16000	-7	-8

Table 1.2 Octave band centre frequency adjustments for A- and C-weighting curves

- The A-weighting curve introduces a large correction to sound pressure levels for low frequency sounds. Sound pressure levels, expressed in dB (no frequency correction) and dB(A), will therefore vary widely for sounds with strong, low frequency components.

Example:

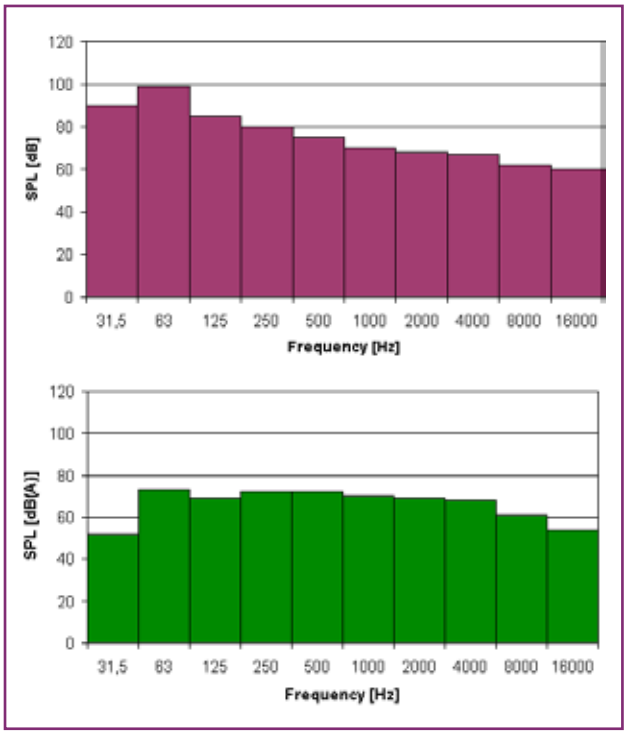


Figure 1.22 Spectra of the same sound expressed in dB and dB(A)

6.4. Exposure and exposure level

A quantity called A-weighted sound exposure ($E_{A,\ 8h}$) is used to assess the damaging effect of noise on a person (standard ISO 1999:1990).

- The damaging effect of noise on hearing depends on the quantity of sound energy absorbed by a person's ears and therefore depends on parameters such as the noise sound pressure level and the exposure duration.
- While performing his tasks, a worker may be subject to noise at different sound pressure levels for varying periods of time. This is why assessment of the damaging effects of noise is conducted with reference to a nominal 8-hour working day or nominal five 8-hour working day week as specified in standard ISO 1999:1990.
- Exposure is a quantity corresponding to the amount of sound energy absorbed and is therefore sometimes called 'noise dose'.

Examples:

A carpenter's tasks include repairing various wooden components of equipment. These are jobs, during which the worker is not usually exposed to noise, e.g. hand-working wood, glueing wooden parts and varnishing. However, from time to time, the worker has to work with power tools such as a circular saw, a plane, etc., which generate noise at considerable sound pressure levels right up to 115 dB(A). The risk associated with a damaging noise level at this type of work station is assessed with reference to a nominal 8-hour working day.

The effect of noise on a person can be compared to sunbathing. Sensible sunbathing will not result in undesirable effects. However, excessive exposure to strong rays will quickly lead to sunburn. The same effect will occur when the subject is exposed to weak rays over a prolonged period, due to the amount of solar energy absorbed by the skin during this period. Noise exposure represents a similar case. Even the shortest exposure to high sound pressure level noise will lead to hearing damage, while exposure to low-level noise over a longer period will have a similar effect.

Exposure level expressed in decibels ($L_{EX,\ 8h}$) is very often used instead of the noise exposure ($E_{A,\ 8h}$). Directive 2003/10/EC[17] defines the following levels of exposure to noise.

- Daily noise exposure level ($L_{EX,\ 8h}$) (dB(A) re. 20 µPa): the time-weighted average of the noise exposure levels for a nominal 8-hour working day, as defined by international standard ISO 1999: 1990.
- Weekly noise exposure level ($\overline{L}_{EX,\ 8h}$): the time-weighted average of the daily noise exposure levels for a nominal five 8-hour working day week, as defined by international standard ISO 1999:1990. Note that $\overline{L}_{EX,\ 8h}$ is the mean exposure level calculated from $L_{EX,\ 8h}$ for each working day in week.

6.5. Equivalent continuous A-weighted Sound Pressure Level

The equivalent continuous A-weighted Sound Pressure Level of non-steady noise is that A-weighted sound pressure level of steady noise, which would cause the same effect on a person as the noise, for which we calculate the equivalent continuous A-weighted sound pressure level.

- In the case of steady noise (i.e. noise whose SPL does not vary more than 5 dB during its presence) affecting a person during a nominal 8-hour working day, the daily noise exposure level will equal its SPL expressed in dB(A).
- In the case of non-steady noise (i.e. noise whose SPL varies more than 5 dB), an equivalent continuous A-weighted SPL (LA_{eq}, T) is used to calculate the daily noise exposure level.

Example:

During his first three hours of work, a worker was exposed to a noise level of 85 dB(A). During the next four hours, he worked in a quiet room [60 dB(A)] and during the next hour he worked on a machine generating noise with a sound pressure level of 100 dB(A). The equivalent continuous A-weighted SPL calculated for 8 hours of work therefore equals 91 dB(A).

17. Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003, on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise), O.J. No L 42 of 15.02.2003, page 38.

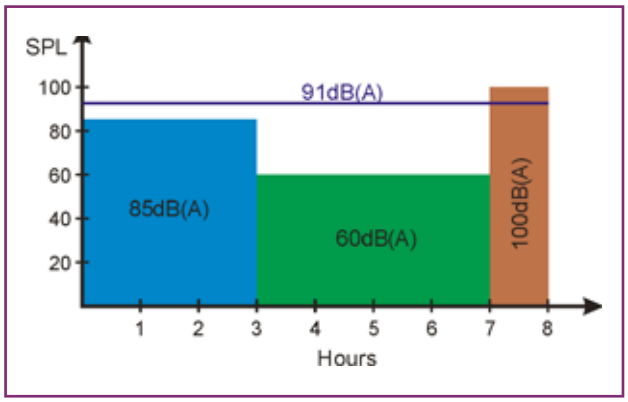


Figure 1.23 Equivalent level [91 dB(A)] during 8-hour working day

6.6. Peak Sound Pressure

Peak sound pressure (p_{peak}) is the maximum value of 'C'-frequency weighted instantaneous noise pressure.

- Peak sound pressure (p_{peak}) is very often used to assess the damaging effect of noise in addition to the level of exposure to noise.
- Exposure limit values of peak sound pressure, quoted in the Directive, are values of sound pressure, at which there is a serious risk of instant hearing damage.
- We can say that:
  - Noise exposure level provides an assessment of the effects of prolonged exposure to noise.
  - Peak sound pressure provides an assessment of the effects of exposure to short, very loud sounds (impulse noise).

7. WARNING SIGNAL RECOGNITION AND SPEECH INTELLIGIBILITY

Speech intelligibility in noisy environments is defined as a percentage of correctly recognised words, utterances etc. It can be calculated using various methods.

- A characteristic phenomenon occurring in presence of noise involves not hearing sounds weaker than the noise. This phenomenon is called sound masking.
- Sound masking is very dangerous at work stations, where an employee requires potential hazard (e.g. machines or their moving parts) warning or has to obey verbal instructions. Sound masking may result in an employee not be able to hear or recognise the warning signals and this may cause accidents.
- Sound masking influences speech intelligibility. Low speech intelligibility may result in misunderstanding of verbal instructions and may also cause accidents.
- According to the provisions of Directives 2003/10/EC and 89/391/EEC[18], the employer shall be particularly careful, when assessing risks of any indirect effects on workers' health and safety resulting from interactions between noise and warning signals or other sounds, which need to be observed to reduce the risk of accidents.

18. 89/391/EEC Council Directive of 12 June 1989, on the introduction of measures to encourage improvements in the safety and health of workers at work, O.J. No L 183 of 29.06.1989, page 1.

CHAPTER 2
Risk assessment procedure

SUMMARY PAGE

Risk assessment is fundamental for the protection of workers from risks to their health and safety arising or likely to arise from exposure to noise risk. Risk assessment shall identify workers exposed to risk from noise and determine their level of noise exposure. Risk assessment is not an end in itself; its purpose is to identify actions required when exposure action values are reached or exceeded.

Employer's obligations

Article 4 of Directive 2003/10/EC[19] requires the employer to assess and, if necessary, to measure the levels of noise, to which the workers are exposed.

Directive 2003/10/EC

(Article 4)

1. *The employer shall assess and, if necessary, measure the levels of noise to which workers are exposed.*
2. *The methods and apparatus used shall be adapted to the prevailing conditions particularly in the light of the characteristics of the noise to be measured, the length of exposure, ambient factors and the characteristics of the measuring apparatus.*

Risk assessment and exposure measurement referred to above must be planned and conducted by competent services at appropriate intervals, taking particular account of the provisions of Article 7 of Directive 89/391/EEC[20] concerning necessary, competent services or persons. Data obtained from assessment and/or measurement of the noise exposure level must be stored in a suitable form to permit consultation at a later stage.

Directive 89/391/EEC

(Article 7)

1. *The employer shall designate one or more workers to carry out activities related to the protection and preventions of occupational risks for the undertaking and/or establishment.*
3. *If such protective and preventive measures cannot be organised for lack of competent personnel in the undertaking and/or establishment, the employer shall enlist competent external services or persons.*

When applying Article 4 of Directive 2003/10/EC, assessment of measurement results must take into account measurement inaccuracies determined in accordance with metrological practice. The methods and apparatus used shall be adapted to the prevailing conditions, particularly in light of the characteristics of the noise to be measured, the length of exposure, ambient factors and the characteristics of the measuring apparatus. These methods and this apparatus shall make it possible to determine the parameters and to decide whether the values have been exceeded.

The methods used may include sampling, which shall be representative of the personal exposure of a worker.

Directive 2003/10/EC

(Article 4)

3. *The methods used may include sampling, which shall be representative of the personal exposure of a worker.*
5. *When applying this Article, the assessment of the measurement results shall take into account the measurement inaccuracies determined in accordance with metrological practice.*

19. Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003, on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise), O.J. No L 42 of 15.02.2003, page 38.

20. 89/391/EEC Council Directive of 12 June 1989, on the introduction of measures to encourage improvements in the safety and health of workers at work, O.J. No L 183, of 29.06.1989, page 1.

The assessment and measurement referred to above shall be planned and carried out by competent services at suitable intervals. The data obtained from the assessment and/or measurement of the level of exposure to noise shall be preserved so as to permit consultation at a later stage.

Finally, the employer must be especially attentive to exposure limit and action values given in Article 3 of Directive 2003/10/EC, to the exposure level, type and duration, including impulsive noise exposure and to all health and safety related effects on workers belonging to particularly sensitive risk groups, effects of interactions between noise and ototoxic substances and vibrations, and effects of interactions between noise and warning signals, etc.

Directive 2003/10/EC

(Article 3)

Exposure limit values and exposure action values

1. *For the purposes of this Directive the exposure limit values and exposure action values in respect of the daily noise exposure levels and peak sound pressure are fixed at:*
   a. *exposure limit values: $L_{EX,8h}$ = 87 dB(A) and p_{peak} = 200 Pa (1) respectively;*
   b. *upper exposure action values: LEX,8h 85 dB(A) and ppeak = 140 Pa (2) respectively;*
   c. *lower exposure action values: LEX,8h = 80 dB(A) and ppeak = 112 Pa (3) respectively.*
2. *When applying the exposure limit values, the determination of the worker's effective exposure shall take account of the attenuation provided by the individual hearing protectors worn by the worker. The exposure action values shall not take account of the effect of any such protectors.*
3. *In duly justified circumstances, for activities where daily noise exposure varies markedly from one working day to the next, Member States may, for the purposes of applying the exposure limit values and the exposure action values, use the weekly noise exposure level in place of the daily noise exposure level to assess the levels of noise to which workers are exposed, on condition that:*
   a. *the weekly noise exposure level as shown by adequate monitoring does not exceed the exposure limit value of 87 dB(A); and*
   b. *appropriate measures are taken in order to reduce the risk associated with these activities to a minimum.*

When does a risk exist?

Risk is determined by daily noise exposure level ($L_{EX, 8h}$)[21]:

Noise exposure is determined from exposure duration and average sound pressure level (L_{eq}) during the exposure period.

Daily noise exposure is determined by summing up each individual period of noise exposure during the day to give the overall daily value. This daily period is normalised to eight hours.

Risk is also determined by maximum peak sound pressure expressed as a C-weighted peak sound level.

A worker is considered to be at risk if his/her daily noise exposure or peak noise exposure exceeds the lower action values.

How do I assess the risk?

Initial checks can be used to estimate whether lower action values are likely to be exceeded. These initial checks are not accurate, but simply adequate to ensure a first approximation or whether there is a critical risk potential.

A quantitative assessment is required if there is any likelihood that lower exposure action values could be reached or exceeded. In this case, the assessment must consider how the work is performed and how it may vary from day to day. Reliable information on the level of the noise associated with each task is also required; this may be provided by measurements in the workplace or by other reliable sources.

Evaluation uncertainty must be considered, when comparing results with action values. When it is possible, rather than certain, that an exposure action value or limit value is exceeded, action shall be taken on the assumption that it is exceeded.

Risk assessment shall identify workers at risk and help to identify areas and tasks contributing most to worker noise exposure. This will form a basis for planning noise controls, health surveillance and hearing protection requirements. Keep a record of findings and review your assessment, when workplace alterations affect noise exposure.

21. Daily noise exposure is given in dB(A). It shall not be confused with other values also given in dB(A) such as:
    - Sound pressure level (Lp) – immediate sound pressure level.
    - Sound power level (Lw) – total Sound Power output (emission) associated with an item of noisy equipment.

    Noise parameters are introduced in Chapter 1.

1. DIRECTIVE REQUIREMENTS

Paragraphs 1, 2, 3, 4 and 5 of Article 4 of Directive 2003/10/CE include the following provisions.

1. In carrying out the obligations laid down in Articles 6(3) and 9(1) of Directive 89/391/EEC, the employer shall assess and, if necessary, measure the levels of noise to which workers are exposed.

2. The methods and apparatus used shall be adapted to the prevailing conditions particularly in the light of the characteristics of the noise to be measured, the length of exposure, ambient factors and the characteristics of the measuring apparatus.

   These methods and this apparatus shall make it possible to determine the parameters defined in Article 2 and to decide whether, in a given case, the values fixed in Article 3 have been exceeded.

3. The methods used may include sampling, which shall be representative of the personal exposure of a worker.

4. The assessment and measurement referred to in paragraph 1 shall be planned and carried out by competent services at suitable intervals, taking particular account of the provisions of Article 7 of Directive 89/391/EEC concerning the necessary competent services or persons. The data obtained from the assessment and/or measurement of the level of exposure to noise shall be preserved in a suitable form so as to permit consultation at a later stage.

5. When applying this Article, the assessment of the measurement results shall take into account the measurement inaccuracies determined in accordance with metrological practice.

6. Pursuant to Article 6(3) of Directive 89/391/EEC, the employer shall give particular attention, when carrying out the risk assessment, to the following:
   (a) the level, type and duration of exposure, including any exposure to impulsive noise;
   (b) the exposure limit values and the exposure action values laid down in Article 3 of this Directive;
   (c) any effects concerning the health and safety of workers belonging to particularly sensitive risk groups;
   (d) as far as technically achievable, any effects on workers' health and safety resulting from interactions between noise and work-related ototoxic substances, and between noise and vibrations;
   (e) any indirect effects on workers' health and safety resulting from interactions between noise and warning signals or other sounds that need to be observed in order to reduce the risk of accidents;
   (f) information on noise emission provided by manufacturers of work equipment in accordance with the relevant Community directives;
   (g) the existence of alternative work equipment designed to reduce the noise emission;
   (h) the extension of exposure to noise beyond normal working hours under the employer's responsibility;
   (i) appropriate information obtained following health surveillance, including published information, as far as possible;
   (j) the availability of hearing protectors with adequate attenuation characteristics.

7. The employer shall be in possession of an assessment of the risk in accordance with Article 9(1)(a) of Directive 89/391/EEC, and shall identify which measures must be taken in accordance with Articles 5, 6, 7 and 8 of this Directive. The risk assessment shall be recorded on a suitable medium, according to national law and practice. The risk assessment shall be kept up to date on a regular basis, particularly if there have been significant changes which could render it out of date, or when the results of health surveillance show it to be necessary.

2. INTRODUCTION

Risk assessment shall identify those workers who are likely to be at risk, determine their noise exposure and provide information for noise control and selection of hearing protection.

This chapter contains guidance on the following:

- Making initial estimates of noise levels;
- Planning and making an assessment;
- Taking measurements with a sound level meter or dosimeter;
- Noise exposure calculation;
- Identifying significant noise sources;
- Information, consultation, participation and training of workers.

3. OVERVIEW OF NOISE RISK ASSESSMENT PROCEDURE

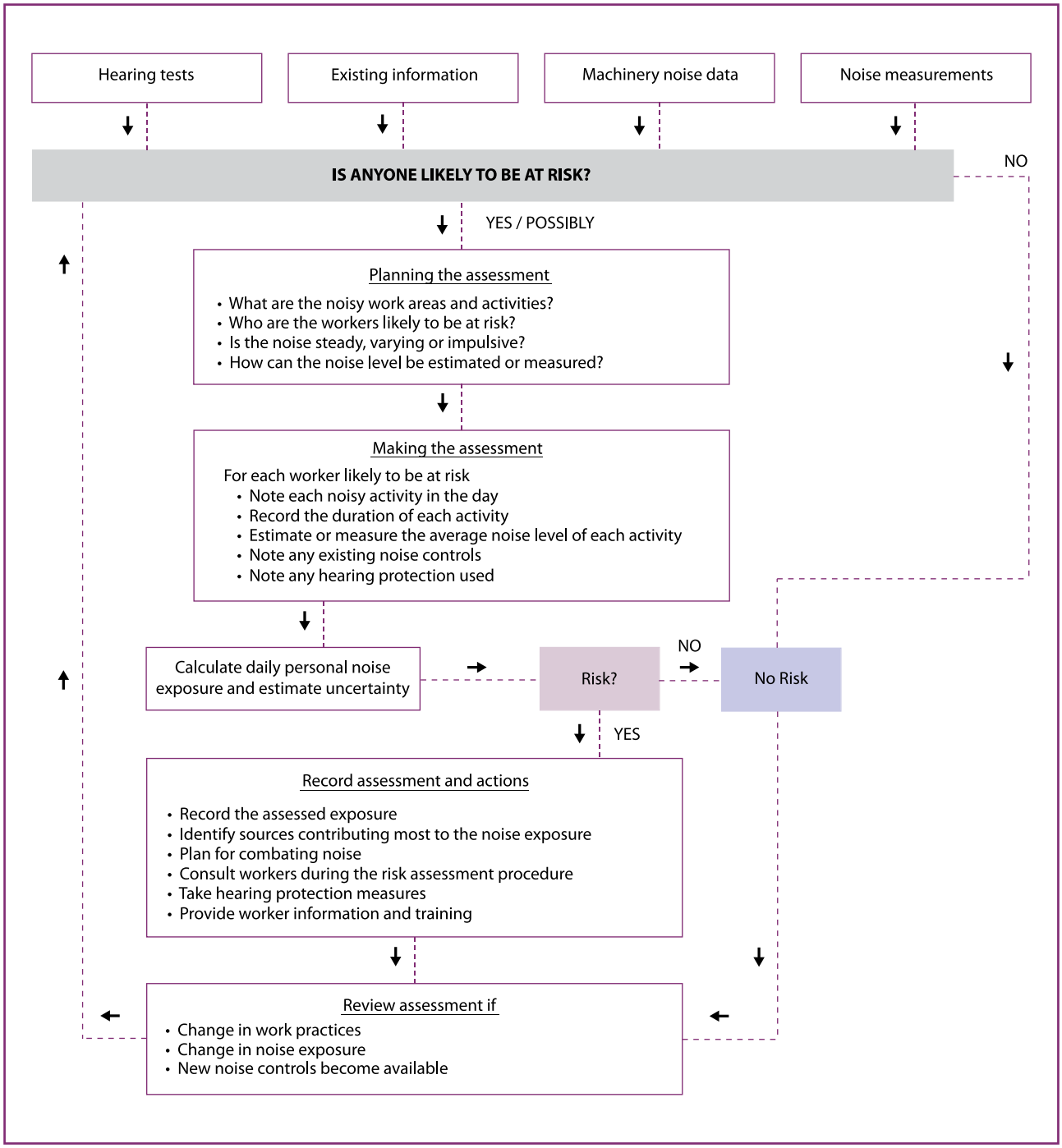


Figure 2.1 Diagram showing assessment procedure stages

4. IS ANYONE LIKELY TO BE AT RISK? – INITIAL CHECKS

A noise assessment may simply determine whether or not a risk exists. If a worker's noise exposure is likely to reach the lower noise action values a quantitative assessment of their noise exposure is necessary. Listening checks, existing information on typical noise levels and simple noise measurements can help you decide where a risk may exist.

4.1. Listening and simple checks for steady noise

Daily exposure is a function of both the level and duration. Listening checks help to estimate the noise level and help the employer to decide whether a worker's exposure is likely to exceed the lower action value. Remember listening checks are only approximate.

Figure 2.2 Listening checks, indicative steady noise levels and typical sounds

At this stage you can also use inexpensive, simple sound level meters to make approximate measurements of steady noise, and confirm your listening check. If you suspect that the lower daily exposure action value is exceeded you will need to make a more precise assessment as described later in this chapter.

Example:

A listening check is made in a supermarket. Normal conversation is unhindered in most areas confirming there is no risk. In the bakery you have to shout at close distances to talk when certain machinery is operating. Measurements with a simple sound level meter in the bakery suggest the lower exposure action value may be exceeded. A more precise assessment is required to determine whether the upper exposure action value is also exceeded.

4.2. Simple checks of maximum peak sound pressure levels

There are no listening checks for estimating peak sound pressure levels and measurements are only possible with sound level meters that meet European standard requirements. Published values for the peak level at the operator position are the best means of initially assessing whether there is a risk that peak exposure is likely to exceed the lower peak action value. The table below lists typical peak sound pressures of different noise sources.

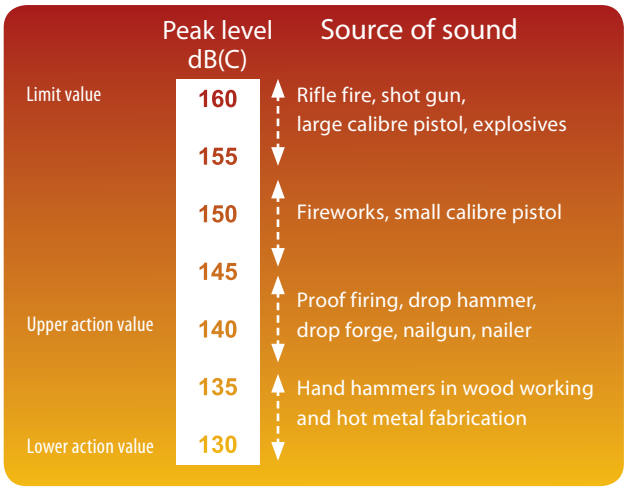


Figure 2.3 Typical peak sound pressure levels of impulsive sources

Example:

A gamekeeper always uses a moderator (silencer) with his rifle. Published measurements for the combination of his rifle, ammunition and moderator give a maximum peak level of 130 dB(C) and a daily noise exposure level of 76 dB(A) when 100 shots are fired in a day.

The number of shots fired in a day is limited to below 100. Thus the lower action values are not exceeded so no hearing protection is required.

A record is kept of the published measurements and the noise controls required when using the rifle. This record forms the noise risk assessment.

Other examples such as 'Rotary hammer drill' and 'Straightening operations' are include in Table 2.1:

NOISE SOURCES WITH HIGH PEAK SOUND PRESSURE LEVELS					
Noise source	**Sound pressure level in dB**				
	L_{Cpeak}	L_{AImax}	L_{AFmax}	L_{Aeq}	$(L_{A,1s})$
Heel lasting machine	111	97	93	85	
Bottling plant (combiner)	120	105	101	92	
Rotary hammer drill	118	100	99	96	
	126	110	108	100	
Hammer drill	123	110	109	106	
Nail driven into wood:					
pneumatic nailer	130	108	105	91	(97)
hand-held hammer	120	103	100	90	
Stud gun	130	108	104	–	(96)
	149	126	122	–	(111)
Straightening operations	134	114	111	96	(103)
	140	126	123	107	(115)
Eccentric press (10 t)	123	107	102	91	
Guillotine shear	138	120	115	–	(107)
Collecting pocket for heavy steel sections	136	127	125	–	(120)
Forging hammer:					
drop hammer (750 kg)	144	126	118	100	(110)
double-acting (10 t)	144	126	122	113	(115)
Pile driving with diesel pile hammer (Hohmann)	133	116	113	102	

Table 2.1 Noise sources with high peak sound pressure levels: sound pressure level in dB.
BIA – Berufsgenossenschaftliches Institut für Arbeitsschutz (Institute for Occupational Safety).

5. PLANNING A RISK ASSESSMENT

A quantitative assessment of noise exposure will need to be made when exposure is likely to exceed the lower action values. This section considers the planning including deciding what information, equipment, and skills you will require for making the assessment.

5.1. Skills required

The skills needed depend on the complexity of the situation. As a minimum those making the assessment shall:

- Be familiar with the work patterns of the workers and processes.
- Understand the purpose of the measurements and the information required to assess exposure.
- Know how to use the instrumentation.
- Be familiar with the basics of physical acoustics.

Those using the measurements or other supplied data shall understand:

- How to assess exposure.
- The actions required when action and limit values are exceeded.
- How to initiate a noise control programme.

Example:

Staff provide a noise assessment and control programme by combining their skills.

A foreman identifies the workers possibly at risk in the noisy areas and provides information on their working patterns.

A technician measures the noise at locations identified by the foreman.

A safety officer assesses exposure and identifies where noise control shall be applied.

5.2. Checking the situation

As an aid to planning the assessment make an initial check of the overall noise problem:

- Identify the areas or activities where staff may be at risk;
- Identify the workers at risk. Make a specific note of any who may be at particular risk such as those with a pre-existing hearing condition, pregnant women and young people.
- Consider whether the noise is steady, varying or impulsive.
- Note any simple noise control measures that could be made immediately; you may save a lot of effort by controlling noise now rather than continuing with the assessment.

Figure 2.4 Check the situation

Example:

A small woodworking factory has one workshop containing machinery.

A second shop is used for construction and finishing.

The following workers are identified as likely to be at risk:

- Workers in the machinery shop. A previous noise assessment shows the operators' daily noise exposure exceeds the upper action value. Hearing protection is already worn but this is not taken into account when comparing with action values.
- Workers using powered sanders and polishers in a second workshop.
- An employee in the second workshop with tinnitus.

The noise is varying but not impulsive, so the risk arises from the daily noise exposure rather than the peak sound pressure.

5.3. Using existing information rather than noise measurements

To assess the personal noise exposure of workers who are likely to be at risk the noise level of each noisy activity during the working day must be evaluated. This information may be obtained from published information on noise levels, information from machinery manufacturers and suppliers, or by measurement. Remember you need to take account of the noise from all sources and room amplification when estimating the noise level a person is exposed to.

It is important that you ensure any data not obtained by measurement is representative of your work situation and you take account of any uncertainty when determining whether exposure action values are exceeded. Remember quoted sound pressure levels at the operator position may be increased due to reverberant room conditions and background noise.

Assessing sound pressure levels from sound power data can be complex. **Chapter 1** on **'Principles of acoustics'** describes the difference between Sound Power and sound pressure level while **Chapter 3** on **'Workplace design'** explains how to assess noise exposure from sound power data and the workplace acoustic conditions.

Example:

The manufacturer of a hand-held tool has declared the average sound pressure level for the operator to be 85 dB(A) with an uncertainty K value of 5 dB. The tool is used for 30 to 60 minutes a day in an otherwise quiet area. During the rest of the day the operator works in a quiet office where listening tests have confirmed that the sound pressure level is less than 70 dB(A).

The operator is close to the source of the noise so the acoustic characteristics of the workroom are unlikely to significantly affect the level at his ear. To account for the uncertainty the average noise level is assumed to be 90 dB(A) (85 dB(A) + 5 dB(A) uncertainty) and the worst-case exposure duration of 60 minutes is assumed. Thus it is assumed that the lower daily exposure action value of 80 dB(A) could be exceeded.

5.4. Instrumentation for noise measurement

There are two basic types of electronic instruments for measuring sound level: sound level meters and dosimeters (also known as personal sound exposure meters). Some meters are dual purpose and can be used as both sound level meters and dosimeters.

Figure 2.5 Sound level meter with sound calibrator
(Photo © and by courtesy of Bruel & Kjaer)

Sound level meters give a direct reading of the sound level to the operator. Generally, a sound level meter is more accurate because the operator supervises the measurement.

Figure 2.6 Dosimeter
(Photo © and by courtesy of Bruel & Kjaer)

Dosimeters are sound level meters designed to be worn on the body and monitor noise exposure during a full or part shift. A dosimeter shall only be used where measurements with a sound level meter are not practical; for example where access is difficult, or the worker is highly mobile. This is because the dosimeter may be tampered with during unsupervised measurements making the results unreliable.

Some dosimeters log the noise level at intervals during the measurement. This record helps identify the contribution from different noise sources or activities and assists elimination of possible unreliable results.

Whether you use a sound level meter or a dosimeter, choose a meter that meets a European standard. A windshield to protect the microphone and a compatible sound calibrator (calibrated sound source for testing the meter indication) are essential accessories.

Example:

Dosimeters are chosen to monitor the noise exposure of a forklift driver moving in and out of noisy areas, and a steeplejack working at high level. The dosimeters are set to record both the overall A-weighted L_{eq}, and the A-weighted L_{eq} for 1-minute intervals during the monitoring period. The two result sets enable analysis of the variation in sound level as well as giving the overall L_{eq} for the whole period.

A sound level meter is chosen to measure the sound levels machine operators are exposed to in an open workshop. Readings are taken at the operator workstations.

5.5. Measurements required

5.5.1. Sound level meter measurement options

Frequency Weighting	Time constant	Function	Level range dB
A	F	max	140
C	S	SPL	110
L_{Lin}	P	L_{eq}	80

Table 2.2 Typical selections on a sound level meter

A sound level meter will normally include user options for the measurement. These may be selected from a menu on the display or by front panel switch selections. Table 2.2 shows some of the typical options. Some meters may have default settings for daily exposure and peak exposure measurements.

- Frequency weighting options must include A-weighting and C-weighting and may include a linear frequency response.
- Time constants govern the response speed of the displayed sound pressure level and can include the following standard responses:
  - **F** and **S** (Fast and Slow) govern averaging of the RMS sound pressure level display. F allows the display to vary approximately with perceived changes in sound level. **S** is a longer averaging time that smoothes out the more rapid changes in level.
  - **P** has a rapid rise time that enables indication of the peak sound pressure level.
- Function options can include:
  - max – the RMS maximum or the Peak maximum during the measurement.
  - **SPL** or **LP** – the immediate sound pressure level;
  - $\mathbf{L_{eq}}$ (equivalent continuous level) – the average sound pressure level over the measurement period. $\mathbf{L_{eq}}$ is also shown as $\mathbf{LA_{eq}}$, or $\mathbf{L_{Ceq}}$ to indicate measurements with **A** or **C** weighting.
- A level range control allows the user to set the operating range of the meter according to the level of the noise. The ranges are often, but not always, identified by the upper limit of the indicator range in dB. Some meters operate on a single wide range and have no level range control.

5.5.2. Daily noise exposure measurements

SPL or $\mathbf{L_p}$ measurements can be used when the sound is relatively steady. On the sound level meter you require the following:

- SPL;
- A-weighting;
- S or F time constant, the slower response of the S time constant will average out small fluctuations;
- A suitable level range for the measurement.

Example:

A petrol-driven domestic lawn mower produces steady sound. The **SPL** is measured with a sound level meter held at head height by the side of the operator as he moves across a lawn. Most variation in level is averaged out by selection of the **S** response. The resultant reading is between 81 and 82 dB(A).

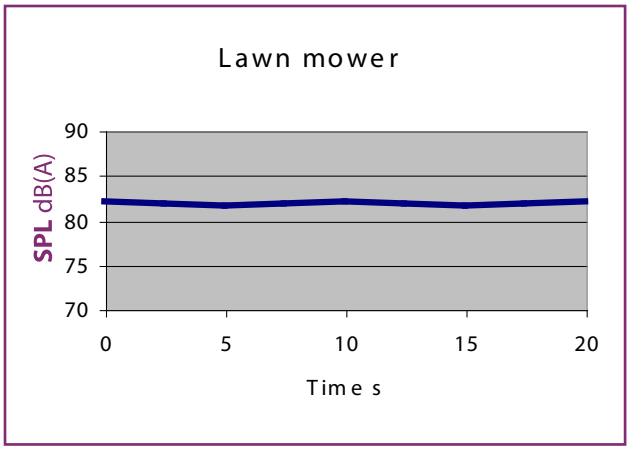


Figure 2.7 The sound from the petrol-driven domestic lawn mower plotted against time

$\mathbf{L_{eq}}$ measurements can be used for both steady and varying sound. On the sound level meter you require the following:

- L_{eq}.
- A-weighting.
- a suitable level range for the measurement.

Example:

A garden shredder produces varying sound. The **SPL** indicated by a sound level meter held at the operator position varies between 69 and 87 dB(A). The $\mathbf{L_{eq}}$ measured over four cycles of typical operation is 82 dB(A).

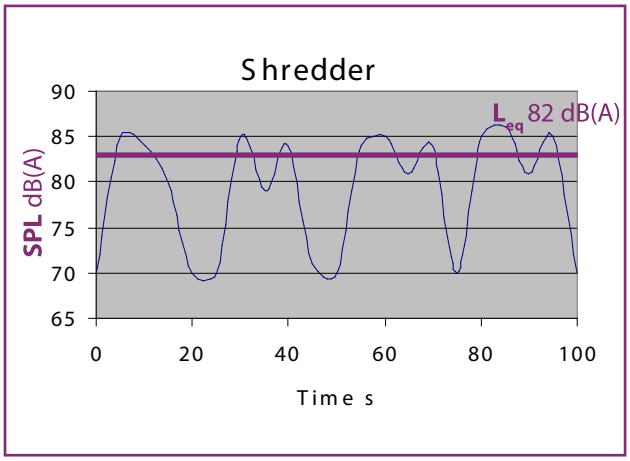


Figure 2.8 Varying noise of the shredder plotted against time with the final $\mathbf{L_{eq}}$ at the end of the period

5.5.3. Measurements of peak sound pressure exposure

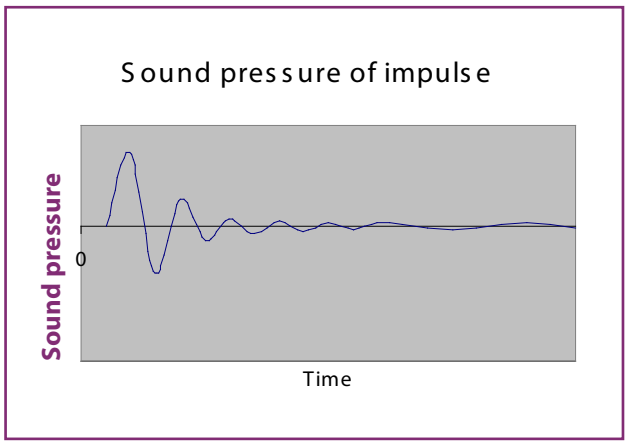


Figure 2.9 Sound pressure wave of an impulsive sound such as a gunshot

For this you need a measurement of the highest instantaneous sound pressure. On the sound level meter you require the following features:

- P (peak) time constant.
- Maximum indication.
- C frequency weighting.
- A measurement range up to at least 140 dB.

Where peak sound pressures are likely to be above 140 dB, ensure your meter has the necessary measurement range.

Example:

Measurements by the operator of a pneumatic nailing machine are made with a sound level meter fitted with a low sensitivity microphone to enable measurements up to 155 dB. Both the C-weighted peak sound pressure and the A-weighted Leq are measured for a 5-minute typical period of operation.

6. MEASUREMENT

6.1. Preparation

Following the manufacturer's instructions:

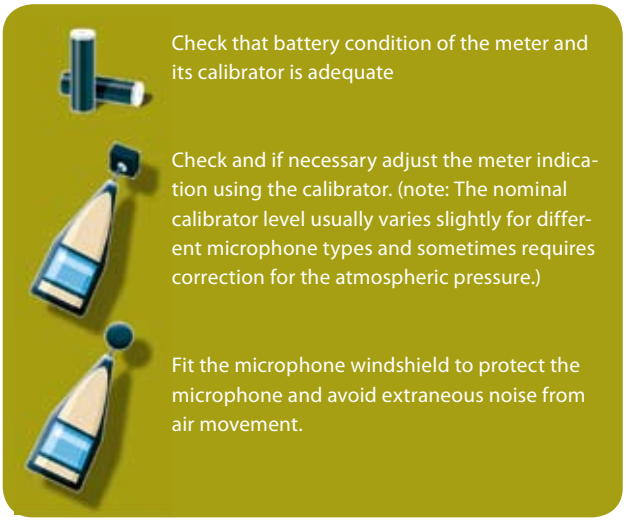


Figure 2.10 Preparation of measurement: manufacturer's instructions

6.2. Measurement with a sound level meter

- Measure at every noisy location a person works in or passes through during the working day. Exposures below 70 dB(A) can usually be ignored but don't forget the noise from radios, personal stereos, and communications if these are significant and the contribution from high-level impulsive sound to the daily exposure.
- Avoid noise reflections from your own body by holding the meter at arm's length or mount it on a tripod and stand at least 50 cm from the back of the meter.
- Measure the noise where the person's head would be with the meter pointing towards the source of sound. If you make the measurement with the person present try to have them stand slightly to one side and keep the microphone at least 15 cm from the head.

Figure 2.11 Measurement of the sound level by the ear of an operator (Photo © and by courtesy of Health and Safety Executive – Great Britain)

- Where the sound is varying measure the Leq long enough to obtain an indication of the average level. You may need to measure the Leq for the entire period the person is present. If you measure for a shorter period wait for the reading to settle to within 1 dB, or measure over a whole number of cycles when the operation is cyclical.
- When measuring very short duration events measure the A-weighted Leq over one or more whole events and note the number of events included.
- Measure both the A-weighted level contributing to the daily sound exposure and the C-weighted peak sound pressure of high level impulsive sounds.

Remember to record:

- The worker or workers to whom the measurement is applicable.
- The work activity during the measurement.
- The measurement location.
- The measured noise levels and the measurement duration.
- The background noise level if significant.
- The typical duration of the exposure or the number of events in the measurement, and number of events included in the working day.
- Any hearing protection worn by worker.

Example:

Record of measurements made with a sound level meter to assess the exposure of a machine operator:

Noise measurement at International Widgets				
Job title	Widget swaging machine casting grinding operator/ despatch			
Measurement date	31 April 2006			
Instrumentation details				
Meter	Type 123		Serial no 12345	
Calibrator	Type 456		Serial no 54321	
Widget swaging machine				
Noise source	**L_{eq} dB(A)**	**Peak dB(C)**	**Measurement time**	**Exposure time**
Operator position	89	115	300 seconds	4 hours
Widget collection point	86	111	50 seconds	30 minutes
Cleaning machine with compressed air	97	126	200 seconds	45 minutes
Widget packaging and despatch	<70	108	100 seconds	1 hour 30 minutes
Measurement by	R Green			

6.3. Measurement with a dosimeter

Figure 2.12 Dosimeter microphone positioned on the shoulder

- Position the microphone on the shoulder, ideally close to the shoulder joint to avoid it touching the neck and rubbing on clothing. Place the meter body securely in a pocket so it is safe from damage.
- Measure for the entire noise exposure during the working day or a shorter period typical of the noise exposure during the day.
- Avoid very short measurements that give a low dose reading, as they may be inaccurate due to the limited resolution of the meter display.
- Remember to record:
  - The worker who wore the dosimeter.
  - The work activity during the monitoring period (this may need to be completed by the worker themselves).
  - The measurement duration and the duration of the daily noise exposure.
  - Any hearing protection worn by worker.

Example:

Measurement report for dosimeter worn over entire working day:

Noise dosimeter measurement at St Swithin's school			
Employee name	D Brown		
Job title	Games teacher		
Measurement date	31 June 2006		
Instrumentation details			
Dosimeter	Type DEM 234	Serial no 654	Microphone on shoulder
Calibrator	Type C 789	Serial no 432	
Daily exposure for measurement period 81 dB(A)			
Activities during day			
Time	**Lesson period**	**Activity**	**Location**
9 to 9.15	-	Registration	Classroom 12
9.15 to 10.15	1	Hockey	Field
10.15 to 11.15	2	Aerobics	Aerobics room
11.15 to 11.30	Break		Staff room
11.30 to 12.30	3	Tennis	Tennis courts
12.30 to 13.30	Lunch		Staff room
13.30 to 14.30	4	Free period	Staff room
14.30 to 14.45	Break	Preparation	Gymnasium
14.45 to 15.45	5	Gymnastics	Gymnasium
After school			
16.00 to 17.00		Football team	Field

Time history — individual A-weighted L_{eq} readings over sequential 15-minute intervals in monitoring period.

Period ending	L_{eq} dB(A)	Period ending	L_{eq} dB(A)
9.15	76	13.15	73
9.30	79	13.30	72
9.45	78	13.45	71
10.00	77	14.00	<70
10.15	77	14.15	<70
10.30	86	14.30	<70
10.45	88	14.45	74
11.00	90	15.00	83
11.15	87	15.15	83
11.30	74	15.30	84
11.45	78	15.45	80
12.00	77	16.00	72
12.15	79	16.15	82
12.30	77	16.30	78
12.45	74	16.45	80
13.00	75	17.00	78

The dosimeter results show the teacher is exposed above the first action value as the daily noise exposure is 81 dB(A). The time history shows the aerobics lesson is the noisiest period during the day.

6.4. Post measurement

Following the manufacturer's instructions:

- Recheck the battery condition of the meter and its calibrator.
- Recheck and record the meter indication using the calibrator.

Remove the batteries from the meter and calibrator to prevent damage while not in use.

6.5. Measurement of noise close to the ear

Noise exposure from sources close to the ear such as communication headsets or earpieces, or while wearing shot-blasting or motorcycle helmets cannot be assessed from measurements with a sound level meter or dosimeter..

Figure 2.13 Measurements of noise at the ear using HATS and MIRE methods (Photo © and by courtesy of Health and Safety Executive – Great Britain)
Left: Head and torso simulator (HATS)
(source HEAD Acoustics GmbH, Germany)
Right: MIRE

The noise level can only be assessed from measurements in the ear. There are two methods for measurements; a microphone in real ear technique (MIRE) described in EN ISO 11904-1:2002, and a technique using an artificial head and torso simulator (HATS) subject of ISO 11904-2:2004. These measurements are complex and shall only be carried out by those with necessary expertise.

7. EVALUATION OF ASSESSMENT RESULTS

7.1. Calculation of noise exposure

7.1.1. Calculation method

Noise exposure is calculated from the level and duration of each period of noise exposure during the day. A variety of simple methods are available; using charts, nomograms, and computer programs. An example of a simple method of calculating the exposure by summing exposure points is given below[22].

1. For sound pressure level or L_{eq} measurements read the corresponding exposure points from Table 2.1.

2. Multiply the number of points by the number of hours' exposure at the corresponding level.

or

For a measurement of discrete events, multiply the number of points (EP) by the duration of the measurement in hours (t) and the number of events in a day (N) and then divide by the number of events in the measurement (m).

$$\frac{EP \times t \times N}{m}$$

3. Sum the exposure points for all the exposure periods in the day.

4. Look up the $L_{EX,d}$ from column 3 corresponding to the total exposure points in column 2.

5. If a calculation of the weekly noise exposure level is also required, total the exposure points for the week, and obtain the weekly average by dividing the total by 5.

Some worked examples are shown after Table 2.3.

Sound pressure level or L_{eq} dB(A)	Exposure points	Daily noise exposure level ($L_{EX,d}$) dB(A)
104	1000	95
103	800	94
102	640	93
101	500	92
100	400	91
99	320	90
98	250	89
97	200	88
96	160	87
95	130	86
94	100	85
93	80	84
92	64	83
91	50	82
90	40	81
89	32	80
88	25	79
87	20	78
86	16	77
85	13	76
84	10	75
83	8.0	
82	6.4	
81	5.0	
80	4.0	
79	3.2	
78	2.5	
77	2.0	
76	1.6	
75	1.3	

Table 2.3 Noise exposure points calculation table

22. A single noise exposure point corresponds to a daily personal noise exposure of 65dB(A)

Examples: Exposure calculation using noise exposure points

Example 1

Grinding castings				
Noise source	**L_{eq} dB(A)**	**Peak dB(C)**	**Measurement time**	**Exposure time**
Operator position	89	115	300 seconds	4 hours
Casting collection point	86	111	50 seconds	30 minutes
Cleaning machinery with compressed air	97	126	200 seconds	45 minutes
Casting packaging and despatch	<70	108	100 seconds	1 hour 30 minutes

Exposure detail	**Exposure points**
4 hours at 89 dB(A)	4 x 32 = 128
0.5 hours at 86 dB(A)	0.5 x 16 = 8
45 minutes at 97 dB(A)	0.75 x 200 = 150
Exposure below 70 dB(A) is insignificant	0
Total Exposure Points	286
Daily noise exposure level	**Between 89 and 90 dB(A)**

Example 2

Noise measurements are made during the proof firing of four shotgun cartridges (m = 4). The L_{eq} is 102 dB(A) (EP = 640) during a 100s (t = 100 seconds = 0.028 hour) measurement. The operator would normally fire 10 (N = 10) cartridges per day. In his work area the background noise is less than 75 dB(A).

Exposure detail	**Exposure points**
10 shots where 4 shots in 100 s gives an L_{eq} of 102 dB(A)	(640 x 0.028 x 10)/4 = 45
Total Exposure Points	45

Formulae for calculation of noise exposure

The daily noise exposure *($L_{EX,d} = L_{EX,8h}$) is found by summing all noise exposures in the day, like time-weighted average of the noise exposure levels for a nominal eight-hour working day as defined by international standards* ***ISO 1999:1990****, point 3.6. This is not a simple addition, because levels in dB are logarithmic and not linear values.*

Where the L_{eq} or SPL has been measured:

$$L_{EX,d} = 10 \log_{10} \left[\frac{1}{T_0} \sum_{i=1}^{i=n} T_i \cdot 10^{0.1(L_{Aeq})_i} \right]$$

where:

the working day comprises n discrete periods of time;
T_0 = 8 hours = 28,800 seconds;
T_i = the duration of period i, in seconds;
$(LA_{eq})i$ = the equivalent continuous A-weighted sound pressure level (or sound pressure level) to which the person is exposed during period i; and

$\sum T_i = T_e =$ the duration of the person's daily noise exposure to sound, in seconds

Where the L_{eq} of discrete events has been measured:

$$L_{EX,d} = L_{eq} + 10 \log_{10} \left[\frac{n.t}{m.T_o} \right]$$

where:

n = number of times the noise event occurs in the working day;
m = number of times the event occurred in the measurement;
T_0 = 8 hours = 28,800 seconds;
t = measurement duration.

Formulae for calculation of noise exposure

The weekly noise exposure level *($L_{EX,w} = L_{EX,8h}$) is found by summing all noise exposures in the week, like time-weighted average of the daily noise exposure levels for a nominal week of five eight-hour working days as defined by international standards* ***ISO 1999:1990****, point 3.6. This is not a simple addition, because levels in dB are logarithmic and not linear values.*

Weekly noise exposure level can be expressed mathematically as shown below:

$$L_{EX,w} = 10\log_{10}\left[\frac{1}{5}\sum_{i=1}^{i=m} 10^{0.1(L_{EX,8h})_i}\right]$$

where:

$(L_{EX,8h})i$ = the values of $L_{EX,d}$ for each of the 'm' working days in the week being considered.

7.1.2. Measurement uncertainty

All measurements have an associated uncertainty. Where variations in level or work pattern are apparent several repeated measurements may be needed and it may be appropriate to base the assessment on the highest likely daily exposure.

Measurement creates uncertainties due to the sound level meter precision and to the methodology applied. The first one is crated by the measurement equipment, and second one is linked to the selection of statistical representative situations due to day-to-day variations in exposure and variations found between repeat measurements (sampling). Type 1 or Class 1 sound level meters are the most precise meters for field measurements; Type 2 or Class 2 sound level meters and dosimeters are less precise. However, which ever precision of meter is used, in many circumstances the uncertainty due to variations in exposure conditions are likely to be more significant than the uncertainty due to the instrument precision.

In every case, a proper assessment report shall include the uncertainty value of procedure-based measurements.

Formulae for calculation of noise exposure:

The standard ***ISO 9612*** *'Acoustics – Measurement and calculation of occupational noise exposure – Engineering method' gives measurement strategies for assessing noise exposure. The methods described in the standard are designed to optimise the effort required to obtain a given degree of accuracy. These procedures are more complex and detailed than the simple procedures given in this guide, but are useful if high measurement precision is required.*

However, Article 4 of Directive 2003/10/EC lays down that:

2. The methods and apparatus used shall be adapted to the prevailing conditions particularly in the light of the characteristics of the noise to be measured, the length of exposure, ambient factors and the characteristics of the measuring apparatus.

   These methods and this apparatus shall make it possible to determine the parameters defined in Article 2 and to decide whether, in a given case, the values fixed in Article 3 have been exceeded.

3. The methods used may include sampling, which shall be representative of the personal exposure of a worker.

4. The assessment and measurement referred to in paragraph 1 shall be planned and carried out by competent services at suitable intervals, taking particular account of the provisions of Article 7 of Directive 89/391/EEC concerning the necessary competent services or persons. The data obtained from the assessment and/or measurement of the level of exposure to noise shall be preserved in a suitable form so as to permit consultation at a later stage.

5. When applying this Article, the assessment of the measurement results shall take into account the measurement inaccuracies determined in accordance with metrological practice.

6. Pursuant to Article 6(3) of Directive 89/391/EEC, the employer shall give particular attention, when carrying out the risk assessment, to the following:
   (a) the level, type and duration of exposure, including any exposure to impulsive noise;

(b) the exposure limit values and the exposure action values laid down in Article 3 of this Directive;
(c) any effects concerning the health and safety of workers belonging to particularly sensitive risk groups;
(d) as far as technically achievable, any effects on workers' health and safety resulting from inter-actions between noise and work-related ototoxic substances, and between noise and vibrations;
(e) any indirect effects on workers' health and safety resulting from interactions between noise and warning signals or other sounds that need to be observed in order to reduce the risk of accidents;
(f) information on noise emission provided by manufacturers of work equipment in accordance with the relevant Community directives;
(g) the existence of alternative work equipment designed to reduce the noise emission;
(h) the extension of exposure to noise beyond normal working hours under the employer's responsibility.

7.2. Identification of significant noise sources

Noise reduction is best accomplished by tackling the areas and activities that most contribute to the daily noise exposure. The most significant source is not necessarily that producing the highest sound level, but the one contributing the most exposure points to the daily noise exposure level.

Example:

Casting grinding operator	Exposure points
Operator position	128
Casting collection point	8
Cleaning machinery with compressed air	150
Casting collection and despatch	0
Total exposure points	286
Daily noise exposure level	**Between 89 and 90 dB(A)**

As the highest noise points are for the cleaning of the machine this task is the priority for noise control or risk reduction. The second priority for action is reducing the noise at the operator position.

7.3. Interaction between noise and work-related ototoxic substances and vibration

Scientific studies have led to common acceptance that noise and both ototoxic substances and vibration interact (see also Chapter 7, point 4.1). Article 4, paragraph 6d) of Directive 2003/10/EC confirms this by requiring these interactions to be taken into account during risk assessment, as far as technically possible.

Chapter 7 on ***'Hearing damage and heath surveillance'*** includes a non-exhaustive list of ototoxic chemical agents related to industries concerned.

Today, exact quantitative dose-response relationships are unavailable for these interactions, even for listed ototoxic substances, and only limited knowledge is available for noise-vibration interactions.

It is currently impossible to provide pragmatic risk assessment rules with threshold limits for these interactions. Further investigation is required, e.g. supported by scientific conferences at Member State and European level.

To ensure preventive measures, despite the lack of scientific knowledge on dose-response relationships, some experts advise lowering health surveillance action values (audiometric tests) by 5 dB for combined exposures to noise and ototoxic substances or to noise and high vibration level on top of the action value requested by the Directive 2002/44/EC[23] on 'vibrations'. Scientific studies show that both hand-arm vibration and whole-body vibration cause interactions with noise. However, exact dose-response relations are not available for these interactions. Guidance on this topic is given in Chapter 7.

7.4. Hearing protection requirements

The Directive requires that when applying the exposure limit values, the determination of the worker's effective exposure shall take account of the attenuation provided by the individual hearing protectors worn by the worker. Noise exposure with the protectors worn is assessed from measurements of the noise exposure level that the wearer is exposed to and calculations using standard test data provided with the protector. Guidance on this topic is given in Chapter 5 on ***'Personal protective equipment (PPE): characteristics and selection of personal hearing protectors (PHP)'***.

23. Directive 2002/44/EC of the European Parliament and of the Council of 25 June 2002, on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration), O.J. n° L 177, of 06.07.2002, page 13.

8. INFORMATION, CONSULTATION, PARTICIPATION AND TRAINING OF WORKERS

Framework Directive 89/391/EEC (Articles 10, 11, 12) requires the employer to take suitable measures to inform, consult, train and ensure the participation of workers and/or their representatives in all matters relating to worker health and safety in the workplace, in accordance with national laws and/or practices.

In particular, Directive 2003/10/EC (Articles 8 and 9) states the following:

Article 8:

Without prejudice to Articles 10 and 12 of Directive 89/391/EEC the employer shall ensure that workers who are exposed to noise at work at or above the lower exposure action values, and/or their representatives, receive information and training relating to risks resulting from exposure to noise concerning, in particular:

(a) the nature of such risks;
(b) the measures taken to implement this Directive in order to eliminate or reduce to a minimum the risks from noise, including the circumstances in which the measures apply;
(c) the exposure limit values and the exposure action values laid down in Article 3 of this Directive;
(d) the results of the assessment and measurement of the noise carried out in accordance with Article 4 of this Directive together with an explanation of their significance and potential risks;
(e) the correct use of hearing protectors;
(f) why and how to detect and report signs of hearing damage;
(g) the circumstances in which workers are entitled to health surveillance and the purpose of health surveillance, in accordance with Article 10 of this Directive;
(h) safe working practices to minimise exposure to noise.

Article 9:

Consultation and participation of workers and/or of their representatives shall take place in accordance with Article 11 of Directive 89/391/EEC on the matters covered by this Directive, in particular:

- the assessment of risks and identification of measures to be taken, referred to in Article 4;
- the actions aimed at eliminating or reducing risks arising from exposure to noise, referred to in Article 5;
- the choice of individual hearing protectors referred to in Article 6(1)(c).

CHAPTER 3
Workplace design

1. DIRECTIVE REQUIREMENTS

Article 6 of Framework Directive 89/391/EEC[24] lays down general obligations on employers:

1. Within the context of his responsibilities, the employer shall take the measures necessary for the safety and health protection of workers, including prevention of occupational risks and provisions of information and training, as well as provision of the necessary organisation and means.

   The employer shall be alert to the need to adjust these measures to take account of changing circumstances and aim to improve existing situations.

2. The employer shall implement the measures referred to above on the basis of the following general principles of prevention:
   (a) avoiding risks;
   (b) evaluating the risks, which cannot be avoided;
   (c) combating the risks at source;
   (d) adapting the work to the individual, especially as regards the design of work places, the choice of work equipment and the choice of working and production methods, with a view, in particular, to alleviating monotonous work and work at a predetermined work-rate and to reducing their effects on health;
   (e) adapting to technical progress;
   (f) replacing the dangerous by the non-dangerous or the less dangerous;
   (g) developing a coherent overall prevention policy which covers technology, organisation of work, working conditions, social relationships and the influence of factors related to the working environment;
   (h) giving collective protective measures priority over individual protective measures;
   (i) giving appropriate instructions to the workers.

The employer must observe the following provisions of Article 9 of Framework Directive 89/391/EEC:

1. The employer shall:
   (a) be in possession of an assessment of the risks to safety and health at work, including those facing groups of workers exposed to particular risks;
   (b) decide on the protective measures to be taken and, if necessary, the protective equipment to be used.

Finally, Article 5 of Noise Directive 2003/10/EC[25] includes provisions aimed at preventing or reducing exposure:

1. Taking account of technical progress and of the availability of measures to control the risk at source, the risks arising from exposure to noise shall be eliminated at their source or reduced to a minimum.

   The reduction of such risks shall be based on the general principles of prevention and take into account in particular:
   (a) other working methods that require less exposure to noise;
   (b) the choice of appropriate work equipment, taking account of the work to be done, emitting the least possible noise, including the possibility of making available to workers work equipment subject to Community provisions with the aim or effect of limiting exposure to noise;
   (c) the design and layout of workplaces and work situations.

2. ROOM INFLUENCE (PRACTICAL)

2.1. Reflection and absorption

All sounds emitted in a workshop reflect on the room walls. These reflected sounds then increase the sound exposure in the room.

- Every time sound reaches a wall, part of its energy is reflected
- The room therefore influences the acoustic atmosphere; this phenomenon is called 'reverberation'
  - The total exposure results from the combined sound emitted directly by equipment and multiple reflections reaching the same location
  - Absorbing devices may be placed on room surfaces or baffles may be suspended on the sound path to damp reflected sound; these systems are further detailed below (see Section 4.2).

24. 89/391/EEC Council Directive of 12 June 1989, on the introduction of measures to encourage improvements in the safety and health of workers at work, O.J. n° L 183, of 29.06.1989, page 1.

25. Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003, on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise), O.J. n° L 42 of 15.02.2003, page 38.

Examples:

Two extreme acoustic room influences are a cathedral (highly reverberant) and a small office lined with acoustic materials and carpets, whilst the most absorbent area is of course the open air!

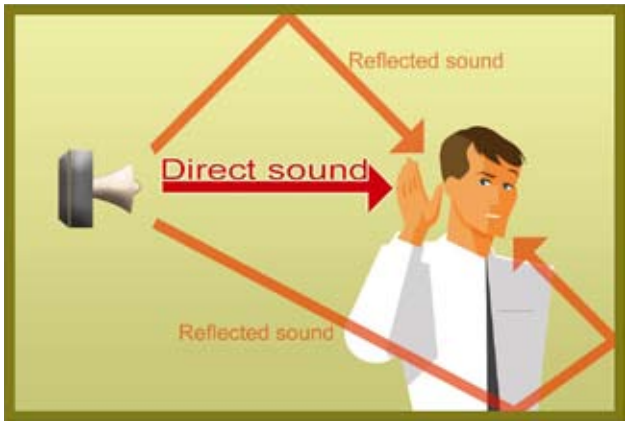


Figure 3.1 Sound emitted by an acoustic source is reflected on workplace walls. Worker exposure combines reflected sound and direct sound

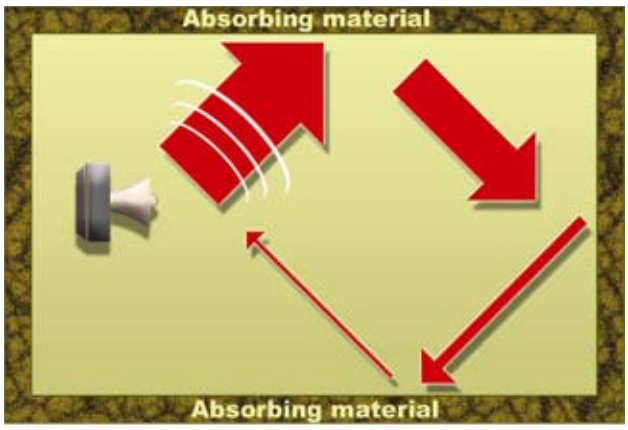


Figure 3.2 Absorbing materials and devices reduce the reflected sound and so allow a reduction in room effect

2.2. Direct and reverberant field

The room influence on sound exposure varies widely according to distance from the noise source. Room effects dominate far from the source.

- The further away from equipment, the greater the influence of reflected sound; the room can therefore be divided into different areas based on distance from the source:
  - direct sound dominates near the source; this area is called the 'direct field'
  - reflected sound dominates far from the source; this area is called the 'reverberant field'; within the reverberant field the noise level is quite constant.
- Acoustic absorption in a room is quite effective within the reverberant field, but it is relatively useless within the direct field.

Examples:

The direct field usually extends a few metres from the machine.

A working tool user is usually in the direct noise field area of his tool; absorptive treatment of adjacent walls would be more effective for surrounding workers than for the tool user himself.

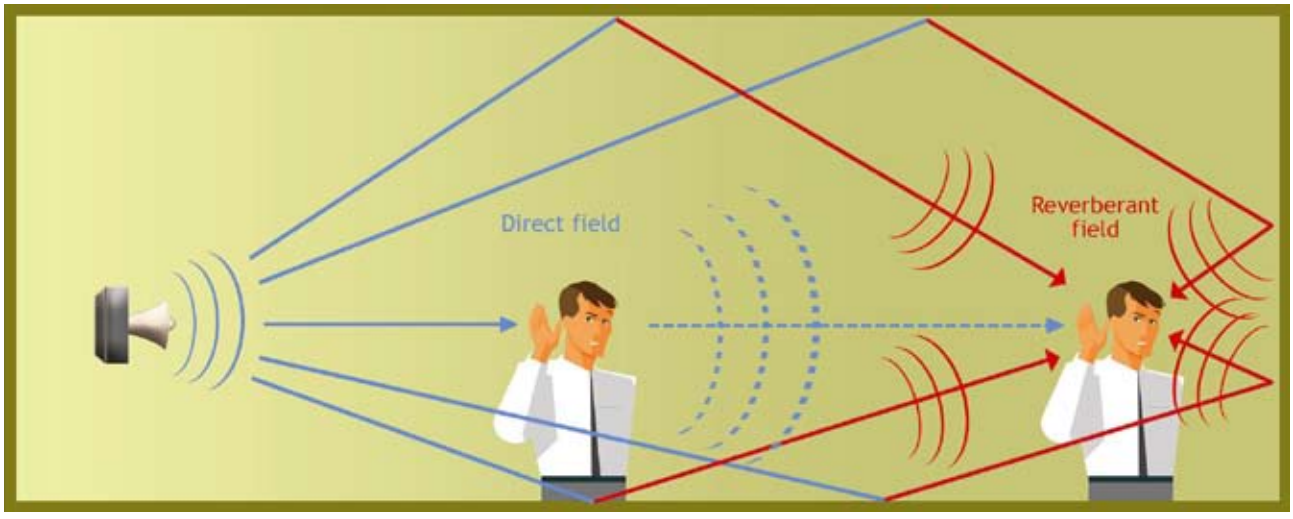


Figure 3.3 Near to the sound source, most noise comes directly from the source itself: this area is called the 'direct field'. Far from the sound source, reflected sound dominates: this area is called the 'reverberant field'

Partitions will provide sound insulation. Sound insulation between a source and a listener attenuates the sound heard. (cf. Chapter 4: 'How do we reduce noise exposure?'). If a workshop is divided by partitions into separate areas, each area should be studied separately in relation to its reverberation.

Many software packages are dedicated to analysing workplace absorption; they allow us to determine the most appropriate quantity and positioning of absorbing materials based on comparing acoustic benefit and cost involved.

Furnishings, screens and large equipment also contribute to workplace acoustic effects; they act in reflection, insulation and absorption. They should be considered in acoustic analysis if they are large compared with the room volume.

3. ROOM CHARACTERISATION

3.1. Reverberation time

Measurement of reverberation time provides an estimate of a room's overall acoustic influence.

- If you suddenly stop a sound source in a room or enclosed space, acoustic reflections continue to travel from wall to wall with their energy decreasing gradually from one reflection to another, until the sound is masked by the room background noise.
- The more reverberant the room, the more slowly the sound level decreases in it. The room acoustic influence can therefore be estimated as a sound level decay time, which is called the 'Reverberation time' (Tr) and is defined for a 60 dB decrease or decay in sound level.
- The sound source used for measuring $\mathbf{T_r}$ may be an impulse-type source (e.g. a shot) or a continuous steady noise, which is suddenly stopped.

Examples:

Average reverberation times are around 0.5 s for a bedroom, 1 - 2 s for a concert hall and 4 - 8 s for a cathedral.

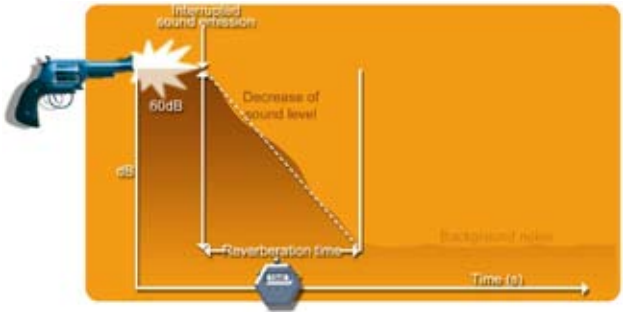


Figure 3.4 Room acoustic influences may be assessed by interrupting a sound and measuring its decay due to surface reflections. 'Reverberation time' (Tr) is the time taken for a 60 dB decrease in sound level

3.2. Spatial sound distribution curve

The spatial acoustic influence of a room may be considered by the sound decay over distance in relation to the overall room dimensions. This can be evaluated by decay rate per unit length or by noise amplification at some points.

- If a continuous steady noise source is placed at the end of a room, the sound level reduction along a room centreline can be measured; the result is then plotted as a 'spatial sound distribution curve'.
- Room influence may be evaluated by the DL_2 parameter. This represents the rate of sound level reduction, when the distance from the source is doubled. $\mathbf{DL_2}$ is called the 'rate of spatial decay per distance doubling'.
- In open air (in a so-called 'free field'), the rate of sound level decay is 6 dB per distance doubling (i.e. $DL_2 = 6$).
- The difference in the sound level at a point in the room and that expected in a free-field ($\mathbf{DL_f}$) is called the 'room noise amplification' or 'excess of sound pressure'.

General considerations for different room acoustic parameters are as follows:

- Low noise amplification of room corresponds to a high DL_2 value and low DL_f and T_r values.
- DL_2, DL_f and T_r values change with frequency; they can be given for octave bands.
- T_r, DL_2 and DL_f values depend on room volume.

Examples:

EN ISO 11690 – 1 recommends the following values: $T_r < 0.8$ s for a room volume < 200 m^3, $T_r < 1.3$ s for a room volume < 1000 m^3 and $DL_2 > 3$ or 4 for a greater room volume.

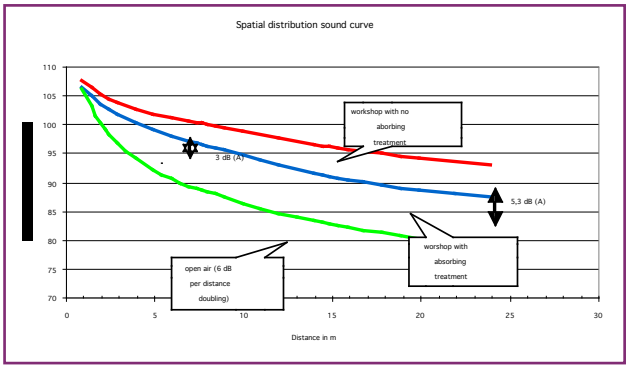


Figure 3.5 Sound decay in a workshop may be measured along a line from the noise source to the end of the room. Room acoustic influence is then considered in two ways: 'average rate' of sound decay or by comparison with an equivalent decay in open air (free field). (© courtesy of INRS-CRAM Rennes)

Room acoustic parameters are not governed by European Directives, but some national regulations define values based on room dimensions and occupancy. EN ISO 11690 recommended values are given above.

DL_2 and DL_f are the most representative workshop assessment parameters, but for small-dimension rooms, which do not allow reliable measurement of DL, the T_r parameter is more appropriate.

Another parameter may characterise room absorption: this is the 'absorption equivalent area', (A_{eq}), which corresponds to a fully absorbent area ensuring absorption equivalent to the room itself.

The 'Sabine formula' is often applied. This relates room volume V, its total area S and reverberation time T_r:

$$\alpha_s = (0.16\ V) / (T_r\ S)$$

where α_s is the so-called 'Sabine absorption coefficient'.

4. SOLUTIONS TO IMPROVE WORKPLACE PERFORMANCE

4.1. Workplace alterations

Workplace alterations embody the noise solutions introduced in Chapter 4 on **'How do we reduce noise exposure?'** of the Guide, namely:

- 'Upstream actions', including organisation solutions combined with workplace alterations such as changing location, using remote controls, etc.
- Air transmission actions include solutions such as screens positioned close to the worker.

4.2. Installation of absorbing materials and devices

Absorbing materials are used to reduce the reflected sound level.

- The absorption performance of a material or system is expressed by the 'absorption factor' α, the ratio of absorbed noise energy to total incident noise energy.
- The full range of possible α values extends from 0 (no absorption) to 1 (total absorption, i.e. equivalent to open air giving no reflection).
- For the same material or system, values of α vary in relation to the sound frequency.
- Absorption solutions may be divided into the following families:
  - Porous materials (glass wool, rock wool, etc.) dissipate sound energy by diffusion through their thickness; they are most efficient at high frequencies; they are fixed to wall surfaces or installed as baffles suspended from ceilings.
  - 'Diaphragms' are wood panels fixed to walls by wood battens; energy dissipation is ensured by panel deformation compressing the air behind; diaphragms are most effective in low frequencies.
  - 'Resonators' are air cavities connected to the ambient air through a neck (as a bottle); air movement in the cavity dissipates sound energy; they are efficient for a selected frequency determined by the device geometry.
- For a same device, values of α vary with geometry, density, thickness, etc.

Examples:

Typical α values are 0.01 for marble, 0.04 for concrete, 0.8 for glass wool, etc. Typical α variation with frequency can be illustrated as follows:

α	250 Hz	500 Hz	1000 Hz	4000 Hz
Glass wool	0.3	0.7	0.9	0.95
Diaphragm	0.6	0.4	0.2	0.1
Resonator (designed at 500 Hz)	0.2	0.9	0.2	0.05

Industrial examples and specifications to be used when procuring absorbing treatment are given in Chapter 4 on **'How do we reduce noise exposure?'**

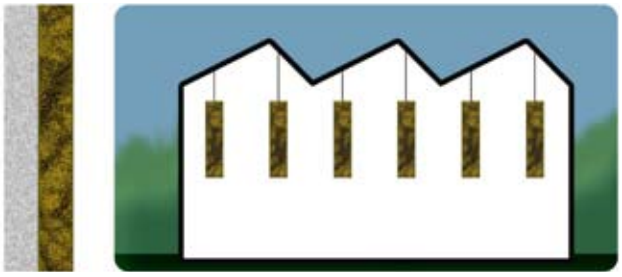


Figure 3.6 Porous materials may be placed on workshop walls or used as 'baffles' suspended from the ceiling to attenuate high-frequency sound

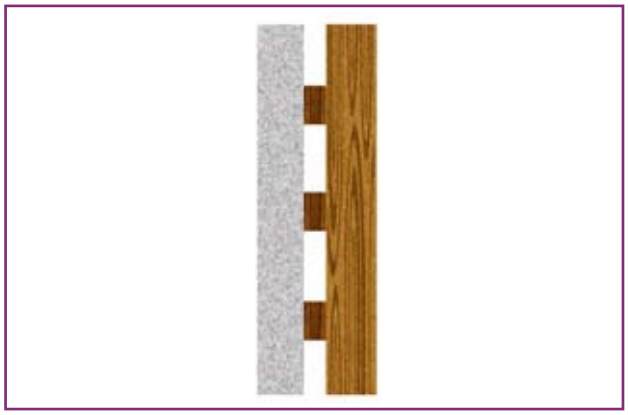


Figure 3.7 'Diaphragms' are wood panels fixed to walls over battens. They attenuate low-frequency sounds

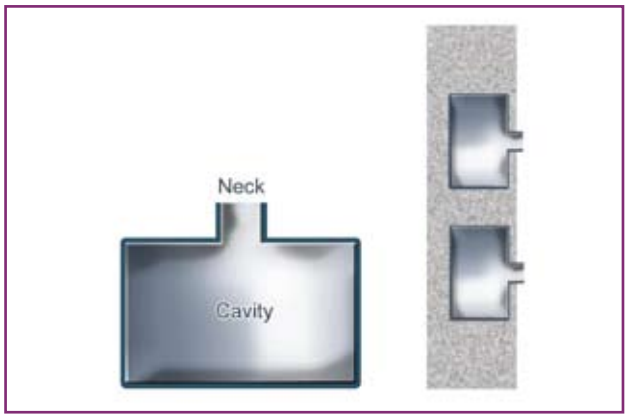


Figure 3.8 Acoustic 'resonators' are open volumes containing air. These are generally located within the wall thickness to attenuate sound of selected frequencies

As we saw above, the room acoustic effect is different when we are close to or far from the noise source. The benefit provided by room absorption differs in the same way: it may be between 1 and 3 dB near the source and between 5 and 12 dB far away from it (ref. EN ISO 11690).

Surface contours have a significant effect on the sound absorption. This is taken into account by an average absorption value measured for an area much larger than the contour geometry.

A wall is seldom uniform in other respects: it includes windows, doors, local coverings, etc. These components must be considered as individual components, when their area is significant compared with that of the wall. If this is not the case, average values for the whole wall may be used.

5. NOISE PREDICTION CALCULATION

There are methods and software for calculating sound pressure at certain points, if we know the sound emission of equipment in the room and the room absorption characteristics.

- We need information about the equipment noise emission.
- We need workplace data: geometry, space occupancy, surface absorption coefficients – the latter may be approximated by theoretical values.
- The results may be sound pressure levels at certain points, noise maps or room absorption parameters.
- The outcome is an immission based on various emission sources and wall reflections. Exposure calculation will also require exposure times at the various work locations.

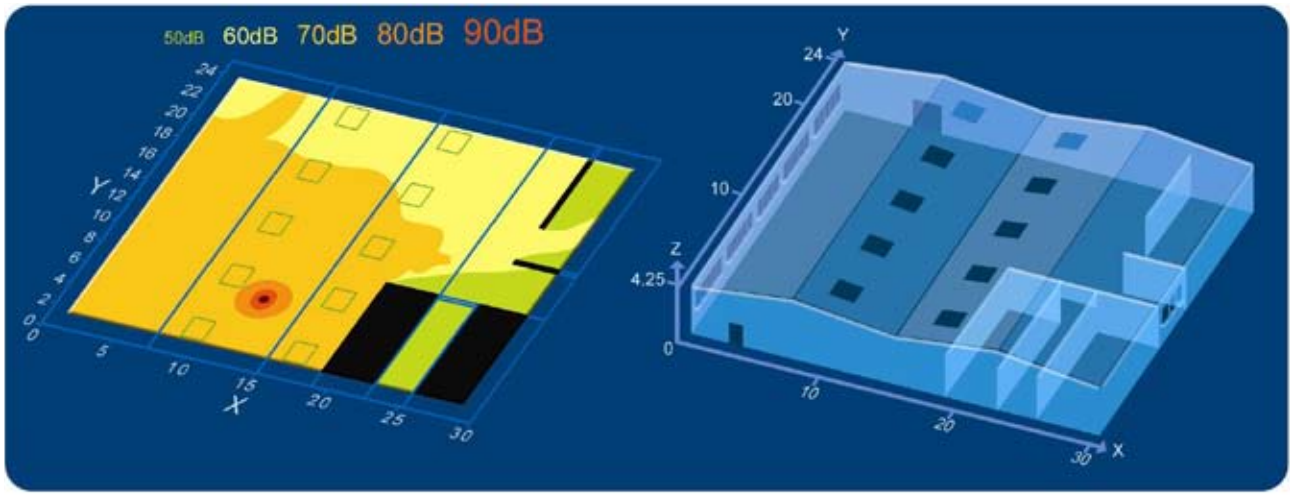


Figure 3.9 Workplace modelling software for calculating sound levels – in this case, a noise map in which noise levels are shown on a colour scale (RayPlus® © software, courtesy of INRS – France)

These aids are used to design new workplaces or workplaces which have been extensively overhauled. They predict a future situation and allow several situations to be compared to give the best solution or to achieve a noise level target.

Various situations can be compared by:

- Changing equipment emissions, which would mean for example installing quieter equipment or using enclosures.
- Altering worker or equipment positions within the workshop.
- Increasing the absorption of relevant surfaces.

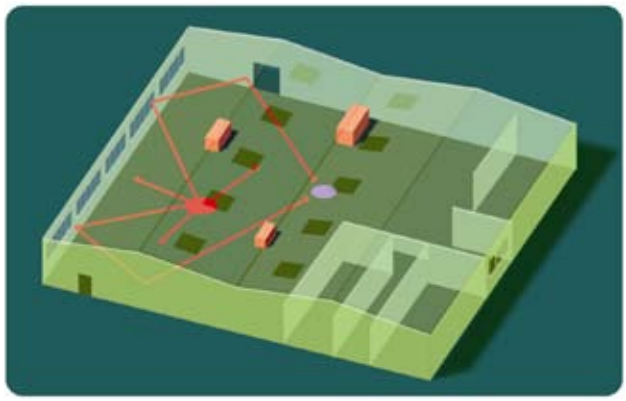


Figure 3.10 Modelling allows simulation of various workplace situation changes and assessment of their benefits (RayPlus® © software, courtesy of INRS – France)

The results feature a degree of uncertainty, depending on the calculation method, the reliability of parameters used and the calculation assumptions. Nevertheless, different results, corresponding to various solutions, can be compared and help in making a judicious choice.

The 'judicious choice' is made by considering:

- The calculated noise level for each situation.
- The consequences of each solution (cost, impact on process, impact on other occupational health and safety factors, pollution, etc.).

*Some methods of predicting workplace sound pressure levels and noise immission are given in **EN ISO 11690-3:1997.***

Various room acoustic prediction software packages are available. They may differ in relation to certain criteria, such as ergonomics, speed of calculation, richness of the available data (geometry, material absorption characteristics, etc.), assumptions and calculation accuracy, etc.

Most methods involve certain simplifying assumptions. These do not usually have a significant impact at the mid frequencies that are most significant in contributing to worker exposure.

CHAPTER 4
How do we reduce noise exposure?

1. DIRECTIVE REQUIREMENTS

Article 5 of Directive 2003/10/EC[26] lays down for prevention or reduction of exposure to noise risks the following provisions:

1. Taking account of technical progress and of the availability of measures to control the risk at source, the risks arising from exposure to noise shall be eliminated at their source or reduced to a minimum.

   The reduction of such risks shall be based on the general principles of prevention and take into account in particular:
   (a) other working methods that require less exposure to noise;
   (b) the choice of appropriate work equipment, taking account of the work to be done, emitting the least possible noise, including the possibility of making available to workers work equipment subject to Community provisions with the aim or effect of limiting exposure to noise;
   (c) the design and layout of workplaces and work situations;
   (d) adequate information and training to instruct workers to use work equipment correctly in order to reduce their exposure to noise to a minimum;
   (e) noise reduction by technical means:
   – reducing airborne noise, e.g. by shields, enclosures, sound-absorbent coverings;
   – reducing structure-borne noise, e.g. by damping or isolation;
   (f) appropriate maintenance programmes for work equipment, the workplace and workplace systems;
   (g) organisation of work to reduce noise:
   – limitation of the duration and intensity of the exposure;
   – appropriate work schedules with adequate periods.

2. On the basis of the risk assessment, if the upper exposure action values are exceeded, the employer shall establish and implement a programme of technical and/or organisational measures intended to reduce the exposure to noise, taking into account measures referred to above.

3. On the basis of the risks assessment, workplaces where workers are likely to be exposed to noise exceeding the upper exposure action values shall be marked with appropriate signs. The areas in question shall also be delimited and access to them restricted where this is technically feasible and the risk of exposure so justify.

4. Where, owing to the nature of the activity, a worker benefits from the use of rest facilities under the responsibility of the employer, noise in these facilities shall be reduced to a level compatible with their purpose and the conditions of use.

5. Pursuant to Article 15 of Directive 89/391/EEC[27], the employer shall adapt the measures referred to in this Article to the requirements of workers belonging to particularly sensitive risk groups.

2. THERE ARE MANY SOLUTIONS TO A NOISE PROBLEM

2.1. Collective solutions have priority

Priority to collective protection forms the basis of prevention defined in the 89/391/CEE Directive. Many collective solutions are available in the noise field.

- All solutions introduced in this chapter are collective.
- Individual actions mainly involve using personal hearing protectors [see Chapter 5 on ***'Personal protective equipment (PPE): characteristics and selection of personal hearing protectors (PHP)'***] and refuges. Refuges are considered here with enclosures because their physical principles are the same.

2.2. Guidance to understanding prevention solutions

There are many collective noise reduction solutions; the important point is to be aware of this wide range and to know how to choose from it.

- This chapter introduces different solution 'families' and explains their principles. Their performance is

26. Directive 2003/10/EC of the European Parliament and the Council of 6 February 2003, on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise), O.J. n° L 42 of 15.02.2003, page 38.

27. 89/391/EEC Council Directive of 12 June 1989, on the introduction of measures to encourage improvements in the safety and health of workers at work, O.J. n° L 183 of 29.06.1989, page 1.

illustrated by quoting acoustic parameter values and examples of their use in industrial solutions are given.
- When a solution is selected, the purchaser shall be provided with specifications to ensure its efficiency and prevent misunderstanding. Information is provided at the end of this chapter to achieve this aim.

2.3. Solution performance varies with frequency

All material and system acoustic properties vary with frequency. Solution acoustic performance will vary widely according to this parameter.

- Acoustic performance increases generally, but not always, with frequency; low frequencies are difficult to resist.
- There are specific frequency bands, in which performance is lower.

3. CLASSIFICATION OF NOISE REDUCTION METHODS

The aim is to determine the best solution from amongst various sound reduction options. The best solution is the one that gives the best result at lower cost and that is subject to fewer constraints.

- Some noise reduction actions are commonly used in industry, but the real choice of solutions is wider than common practice leads us to believe.
- Common solutions are not always suited to the problem or factory situation; moreover, they require optimisation with respect to noise objectives.
- The industrialist must not be put off by certain solutions; simple solutions may very often provide significant benefits.

Examples:

A workshop total acoustic treatment, involving walls and ceiling covered with absorbing material, may be out of proportion and sometimes even pretty inefficient, if the noise source is close to the worker, for example. Similarly, a worker's refuge may be totally inefficient if he has to leave it from time to time.

Noise reduction methods can belong to common families and a preliminary overview may guide selection.

- 'Upstream' actions. These involve work organisation, process design and equipment supply. They are most efficient when they are scheduled at the workplace design stage or before a major alteration. They enable problems and later unforeseen work to be avoided.
- 'On the source' actions. These involve equipment modifications. The main difficulty is ensuring equipment warranty if such modifications are made. However, when properly performed, 'at source' actions can provide major noise benefits and impact on the workplace, sometimes through low-cost solutions. Think of simple ideas or 'tricks' and get the maintenance team or supplier involved in the problem.
- Noise transmission actions are the most widely used. These are considered to have less impact on work organisation and equipment operation, but this is not always true. They are efficient for corrective purposes, but may also be considered at the design stage. Their real efficiency depends on the acoustic situation and they may give good results, if suitable, but they may also lead to high costs and provide few acoustic benefits.

Examples:

Positioning noisy utility equipment (fans, compressors, etc.) at distance from workers is a low-cost solution if it is implemented at workshop installation stage. Later, it may be easier to enclose such equipment if permanent machine access is not required.

The type of sound allows the most suitable solutions to be distinguished.

- Chapter 1 introduces different types of sound: solid or structure-borne sound, airborne sound, and liquid sound.
- Airborne and liquid sounds are considered together as 'fluid sounds' because they have much in common.
- These types also apply as much to sound emission as to sound propagation.
- Solid sources are those which exert mechanical forces: gears, rubbing, impacts, etc.
- Fluid sources are generated by pressure disturbances within a fluid: a whistle, turbulence, gunshot, etc.
- Solid propagation is called 'structure-borne': the sound is conveyed by the floor, walls, pipes, etc.
- Air propagation is called 'airborne': the sound spreads through the ambient air and, by extension, we speak of 'fluidborne' sound.

Some solutions are not considered in this chapter because they are described in other parts of the Guide.

- Personal protective equipment (PPE): Characteristics and selection of Personal Hearing Protectors (PHP) (Chapter 5).
- Workplace design (Chapter 3).

Use of technical simulations may be helpful in choosing the best noise reduction action. These range from a simple formula, providing a rough estimate of solution effect, to dedicated software assessing the effect of combined solutions and allowing selection optimisation. The cost of such simulations is often largely offset by the benefit when the work is carried out.

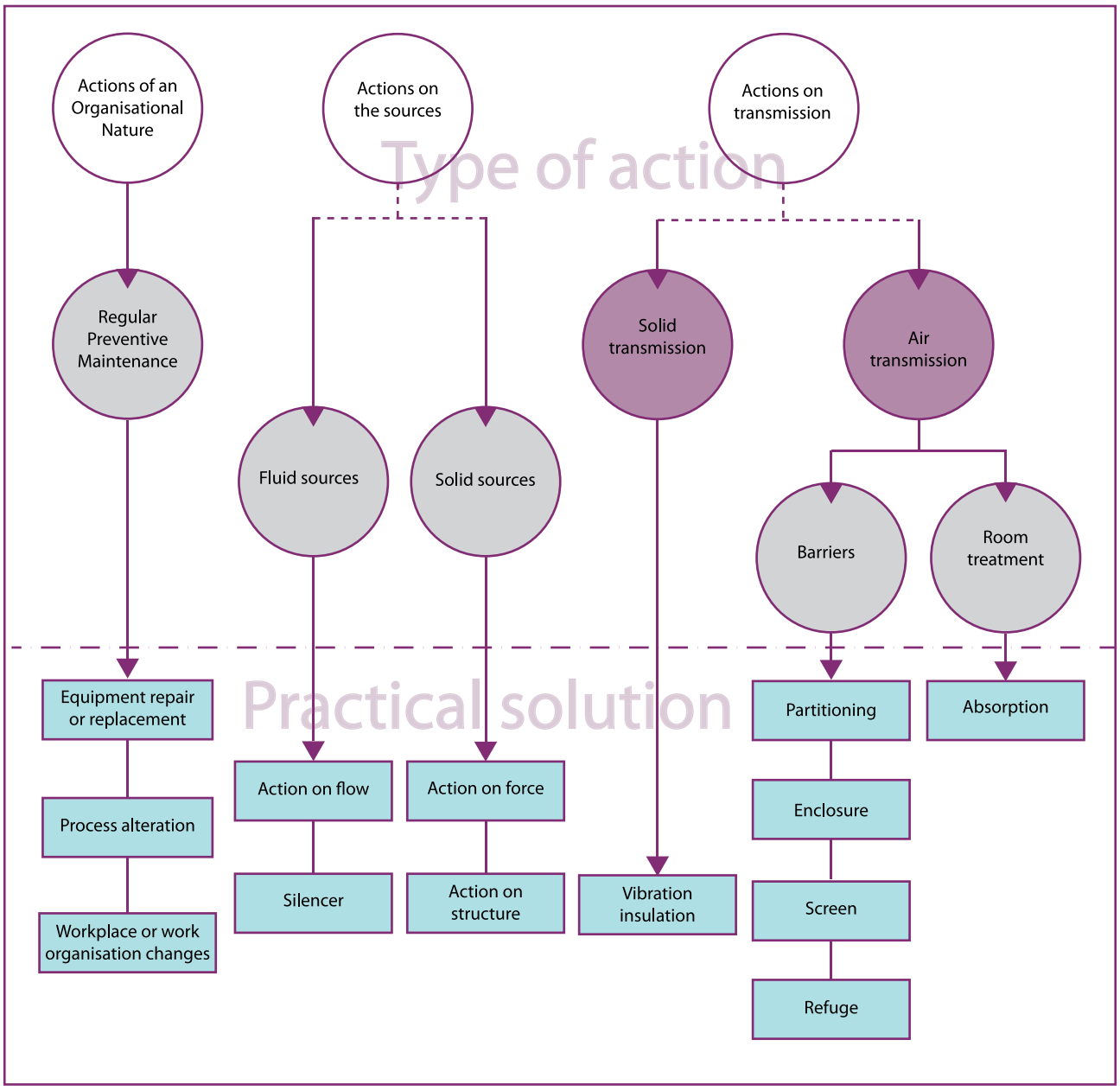


Figure 4.1 Noise Reduction Actions at the Workplace

4. ACTIONS OF ORGANISATIONAL NATURE

Low-noise equipment forms the basis of noise policy.

- Selection of low-noise equipment allows you to avoid implementing extensive noise reduction measures.
- There are more or less noisy equipment models in every machine or tool family: a noise requirement shall be included in equipment specifications for ordering purposes.
- Set up an acceptance procedure integrating checks on equipment noise under operating conditions.
- Ensure proper maintenance throughout the equipment service life: a machine in good condition is a quieter machine.

Examples:

Use of silent tools (saw blades, compressed air blowers, screw drivers, etc.) and silent machines (compressors, motors, fans, etc.).

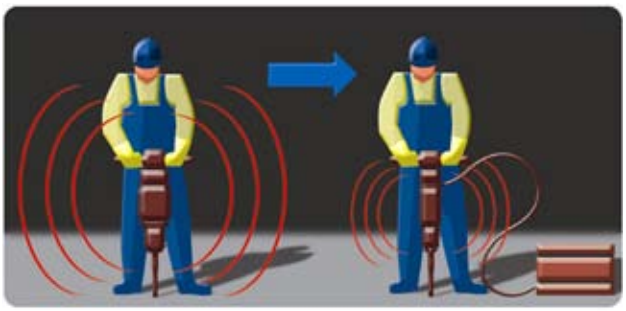


Figure 4.2 Choose silent equipment and ensure proper maintenance

The process creates more or less noisy working conditions.

- A silent process may be used to achieve the same result.
- A silent process often goes hand in hand with performance and quality.
- Minor process components may have a major noise impact (objects falling, air-pressure cleaning, etc.).
- Improving a process may be the opportunity to deal with other forms of pollution (dust, heat, etc.).
- Process parameters can be adjusted to achieve quieter operating conditions, but performance shall be kept in mind.

Examples:

Conveying parts instead of dropping them, using electronic instead of mechanical speed control, curtailing noisy operating periods as much as possible, setting flow velocities or air pressure to the quietest value, etc.

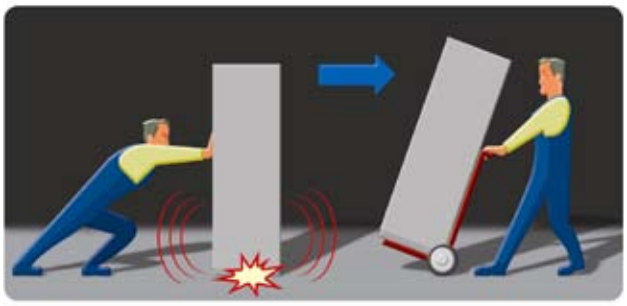


Figure 4.3 Adapt or adjust the process

Examples to illustrate some working methods with reduction of emission level:

Method / working principle	
Reduced noise emission	**Increased noise emission**
Laying down	Throwing down
Sucking away	Blowing away
Punching with a centre drill	Punching with a centre punch
Drilling	Punching
Hammer drill	Percussion drilling machine
Stud welding (shipbuilding)	Welding on of components 'Knacken'
Swivel wrench	Impact wrench
Electric traction	Combustion engine
Casting	Forging
Slide bearing	Roller bearing
Hydraulic forming (Kraftformer)	Flanging with a hammer
Hydraulic pulling/pressing	Straightening with a hammer
Splicing	Riveting
Laser cutting machine	Nibbling machine
Optical signalling	Acoustic signalling
Oscillating saw	Cutting off by grinding
Plasma arc cutting	Mechanical cutting
Embossing (e.g. stamp rolling)	Punch stamping
Pressing	Beating
Belt drive	Chain drive
Round filing	Grinding
Sawing	Cutting off by grinding
Screwing	Riveting
Welding	Riveting
Rolling welded joints	Compressing with a hammer
Spraying on welding agent	Chipping off welding spatter
Stamping machine (e.g. for pipes)	Driving in figure stamps
Orbital riveting	Punch riveting
Continual transport	Intermittent transport

Table 4.1 Working methods with reduced noise emission
[BGI 688 'Lärm am Arbeitsplatz in der Metall-Industrie', p. 51]

Organisational measures may be a solution.

Article 5, point 1 (g) (i) of the Directive 2003/10/EC lays down the following requirements:

- Noise can be reduced by 'limitation of the duration and intensity of the exposure to noise' [Taking into account a 50 % reduction in working time only leads to a reduction of 3 dB(A) (see Chapter 1 on 'Principles of acoustics')];
- Noise can be reduced by 'appropriate work schedules with adequate rest periods'.

Moreover, other measures could be taken:

- Organisation-based actions include workshop layout and work arrangement;
- A workshop acoustic layout shall consider equipment positioning in relation to the worker;
- Arrange work to ensure that the noisiest tasks are reduced for exposed workers etc.

No additional equipment is required and they can be inexpensive.

Examples:

Position noisy equipment away from walls and corners; group them away from worker positions or install partitions. Organise workplace rotation to 'distribute' noisy tasks (without 'sacrificing' workers!); use remote controls to keep workers away from noisy equipment, etc.
(see figure 4.5 p. 71)

Actions of organisational nature shall be considered as early as possible at the installation design stage. Working on these actions jointly with suppliers can be beneficial; Chapter 6 deals specifically with this point.

Figure 4.4 Construction – Use of silent blowtorch
(© Yves Cousson – Courtesy of INRS – France)

Blowtorches are major sources of noise in many activities, such as construction work. Use of silent blowtorches allows noise emission to be reduced by between 7 to 20 dB(A), depending on gas flow.

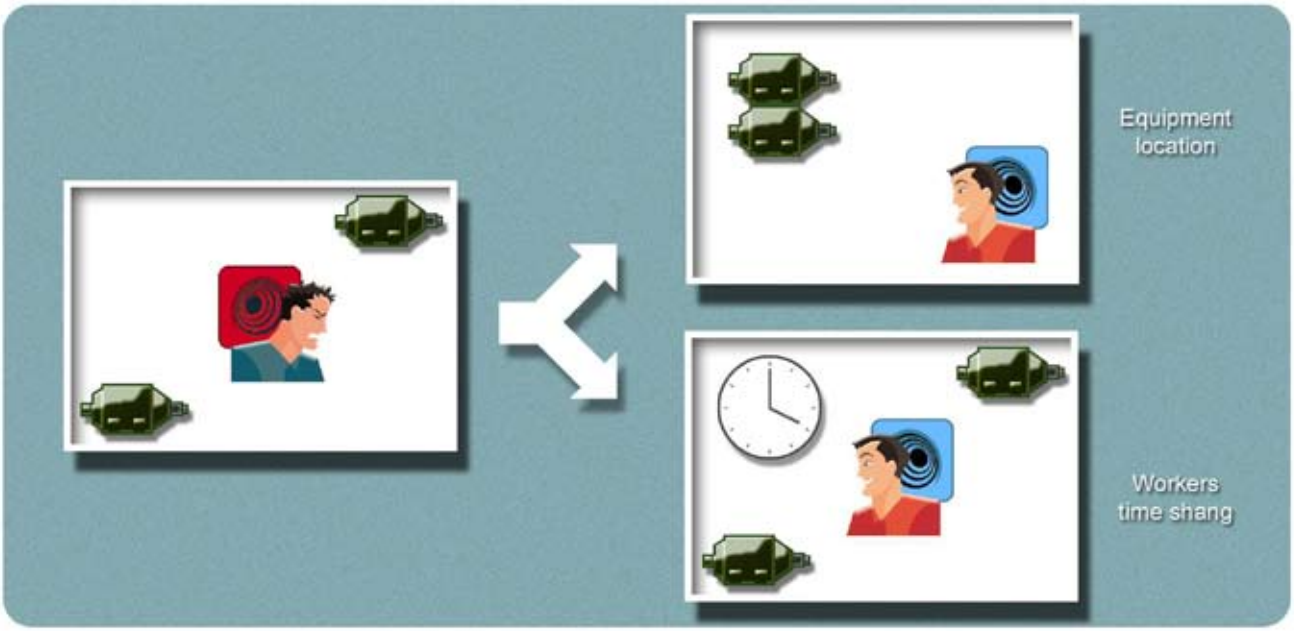


Figure 4.5 Workplace layouts; work organisation

5. ACTION AT THE SOURCE

5.1. Actions on fluid sources

Generally actions at fluid sources are intended to reduce flow turbulence.

- Reduce flow speed.
- Improve surface quality.
- Act on obstacles: reduce their size, optimise their shape.
- Avoid sharp bends, sudden cross section changes, etc. in pipes.

Silencers may be included as close as possible to the source.

- 'Dissipative' silencers incorporating noise-absorbing materials: for low-speed airflows, sometimes called 'baffles'.
- 'Reactive' silencers based on geometric design: e.g. mufflers.
- 'Expansion' silencers used mainly on compressed gas exhausts and inlets.

Examples:

On a grinding machine, position the airflow collector in the flow direction instead of at an angle. Fit smooth-walled pipes; install dissipative silencers at the air fan inlet and outlet in a dust collection system. Replace worn expansion silencers when filled up at gas expansion outlets of moulding injection machines.

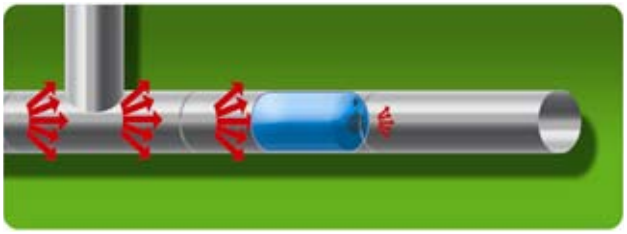


Figure 4.6 Fluid-borne sources: act on flow or use silencers

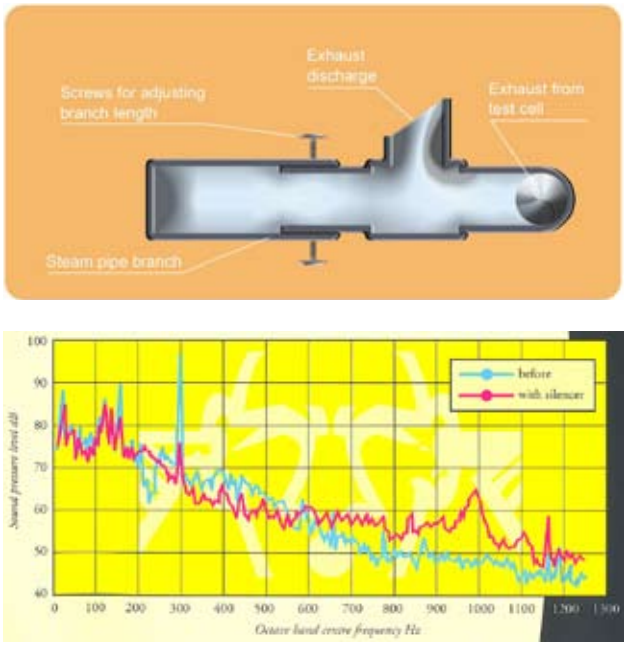


Figure 4.7 Engine testing – Use of silencers
(© Courtesy of Health & Safety Executive – U.K.)

Exhaust noise dominates the sound generated by many engines, especially combustion engines. Use of suitable silencers may produce an acoustic benefit of between 20 and 40 dB(A). A custom-designed silencer is based on the resonation principle (see Chapter 3 on '**Workplace design**'); its length is tuned according to the frequency to be absorbed. Spectrum analysis reveals that the dominant frequency is almost entirely suppressed.

5.2. Actions on solid sources

General actions on solid sources focus on the mechanical force itself:

- Prevent friction.
- Prevent impact.
- Make forces as continuous as possible.
- Reduce kinetic energy: reduce clearances, mass of moving parts, etc.

Equipment can generate more or less vibration and noise in exerting the same force; this capacity can be controlled by making structural alterations:

- Prevent resonance by altering structural mass or stiffness.
- Provide structural damping using specific devices (coverings, dampers, etc.), damping converts vibration energy into heat, which is then dissipated inside the device.
- Use structures that transmit less vibration and radiate less sound.

Examples:

Lubricate contacts, use plastic rather than metal gears, reduce part dropping heights, use perforated rather than full plates, cover structural components with damping layers, etc.

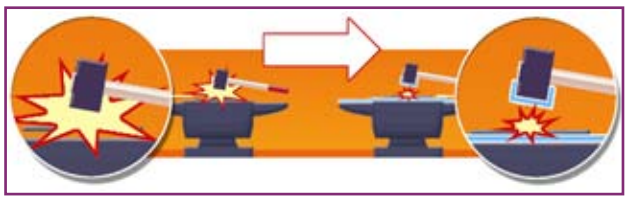


Figure 4.8 Solid-borne sources: act on forces or equipment structure

Apart from greater damping, which invariably improves the noise situation, actions on equipment structure can rarely be carried out through intuition alone. It is better to design them based on specific analysis using suitable measurement and calculation aids.

'Active control' is a solution, which can be theoretically used either for airborne or structure-borne noise sources. The principle involves creating an anti phase 'counter-noise' or 'counter-force' opposite to the original source. The current state of the art limits the usage of such solutions in industry and they are more often considered in relation to low-frequency airborne noise.

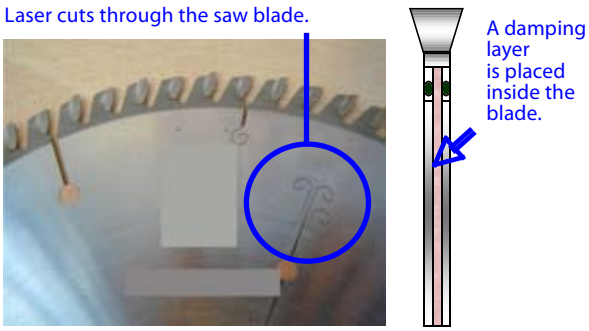


Figure 4.9 Wood sawing – Use of silent blades
(© Courtesy of INRS – France)

The blade is the main noise source in wood sawing. Many manufacturers offer 'silent blades' based on various technologies: 'laser cutting' (a) or 'sandwich' blades (b). The most efficient blades can reduce operating noise by up to 7 dB(A).

Figure 4.10 Metalworking – Containers for mechanical parts

In metalworking, handling of mechanical parts often generates impulse noises due to impacts between parts. Here, we see a container used for handling parts during a washing process. The use of wire-meshed walls on the container ensures reduced sound radiation.

Two simple methods can be used to reduce noise due to parts falling into a container: guide the movement with a sloping plate (a) or reduce container radiation by wire-meshed walls (b).

When letting 0.5 kg bolts fall from 1 m into an empty container, acoustic benefits are approximately 6 dB(A) for solution (a) and 14 dB(A) for solution (b).

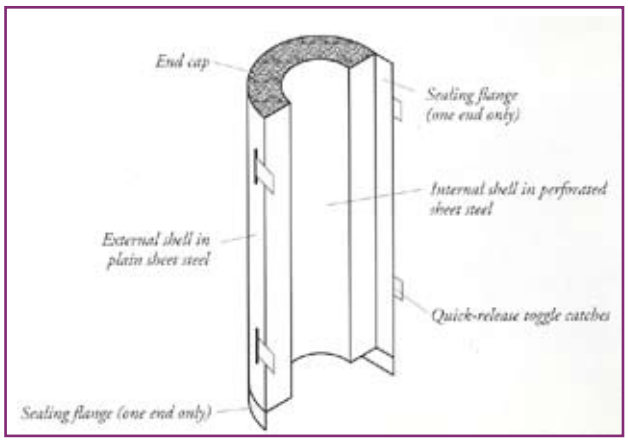


Figure 4.11 Good processing – Pipe lagging
(© Courtesy of Health & Safety Executive – U.K.)

Solid particles are conveyed through a rigid pipe system. A noise reduction of approximately 10-15 dB(A) is achieved by applying acoustic lagging to pipes. Acoustic lagging is made of thick semi-rigid mineral wool encased in sheet-steel.

6. ACTION ON AIRBORNE TRANSMISSION

6.1. Partitioning

Partitioning the workplace may provide air noise insulation; the walls must have good insulation properties.

- Noisy equipment can be grouped together at a location, which is separated from the workshop by airtight walls.
- Consider traffic and access-related constraints.
- High surface mass generally goes hand in hand with greater insulation.
- Use of multiple walls may provide good insulation.
- Windows and doors must be acoustically designed: a small 'acoustic weakness' reduces considerably the overall insulation.
- Prevent all leakage, even when considered small; use sealant.
- Insulation generally increases with frequency but every wall has frequency ranges, in which insulation is insufficient; try to recognise these areas using product documentation or rough calculations.

Examples:

Influence of wall apertures and leakage: a 1 % aperture area reduces the wall's insulation factor from 30 to 20 dB.

The table below includes examples of mean insulation values for certain wall types.

Wall	R dB(A)
7 cm single plasterboard	34
1 cm glass	33
5 cm brick-filled	39
7 cm plasterboard + fibre + 7 cm plasterboard	54
0.8 cm glass + 1.4 cm air + 1 cm glass	35
9 cm concrete	47
9 cm concrete + 5 cm fibre + 1 cm hardback plaster	61

Figure 4.12 Separate noisy equipment by walls

Figure 4.13 Textile industry – partitioning of textile workplace
(© Bernard Floret – Courtesy of INRS – France)

In this haberdashery workplace, a noisy workshop has been partitioned by an acoustic wall, which features double-glazed windows to allow viewing from one side to the other.

6.2. Enclosures – Refuges

An enclosure is a 'box' containing noisy equipment; general partitioning considerations apply to this solution, but a number of specific points require attention.

- Enclosure creates equipment access constraints, which require consideration.
- Enclosure very often requires openings for product input and output, ventilation, etc.
- Openings must be acoustically treated: consider silencers, absorption tunnels, insulating curtains, etc.
- The internal surfaces of an enclosure must be covered with absorbing material to prevent sound amplification inside the enclosure.
- The equipment must be totally uncoupled from the enclosure (see § 7).

Examples:

Enclosure acoustic benefit can be 20 to 30 dB(A). If no absorbing materials are fitted inside, this benefit may decrease by up to 10 dB. An enclosure around a bottle conveyor with plastic strips fitted to one open face can provide a gain of 7 dB(A).

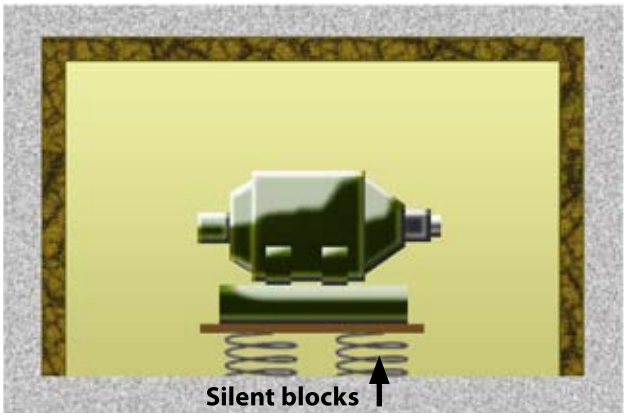


Fig. 4.14 Enclose noisy equipment

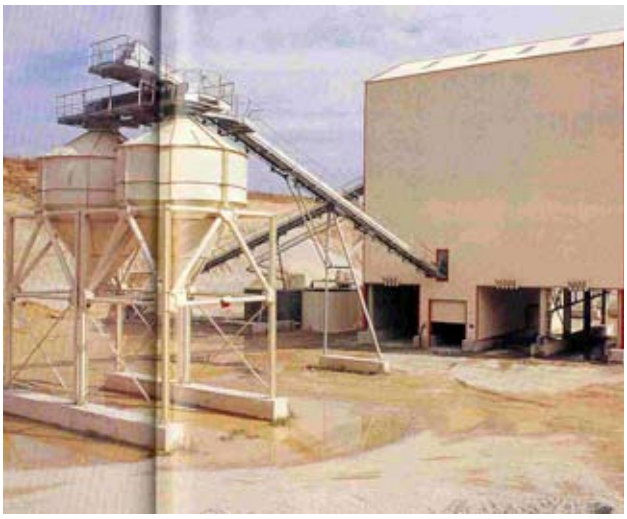


Figure 4.15 Mining and quarrying – Enclosure
(© Bernard Floret – Courtesy of INRS – France)

In the mining and quarrying sector, dust and noise are the most major sources of pollution.

To combat both, this quarry has enclosed a crusher inside a 25 m-high enclosure made of double boarding separated by rock wool.

A refuge is a cab, in which a worker is enclosed; physically, a refuge behaves in the same way as an enclosure and similar rules govern its design. Specific requirements shall be considered in relation to worker protection.

- As with personal hearing protectors, refuges represent a personal solution, which shall only be considered as a last resort.
- Refuge efficiency is significantly reduced by the time the worker spends outside; attenuation decreases at the

same rate as that of hearing protectors (cf. Chapter 5).
- Worker protection must take into account other prevention issues, such as ventilation, temperature, external communication methods, awareness of danger signals, etc.

Examples:

Refuge acoustic benefit can range from 25 to 35 dB(A).

Figure 4.16 Transport – Noise is reduced in the cab of this crew-carrying road vehicle by lining the floor and sidewalls with sheet-steel-clad fibreglass and other surfaces with absorbing material
(© Courtesy of Health & Safety Executive, U.K.)

6.3. Screens

Screens are wall sections, which are not joined at one or more of their edges; they prevent access problems, but their performance is limited and minimum requirements must be complied with.

- Position screens as close as possible to workers.
- Ensure sufficient screen height (ideally twice the ear height).
- Consider screen width, which shall be approximately twice the height.
- Cover screen surfaces with absorbing material.
- Screen material shall be such that it will ensure 20 dB air insulation as a wall.
- Treat the rest of the room for absorption.

Concerning the use of screens in the music and entertainment sectors, see Chapter 8.

Examples:

Screen acoustic benefit may be barely 10 dB and a maximum of 5 dB can only be anticipated in a reverberant room.

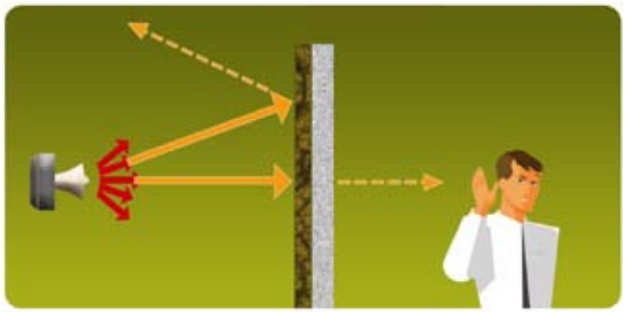


Figure 4.17 Place screens right next to workers

Figure 4.18 Metalworking – Screen
(© Yves Cousson – Courtesy of INRS – France)

In this workshop, employees are separated by screens protecting their immediate environment. The room is treated for absorption, so each worker may be protected from his neighbour by up to 5 dB(A).

6.4. Room absorption

Room absorption is introduced in the Chapter 3 *'Workplace design'*.

Examples are provided in this Chapter; see section 8, page 77 ***'Solution procurement: specifications'.***

Figure 4.19 Garage – Room absorption
(© Yves Cousson – Courtesy of INRS – France)

Garages often have reflecting surfaces that amplify noise. Absorbing material can be installed in different ways: by suspending baffles (left) (providing a wide absorption surface), by covering walls and ceiling either completely or with layers (right).

All solutions quoted offer performance characteristics, which vary with frequency: their efficiency will differ depending on the type of noise to be treated. For example, a screen that is more efficient at high frequencies will ensure different benefits depending on whether the noise is low or high frequency. This issue is complicated in relation to insulation, as solutions generally suffer from deficiencies at specific frequencies, depending on their geometry and construction. This issue shall therefore be considered in all acoustic studies, through examination of measurements and technical datasheets.

People are often confused about absorption and insulation. Explanations provided in this guide show that methods and aims differ: absorption is relevant to room internal noise, whilst insulation concerns noise transmission between rooms. For example, glass wool is an excellent absorption material, but has poor insulation properties (17 dB at 1000 Hz for a density of 20 kg/m³).

7. ACTION ON SOLID PROPAGATION / TRANSMISSION

Make sure that solid propagation/transmission is your problem before acting on it.

- Solid transmission generally involves vibration problems: vibration comfort, structural damage, etc.
- In relation to noise exposure at work, the solid transmission portion seldom dominates over air transmission.
- Dedicated measurement methods can allow the solid transmission portion of noise exposure to be determined. Alternatively, some components may be reckoned to be significant: high vibration levels of large structures (slabs, walls), low-frequency noise, distant noise propagation, etc.

Vibration insulation is the answer to solid transmission. This mainly involves the use of flexible anti-vibration mounts, but certain requirements are necessary.

- The principle underlying vibration insulation is to 'suspend' the equipment, as if it was independent of its surroundings.
- Equipment shall therefore be supported by anti-vibration mounts, which are as flexible as possible, whilst being capable of supporting the equipment without crushing.
- All equipment links to its surroundings shall be considered: pipes, cables, etc.
- The supporting structure (slab, floor plate, etc.) shall be sufficiently rigid: beware of thin concrete floors or lightweight steel frames.

Examples:

Reciprocating machines represent typical equipment to be insulated. If the energy they generate is excessive, they can be insulated and supported by mass-concrete blocks.

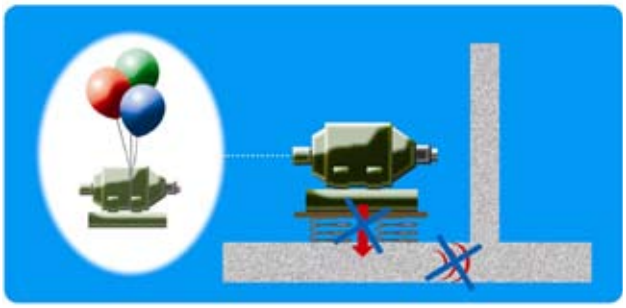


Figure 4.20 Vibration insulation of equipment is ensured by flexible mountings

The principle underlying the method to evaluate the solid transmission portion involves comparing the equipment real solid transmission with the airborne transmission only; the latter value is obtained using a loudspeaker source, for example.

Vibration insulation becomes effective only above a certain frequency, whose value is 1.4 times the so-called 'natural mounting frequency'. The latter frequency is directly proportional to the mounting rigidity and inversely proportional to the equipment mass. This is why it is very difficult to insulate equipment with low operating frequencies (below 8 Hz).

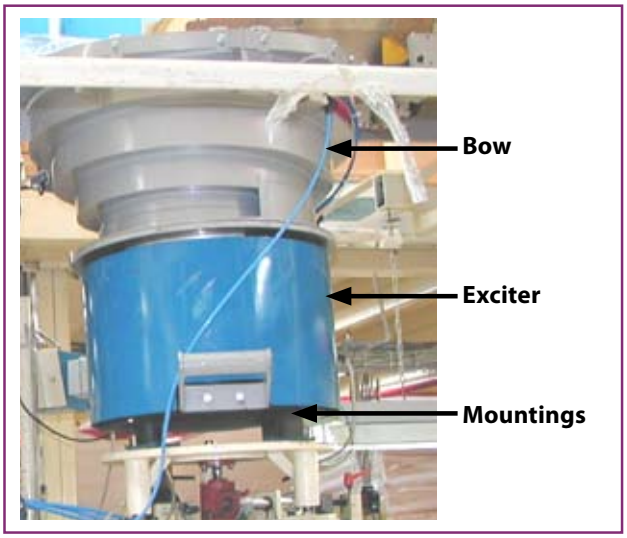


Figure 4.21 Parts manufacturing – Vibration insulation
(© Courtesy of INRS – CRAM Nancy – France)

Small parts for the automobile industry are in vibrating bowl feeders. This equipment generates low-frequency noise ('hum') because of its fundamental vibration frequency of 50 Hz. Fitting of suitable vibration insulation and flexible anti-vibration mounts allows the noise propagation through the solid structures to be reduced. At the same time, vibration exposure of workers near the machine is significantly reduced.

8. SOLUTION PROCUREMENT: SPECIFICATIONS

N.B. This paragraph offers guidelines to procuring a number of acoustic solutions, which have been introduced in this chapter. It does not concern procurement of so-called 'quiet' equipment, which is dealt with in Chapter 6 of this Guide.

8.1. Necessary specifications

It is essential to ensure that the chosen solution will effectively solve the noise problem: acoustic specifications shall therefore be included with the order.

- Analysing the problem and taking commonsense actions can provide some noise solutions. But in most cases, the SME has to rely upon a specialist to find and purchase the 'right' solution.
- It is then necessary to write a clear specification, which cannot be misinterpreted when an acceptance test is conducted.
- Different factors may lead to significant differences in what is considered the final noise level: measurement parameters,units, measurement conditions, and the equipment operating conditions, etc.
- To avoid misunderstandings, we include below a list of helpful suggestions for specifying common solutions. This list is not exhaustive: it is provided only as an aid.

8.2. General specifications

There are common specifications for all acoustic solutions.

- The first one is of course the acoustic requirements, i.e. the parameter used for checking the acoustic benefit obtained.
- A general parameter, which is easy to measure, is L_{pA} [sound pressure level in dB(A)] at a given point, when the equipment is operating and the acoustic solution is in place.
- If possible, the measuring point shall be the operator's workplace.
- To obtain a noise level comparison before and after solution implementation, a number of 'acceptance test' conditions shall be specified.
- Some of these conditions concern equipment operation and the environment, including:
  - equipment location with respect to workplace situation
  - equipment operating conditions
  - room absorption characteristics
  - room overcrowding.
- Other conditions concern measurement itself, for example:
  - type and precision class of measurement devices
  - traceable calibration of measurement instrumentation
  - calibration check at least at the start and end of testing
  - significance of measured levels, e.g. all measured values shall exceed the background level by at least 6 dB(A)
  - noise level stability, e.g. level variation during measurements must not exceed 3 dB(A).
- 'Construction requirements' may be attached to the specification list:
  - certain construction parameters may affect acoustic performance; e.g. leaks, rigid links, etc.
  - other requirements concern the workplace or process environment: surface protection, biological compatibility, fire or thermal protection, hygrometry, ventilation, equipment access, dismantling capacity, etc.
- Standards are the best references for establishing reliable requirements in relation to acoustic solutions and they do exist for the most common solutions (see Section 8.3 below).

8.3. Selected standards

Standards are the best reference for drawing up a specification chart; they are specific to each acoustic solution.

- Standards provide accurate definitions of relevant parameters.
- Standards can provide practical information specific to the considered solution.

Standards generally specify acoustic parameters, which are more technically adapted to the solution concerned.
Measurement of these parameters is generally more complicated than that of L_{pA}, but the result is more reliable.

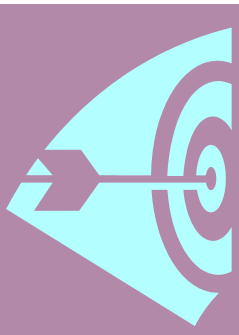
Examples:

The table below includes standard references providing general information on acoustic specifications or specific to acoustic solutions. (see Table 4.2)

Standard reference	Title
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 15667:2000	Acoustics – Guidelines for noise control by enclosures and cabins
ISO 12001:1996	Acoustics – Noise emitted by machinery and equipment – Rules for the drafting and presentation of a noise test code
ISO 11546-2:1995	Acoustics – Determination of sound insulation performances of enclosures – Part 2: Measurements in situ (for acceptance and verification purposes)
ISO 11957:1996	Acoustics – Determination of sound insulation performance of cabins – Laboratory and in-situ measurements
ISO 14257:2001	Acoustics – Measurement and parametric description of spatial sound distribution curves in workrooms for evaluation of their acoustical performance
ISO 354:2003	Acoustics – Measurement of sound absorption in a reverberation room
ISO 11821:1997	Acoustics – Measurement of the in-situ sound attenuation of a removable screen
ISO 11820:1996	Acoustics – Measurements on silencers in situ

Table 4.2 Standard references providing general information on acoustic specifications or specific to acoustic solutions

CHAPTER 5
Personal Protective Equipment (PPE): Characteristics and selection of personal hearing protectors (PHP)



It shall be stressed that

'The employer shall implement the prevention measures giving collective protective measures priority over individual protective measures.'
(Article 6, § 2 (i) of the Framework Directive 89/391/EEC)

'Personal protective equipment shall be used when the risks cannot be avoided or sufficiently limited by technical means of collective protection or by measures, methods or procedures of work organisation.'
(Article 3 of the PPE Directive 89/656/EEC)

1. DIRECTIVE REQUIREMENTS

Several directives apply to the selection and use of personal hearing protectors as personal protective equipment.

Article 6, paragraph 2 (h) of Framework Directive 89/391/EEC[28] foresees, 'The employer shall implement the measures referred to in the first subparagraph of paragraph 1 on the basis of the following general principles of prevention:

(h) giving collective protective measures priority over individual protective measures'.

Moreover, **Article 13, paragraph 2 (b)** of Framework Directive 89/391/EEC states:

'It shall be the responsibility of each worker to take care as far as possible of his own safety and health and that of other persons affected by his acts or Commissions at work in accordance with his training and the instructions given by his employer.
To this end, workers must in particular, in accordance with their training and the instructions given by their employer:

(a) make correct use of machinery, apparatus, tools, dangerous substances, transport equipment and other means of production;
(b) make correct use of the personal protective equipment supplied to them and, after use, return it to its proper place'.

Council Directive 89/656/EEC[29] concerning minimum health and safety requirements for workers using personal protective equipment also applies, without prejudice to the requirements of Directive 89/391/EEC. It shall be stressed that Article 3 'General rule' recalls 'Personal protective equipment shall be used when the risks cannot be avoided or sufficiently limited by technical means of collective protection or by measures, methods or procedures of work organisation.'

Furthermore, **Article 4** states:

1. Personal protective equipment must comply with the relevant Community provisions on design and manufacture with respect to safety and health.

All personal protective equipment must:

(a) be appropriate for the risks involved, without itself leading to any increased risk;
(b) correspond to existing conditions at the workplace;
(c) **take account of ergonomic requirements** and the worker's state of health.

5. Adequate information on each item of personal protective equipment, required under paragraphs 1 and 2, shall be provided and made available within the undertaking and/or establishment.

6. Personal protective equipment shall be provided free of charge by the employer, who shall ensure its good working order and satisfactory hygienic condition by means of the necessary maintenance, repair and replacements.

28. 89/391/EEC Council Directive of 12 June 1989, on the introduction of measures to encourage improvements in the safety and health of workers at work, O.J. n° L 183 of 29.06.1989, page 1.

29. 89/656/EEC Council Directive of 30 November 1989, on the minimum health and safety requirements for the use by workers of personal protective equipment at the workplace, O.J. n° L 393 of 30.12.1989, page 18.

In this connection, it shall be remembered that Council Directive 89/686/EEC[30] concerning harmonisation of Member State legislation on personal protective equipment also applies. This directive fixes conditions for placement on the market, intracommunity free circulation and essential safety requirements, with which personal protective equipment must comply in view of preserving the health and ensuring the safety of users.

To facilitate the application of Directive 89/686/EEC – and it is the relevant national transposition of the text of the directive which is legally binding – a Guideline has been prepared by the relevant services of the Directorate General 'Enterprise and Industry' of the European Commission in collaboration with Member States, European industry, European standardisation and Notified Bodies:
http://ec.europa.eu/enterprise/mechan_equipment/ppe/guide.htm

However the Commission accepts no responsibility or liability whatsoever with regard to the information in this guide. Further guidance, especially concerning specific types of products, can be found on the Commission's website:
http://ec.europa.eu/enterprise/mechan_equipment/ppe/index.htm

This equipment is required to comply with procedures governing certification and examination of standard models by approved bodies guaranteeing 'CE' quality of the end product. The directive sets up a product inspection system and includes provisions enabling Member States to remove the personal protective equipment from the market and to prohibit its replacement on the market or its free circulation, if it is observed that this personal protective equipment, bearing the 'CE' mark and used according to its intended aim, may compromise personal safety.

Personal hearing protectors must combine the essential health and safety requirements included in Annex II, paragraph 3.5 of the directive. Personal hearing protectors intended for preventing harmful effects of noise must be capable of attenuating noise, such that equivalent sound levels perceived by the user under no circumstances exceed the exposure limit values quoted in Directive 2003/10/EC[31].

30. 89/686/EEC Council Directive of 21 December 1989, on the approximation of the laws of the Member States relating to personal protective equipment, O.J. L n° 399 of 30.12.1989, page 18.

31. Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003, on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise), O.J. n° L 42 of 15.02.2003, page 38.

Every personal hearing protector must bear a label displaying the level of sound reduction level and the value of the comfort index provided by the personal protective equipment. If this is impossible, the label must be affixed to the product packaging.

It shall be remembered that

'If the risks arising from exposure to noise cannot be prevented by other means, properly fitting individual hearing protectors shall be made available to workers and used by them under the following conditions:
- where noise exposure exceeds the lower exposure action values, the employer shall make individual hearing protectors available to workers;
- where noise exposure matches or exceeds the upper exposure action values, individual hearing protectors shall be used;
- the individual hearing protectors shall be so selected as to eliminate the risk to hearing or to reduce the risk to a minimum.'
(Article 6, § 1 of Directive 2003/10/EC)

2. INTRODUCTION

Workers shall be provided with hearing protectors if the risks arising from exposure to noise cannot be avoided or prevented by other means:

- If at a work station the daily noise exposure (normalised over 8 hours) exceeds the lower exposure action values, the employer shall make hearing protectors available for workers.
- If the daily noise exposure (normalised over 8 hours) matches or exceeds the upper exposure action values, workers must use hearing protectors.

In this context the employer shall make every effort to

1. Avoid the source of noise or to avoid the exposure of workers to noise;
2. Apply appropriate technical and organisational measures to reduce emission of noise at source;
3. Apply appropriate technical and organisational measures to reduce exposure of workers to noise;
4. Finally, if an employer cannot implement the above mentioned technical and organisational measures priority, it shall provide to workers appropriate individual hearing protectors.

Workers and/or their representatives must be consulted when the types of individual hearing protectors are being selected and chosen.

Each worker shall also be involved in the selection of his/her individual protector.

Efficiency of hearing protectors depends primarily on their being worn continuously and properly:

- Multiple objective parameters are used to select the most suitable hearing protector (see Section 5 of this chapter) and the worker's choice is relevant;
- 'Subjective' parameters such as discomfort and inconvenience may reduce the actual time the hearing protector is worn and shall therefore be considered.

Examples:

1. At the workstation, a measured value of noise is 83 dB(A), but the lower exposure action value is 80 dB(A) according to the European 'Noise' directive; the employer shall supply work station operators with hearing protectors.

Figure 5.1 Noise exposure exceeds lower exposure action values; hearing protectors are available for workers

2. At the work-station, the measured value of noise is 87 dB(A), but the upper exposure action value is 85 dB(A) according to the 2003/10/EC 'Noise' directive; workers must therefore wear hearing protectors.

Figure 5.2 Noise exposure matches or exceeds upper exposure action values; workers must use hearing protectors

3. TYPES OF HEARING PROTECTOR

There are many types of hearing protector. Generally, they can be divided into ear-muffs or ear-plugs.

Ear-muffs consist of two cups, which are usually connected by a headband.

- Cups completely cover the ear and are held tightly in place by a headband.
- Cups are usually fitted with acoustically absorbing material. Cup rims are cushioned, usually with plastic foam or fluid, to improve ear-muff comfort and fit.
- An ear-muff headband may be worn over or behind the head, under the chin or behind the neck.
- Ear-muffs are available in three sizes: small, medium and large.

Figure 5.3 Ear-muff construction
(© Courtesy of Bacou-Dalloz / Howard Leight / Bilsom)

Ear-muffs with headbands must not be worn with safety helmets. Ear-muffs with neckbands and chin-bands may be worn with safety helmets. Ear-muffs may also be attached to safety helmets.

Ear-plugs are hearing protectors, which are inserted into or over the ear canal to seal it.

- Reusable ear-plugs are usually made of silicon, rubber or plastic; some are provided with an interconnecting cord or headband.

- Disposable ear-plugs are usually made of foam or cotton wool.
- User formable ear-plugs are made from compressible materials, which users shape themselves before insertion into their ear canals.
- Custom-moulded ear-plugs are individually moulded to fit the ear canal shape or cover the entire external ear of a specific user.

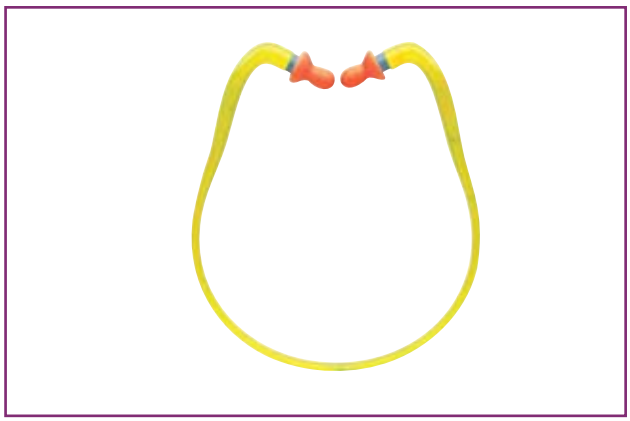


Figure 5.4 Various ear-plug models
(© Courtesy of Bacou-Dalloz / Howard Leight / Bilsom)

Figure 5.5 Custom-moulded 'otoplastic' ear-plugs
(© Courtesy of Auditech)

Some ear-plug models may be manufactured in three sizes: small, medium and large. Disposable ear-plugs are designed to be fitted (i.e. worn) only once. If disposable ear-plugs are fitted more than once, they will not provide the expected noise attenuation.

To produce custom-moulded ear-plugs, silicon impressions of user ear canals or external ears are made, from which casts are produced for the ear plugs. Custom-moulded ear-plugs are made of silicon (soft otoplastic) or acrylate (hard otoplastic) and are coated with a specific varnish layer to improve skin compatibility. High sound attenuation values are achieved (45 dB and 30 dB for high and low frequencies respectively). Ear-plugs are fitted with different filter elements to reduce and shape the sound attenuation characteristic.

In addition to passive hearing protectors, there are hearing protectors fitted with electronic systems.

- Level-dependent ear-muffs and ear-plugs are fitted with electronic sound restoration systems. These protectors are designed to be used in intermittent or impulse noise environments, where it is essential that speech and warning sounds be heard during quiet periods.
- Active noise reduction ear-muffs are fitted with electronic systems designed to provide additional low frequency noise attenuation.
- Ear-muffs fitted with communication facilities to receive information or warning signals and simultaneously ensure the required noise attenuation.

The following standards provide further information on the performance of hearing protectors fitted with electronic systems: for level-dependent ear-muffs – EN 352-4:2001; for active noise reduction ear-muffs – EN 352-5:2002; for ear-muffs with electrical audio input – EN 352-6:2002; and for level-dependent ear-plugs – EN 352-7:2002.

4. HEARING PROTECTOR PARAMETERS AND THEIR INFLUENCE ON PERFORMANCE

Hearing protector performance depends mainly on noise attenuation capacity.

Hearing protector noise attenuation may be defined by the following parameters, which are laboratory-evaluated during the certification process:

- Sound attenuation mean value and standard deviation.
- High-frequency attenuation – H.
- Medium-frequency attenuation – M.
- Low-frequency attenuation – L.
- Single number rating –SNR.

Sound attenuation mean value provides the most accurate evaluation of hearing protector performance.

This parameter specifies noise attenuation in each frequency band within the range of 125 Hz to 8000 Hz. The mean value is based on laboratory measurements taken on 16 listeners, which means the standard deviation must also be considered. Standard deviation is a statistic, which indicates how closely the 16 different measured sound attenuation values are clustered around the mean value.

Examples:

Frequency	Mean sound attenuation	Standard deviation
125 Hz	11.1 dB	3.3 dB
250 Hz	18.1 dB	3.3 dB
500 Hz	25.1 dB	3.1 dB
1000 Hz	27.0 dB	2.3 dB
2000 Hz	28.6 dB	2.4 dB
4000 Hz	38.6 dB	2.6 dB
8000 Hz	40.2 dB	3.3 dB

Noise attenuation provided by passive hearing protectors without electronic systems increases as the noise frequency rises. Exceptions are hearing protectors fitted with acoustic filters, e.g. ear-plugs designed specially for musicians. Standard EN 13819-2:2002 gives further information on the method of testing sound attenuation.

High-frequency (H), medium-frequency (M) and low-frequency (L) attenuation values characterise hearing protector performance in relation to high-, medium- and low-frequency noise.

These parameters indicate the number decibels; high, middle and low-frequency noise is effectively attenuated by the hearing protector concerned, e.g.: **H** = 29 dB, **M** = 23 dB, **L** = 15 dB.

Single Number Rating (SNR) is a less accurate indicator of a hearing protector's capacity to attenuate noise.

SNR indicates the number of decibels by which the noise level is reduced, when using the hearing protectors, e.g. **SNR** = 26 dB.

Standard EN ISO 4869-2 provides further information on calculating H, M and L attenuations and SNR.

Hearing protector attenuation in various frequency bands depends on construction.

Ear-muff performance is affected by:
- Mass and size.
- Cup rotation and adjustability for proper fit against area around wearer's ears.
- Headband force and cushion pressure against area around wearer's ears.
- Resistance to high and low temperatures.

Ear-plug performance is affected by:
- Construction material.
- Shape and size.

To ensure optimum ear-muff performance, the whole cup cushion area must fit snugly against the wearer's head. Similarly, to ensure optimum ear-plug performance, insertion into ear canals must be correct.
Standard EN 13819-1:2002 provides further information on methods of testing hearing protector physical parameters.

5. SELECTING THE MOST SUITABLE HEARING PROTECTOR TYPE

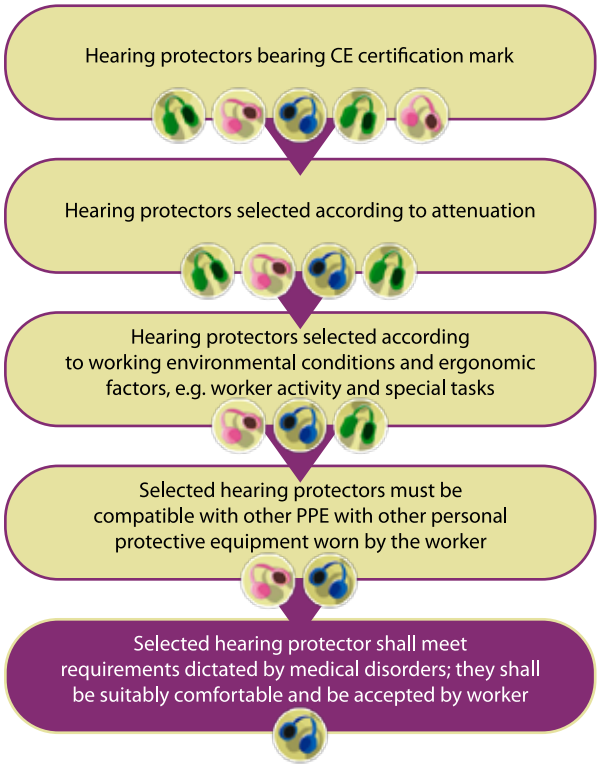


Figure 5.6 Selection scheme flow chart

5.1. Hearing protectors bearing CE certification mark

When selecting a hearing protector to be used in a work environment, it is essential to choose from those bearing the CE certification mark.

There are dozens of hearing protector models on the European market.

If a hearing protector bears the CE certification mark, it meets the requirements of standard EN 352.

PPE (PHP) intended for preventing harmful effects of noise must comply with provisions included in Annex II, paragraph 3.5 of the Directive 89/686/EEC.

Figure 5.7 CE certification mark

5.2. Hearing protector selection according to attenuation

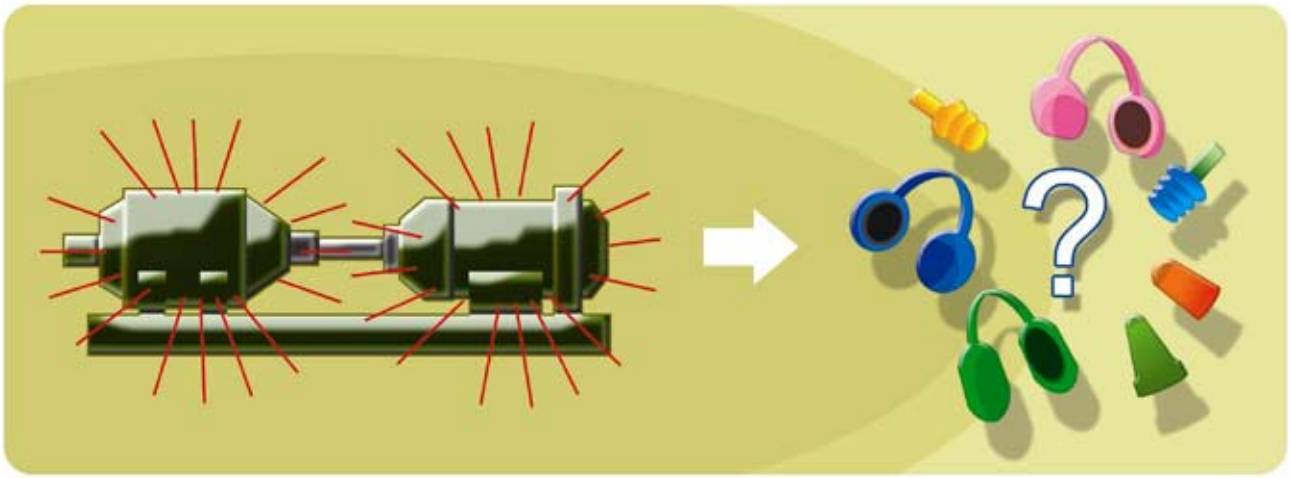


Figure 5.8 Specific noise demands the right hearing protector model

Hearing protectors may be chosen according to their attenuation characteristics, which shall be suited to the level and spectrum of the noise the worker is exposed to.

- The selected hearing protector must reduce the noise level at the wearer's ears to below the appropriate action level as determined by national regulations.
- The most suitable hearing protector ensures a noise level at the wearer's eardrum between 5 to 10 dB less than the action level. It is in fact wrong to believe that the higher the attenuation, the better the hearing protector (see Figure 5.9).
- The worker shall not be provided with a hearing protector with an unnecessarily high attenuation characteristic, reducing the noise level by more than 15 dB below the action level (see Figure 5.9).
- Over-protection may cause communication problems and prevent hearing of warning signals. The worker may experience feelings of discomfort and isolation and may therefore choose not to wear the hearing protector.

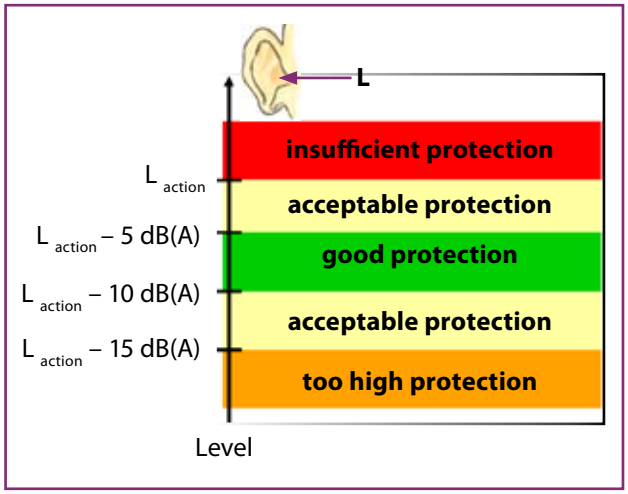


Figure 5.9 Noise level beneath a hearing protector (at the eardrum) must be acceptable (EN 458)

Examples:

If the action level is 85 dB(A):

- the worker is well protected by a hearing protector when the noise level effective at the ear is between 75 dB(A) – 80 dB(A);
- acceptable noise levels effective at the ear are between 80 dB(A) – 85 dB(A) and 75 dB(A) – 70 dB(A);
- a worker is over-protected when the noise level effective at the ear is less than 70 dB(A).

There are four methods of evaluating A-weighted sound pressure level beneath the hearing protector: the octave band method, the HML method, the HML check method and the SNR method.

- The octave band method is based on hearing protector sound attenuation data and work octave band sound pressure levels of the workplace noise.
- The HML method is based on high (H), medium (M) and low (L) frequency attenuation values for hearing protectors as well as A-weighted sound pressure level and C-weighted sound pressure level of the work station noise.
- The HML check method requires a subjective choice between two noise classes, based on noise source examples.
- The SNR method is based on the hearing protector Single Number Rating (SNR) as well as A-weighted sound pressure level and C-weighted sound pressure level of the workplace noise.

European standards EN 458:2004 and EN ISO 4869-2:1995 provide further detailed information concerning methods of evaluating noise level beneath hearing protectors.

5.3. 'Real-world' hearing protector attenuation

Hearing protector attenuation in real working environments may be lower than that obtained from tests conducted in a laboratory for certification purposes and user information published by the manufacturer. It is therefore not always possible to use directly the information provided by the PPE manufacturer for evaluating real attenuation, considering the noise level and frequency range, to which workers wearing PPE will be exposed.

This may be due to:

- Poor fitting of hearing protectors due to long hair (ear-muffs).
- Incorrect insertion into ear canal (ear-plugs).
- Wearing of obstructing equipment or other personal protective equipment.
- Natural deterioration of products with time.
- Differences in acoustic conditions between laboratory test sites and workplaces.

Laboratory-measured attenuation continues to provide valuable information for selecting the most suitable hearing protector.

- Laboratory-measured attenuations provide initial 'grading' for personal hearing protector performance; they also provide information on performance variation with respect to frequency.

Influence of 'real-world' acoustic conditions on the hearing protector attenuation is currently under investigation.

5.4. Hearing protector selection according to special requirements

There are work stations, subject to special conditions, which demand wearing of special types of hearing protectors.

- Work stations at which noisy and quiet periods alternate, e.g. shooting ranges, quarries, etc. Here, the worker must be ensured sufficient speech intelligibility and warning signal perception during quiet periods. Such circumstances dictate selection of level-dependent hearing protectors providing good speech intelligibility and warning signal perception during the latter periods.
- If there are doubts in relation to a worker's ability to hear essential alarms, warnings, emergency contacts, etc., alternative communication means, e.g. flashing warning lights or other devices such as vibrating pads, must be provided.

Figure 5.10 Worker wearing level-dependent ear-muffs at shooting range

- Ear-muffs fitted with electronic communication systems shall be chosen for workplaces, where noise is continuous and workers need to communicate with others or require instructions, e.g. pilots of small planes or helicopters, T.V. cameramen, etc.

Figure 5.11 At a workstation, where communication is required, a worker uses ear-muffs fitted with electronic communication systems

- If workers are exposed to low or high temperatures (about –20 °C or +50 °C), e.g. forestry workers, then ear-muffs suited to these conditions must be selected.

Figure 5.12 In winter, the forestry worker uses low-temperature ear-muffs (© Photo of B. Floret, Courtesy of INRS – France)

- When working in a humid environment, uncomfortable perspiration may occur beneath the worker's ear-muff cushions. In these circumstances, ear-plugs or ear-muffs with lightweight, absorbent, hygienic cushion covers are recommended. If such hygienic covers are used, noise attenuation values quoted in the user's information pack must relate to the combined ear-muffs and hygiene covers.

5.5. Hearing protector selection according to Personal Protective Equipment (PPE) compatibility

There are many work stations where workers need to use other personal protective equipment in addition to ear-muffs.

- Using ear-muffs plus respiratory protection devices, glasses, goggles, face shields, for example, and may reduce the efficiency of the seal between ear-muff cushions and the head, thereby reducing noise attenuation. Ear-plugs are usually recommended in these cases.
- Ear-muffs attached to helmets are generally recommended, when safety helmets and hearing protectors need to be simultaneously worn. However, given the uncomfortable nature of this combination, it is necessary to convince the workers of its importance in order to protect their health and safety.

Figure 5.13 A worker uses ear-muffs attached to his helmet at a workstation where head protection is required

5.6. Hearing protector selection according to wearer comfort and medical disorders

Comfort is a very important factor when selecting hearing protectors.

- A hearing protector shall not cause discomfort, especially when the worker shall wear it throughout the working day.
- Some types of hearing protectors are not suited for every individual. Everyone is different and ear anatomy differs widely from person to person.

When wearing ear-muffs, user comfort depends on:
- Weight of hearing protector.
- Cushion pressure.
- Headband force, adjustability.
- Type of cushion material.

When wearing ear-plugs, user comfort depends on:
- Ease of fitting and removal.
- Overall fit within the ear canal.

Sometimes a worker who is supposed to wear a hearing protector, complains of earache, irritation of the ear canal, and discharge from the ear or hearing loss.
In these cases, the worker may be justifiably reluctant to wear a particular type of hearing protector. Worker approval shall always be sought before reaching a final decision on hearing protector selection.

Examples:

If the ear canal of a worker is not typical, is narrow or of a complex shape, pre-moulded flange ear-plugs will be unsuitable for the worker concerned.

A worker is undergoing treatment for a skin disorder of the ear canal. In this case, use of ear-muffs is recommended.

6. HEARING PROTECTOR EFFECTIVE PROTECTION ACCORDING TO TIME WORN

When the use of the PPE is necessary, hearing protectors must be worn under all circumstances for workers to benefit from effective hearing protection.

- Even a very short break from wearing hearing protectors significantly reduces the effective attenuation and protection.
- The table below gives an example of effective protection for different time periods spent without the hearing protector, during an 8-hour working day.

Time spent without hearing protectors [minutes]	Effective protection [dB]
0	30
5	20
24	13
48	10
96	7
144	5
192	4
240	3

Figure 5.14 Effective protection when hearing protection is removed in the noisy environment during an 8-hour working day

Examples:

If a worker wears a hearing protector for a full 8-hour day, he will receive the 30 dB maximum protection level. However, a 1-hour break without the hearing protector causes the maximum protection level to fall to 9 dB.

7. INFORMATION FOR EMPLOYER AND EMPLOYEES

Every hearing protector bearing the CE certification mark is marketed along with user information supplied by the manufacturer.

- Before selecting the personal hearing protectors, employers must collect information and technical specifications in order to make the best choice.
- Once the hearing protector is bought, you must read the information supplied by the manufacturer detailing the hearing protector performance, method of usage, maintenance, etc.

The following information is invariably quoted for every type of hearing protector:

- Standards with which the hearing protector complies.
- Manufacturer's name.
- Intended purpose of hearing protector model.
- When applicable, details of whether a particular hearing protector can be used at low or high temperatures.
- Instructions for proper fitting and use of the particular hearing protector model.
- Hearing protector size.
- Recommended storage conditions.
- Sound attenuation values – required for selecting a hearing protector suited to the noise concerned.
- Address at which further employee-related information may be obtained.

In the case of ear-muffs attached to safety helmets, all given information refers only to the specific combination concerned.

For ear-muffs and reusable ear-plugs, methods of cleaning and disinfection are described.

In the case of single-use disposable ear-plugs, it is very important to remember that sound attenuation values are valid only for their first/single use. Repeat usage of the same single-use disposable ear-plugs will significantly decrease their attenuation.

For hearing protectors fitted with electronic systems, additional information is provided concerning safety, operation and performance of the electronic system as well as battery maintenance.

Figure 5.15 What does the employer have to tell his employee?

8. SPECIAL CASES

With respect to cases or specific work activities whereby hearing protection must be worn by workers, due to the level of noise at the workplace, it must be considered that as a function of their work activities, certain workers must also be able to receive appropriate information or instructions while wearing this PPE in order to carryout their work activity, e.g. camera men on sets, workers on the apron of airports, etc.

Musician ear plugs

Musicians should opt for special earplugs, which provide uniform attenuation of all frequencies. This allows music to be heard with a natural sound characteristic.
These custom-fitted silicone earplugs are equipped with an interchangeable diaphragm filter available for attenuation levels of 9, 15 or 25 dB(A). Most musicians playing with earplugs, even with these special devices, need time to familiarise themselves with altered instrument perception (see Chapter 8).

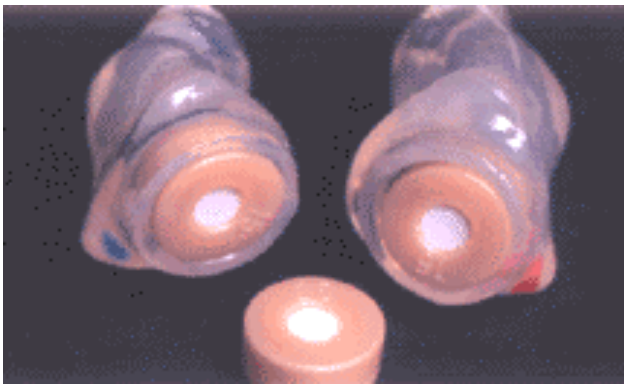
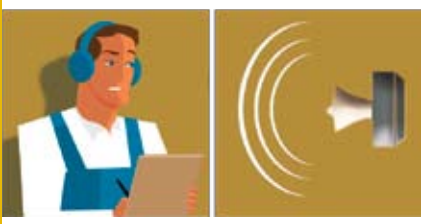


Figure 5.16 Musician ear plugs with interchangeable filters
(© Courtesy by Infield Safety GmbH, Germany)



CHAPTER 6
Purchasing quiet work equipment

1. REQUIREMENTS FROM HEALTH AND SAFETY DIRECTIVES FOR PURCHASING QUIET WORK EQUIPMENT

In order to avoid or reduce to a minimum the exposure of workers in the workplace to the risks of noise, the employer must know and respect the following health and safety directives, including especially the resulting requirements for purchasing quiet work equipment.

Framework Directive 89/391/EEC[32]

Article 6 of the Framework Directive 89/391/EEC provides that

1. *Within the context of his responsibilities, the employer shall take the measures necessary for the safety and health protection of workers, including prevention of occupational risks and provisions of information and training, as well as provision of the necessary organisation and means. The employer shall be alert to the need to adjust these measures to take account of changing circumstances and aim to improve existing situations.*

2. *The employer shall implement the measures referred to in the first subparagraph of paragraph 1 on the basis of the following general principles of prevention:*
   - *Avoiding risks;*
   - *Evaluating the risks which can not avoided;*
   - *Combating the risks at source.*

Directive 2003/10/EC[33] 'Noise'

Article 5 of **Directive 2003/10/EC 'Noise'** lays down provisions to avoid and reduce exposure:

1. Taking account of technical progress and of the availability of measures to control the risk at source, the risks arising from exposure to noise shall be eliminated at their source or reduced to a minimum.

   The reduction of such risks shall be based on the general principles of prevention set out in Article 6 (2) of Directive 89/391/EEC, and take into account in particular:

   (b) the choice of appropriate work equipment, taking account of the work to be done, emitting the least possible noise, including the possibility of making available to workers work equipment subject to Community provisions with the aim or effect of limiting exposure to noise;

   (d) adequate information and training to instruct workers to use work equipment correctly in order to reduce their exposure to noise to a minimum.

Directive 89/655/EEC[34] 'Use of work equipment'

Finally, Article 4 of **Directive 89/655/EEC** on the minimum safety and health requirements for the use of work equipment by workers at work lays down provisions:

'The employer shall take the measures to ensure that the work equipment made available to workers in the undertaking and/or establishment is suitable for the work carried out or properly adapted for that purpose and may be used by workers without impairment to their safety or health.

In selecting the work equipment which he proposes to use, the employer shall pay attention to the specific working conditions and characteristics and to the hazards which exist in the undertaking and/or establishment, in particular at the workplace, for the safety and health of the workers, and/or any additional hazards posed by the use of work equipment in question.'

32. Council Directive 89/391/EEC of 12 June 1989, on the introduction of measures to encourage improvements in the safety and health of workers at work, O.J. n° 183 of 29.06.1989, page 1.

33. Council Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003, on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise), O.J. n° 42 of 15.02.2003, page 38.

34. Council Directive 89/655/EEC of 30 November 1989, concerning the minimum safety and health requirements for the use of work equipment by workers at work, O.J. n° L 393 of 31.12.1989, page 13.

2. MACHINERY DIRECTIVE 98/37/EC AND OUTDOOR DIRECTIVE 2000/14/EC

In order to achieve the provisions established in the health and safety directives, what is required to avoid and reduce noise exposure of workers at source, the employer, who is purchasing work equipment, should be informed by manufactures and/or authorised representatives established in the EU (distributors, importers, etc.) on the noise relevant requirements laid down in the:

- **Directive 98/37/EC**[35] **'Machinery'** on the approximation of the laws of the Member States relating to machinery. This directive will be replaced by the Directive 2006/42/EC[36] which will take effect on the 29 December 2009,

and for machines primarily used outdoors:

- **Directive 2000/14/EC**[37] **'Outdoor'** on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoor, amended by Directive 2005/88/EC [38].

Both directives require that machine manufacturers and/or authorised representatives established in the EU (distributors, importers, etc.) provide information about the noise emission of their machines. This will help to evaluate noise in the workplace and to select new work equipment with lower noise emission levels.

35. Directive 98/37/EC of the European Parliament and of the Council of 22 June 1998, on the approximation of the laws of the Member States relating to machinery, O.J. n° L 207 of 23.07.1998, page 1.

36. Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006, on machinery, and amending Directive 95/16/EC, O.J. n° L 157 of 09.06.2006, page 24.

37. Directive 2000/14/EC of the European Parliament and of the Council of 8 May 2000, on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors, O.J. n° L 162 of 03.07.2000, page 1.

38. Directive 2005/88/EC of the European Parliament and of the Council of 14 December 2005, amending Directive 2000/14/EC on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors, O.J. n° L 344 of 27.12.2005, page 44.

2.1. Machinery Directive 98/37/EC (after 29 December 2009 replaced by the Directive 2006/42/EC)

Regarding noise, the 'Machinery' Directive 98/37/EC and the subsequent Directive 2006/42/EC have two essential requirements to be observed by manufacturers and/or authorised representatives established in the EU (distributors, importers, etc.).

First, the minimisation requirement applies:

'Machinery must be so designed and constructed that risks resulting from the emission of airborne noise are reduced to the lowest level taking account of technical progress and the availability of means of reducing noise, in particular at source.'
(see Annex I, point 1.5.8 'Noise')

The new 'Machinery' Directive 2006/42/CE supplements:

'The level of noise emission may be assessed with reference to comparative emission data for similar machinery.'(see Annex I, point 1.5.8 'Noise')

Second, to allow the choice of quieter machines by making the machine market more transparent, noise emission information must be given in the instructions and in the technical documentation presenting the machine.

Additionally the Directive 2006/42/CE states that:

'The sales literature describing the machinery must not contradict the instructions as regards health and safety aspects. Sales literature describing the performance characteristics of machinery must contain the same information on emissions as is contained in the instructions.'
(see Annex I, point 1.7.4.3 'Sales literature').

The manufacturer and/or his authorised representative established in the EU must, in order to certify that machinery and safety components are in conformity with the Machinery Directive, draw up for all machinery an EC declaration and affix to the machine the CE marking (see Article 8 of the Directive 98/37/EC).

For specific machinery, the manufacturer and/or his authorised representative established in the EU must give to the employer (user) a declaration of conformity and the machine must bear CE marking. However, the employer (user) should be aware that a CE marking is not a quality mark.

Regarding the Directive 98/37/EC and after 29 December 2009 the amending Directive 2006/42/EC 'Essential health and safety requirements relating to the design and construction of machinery', Annex I paragraph 1.5.8 of the directives impose on manufacturers, and/or their authorised representative established in the EU, the obligation to ensure that:

'Machinery must be designed and constructed in such a way that risks resulting from the emission of airborne noise are reduced to the lowest level, taking account of technical progress and the availability of means of reducing noise, in particular at source.'

The new Directive 2006/42/EC adds to this paragraph the following sentence:

'The level of noise emission may be assessed with reference to comparative emission data for similar machinery.'

In respect to Article 6, paragraph 2 (c) of Directive 89/391/EEC '*combating the risks at source*' and considering Directive 98/37/EC, Annex I, 1.7.4, manufacturers and/or their authorised representative established in the EU must provide to the employer (user) 'instructions' (extract from Annex I, 1.7.4 'instructions' of Directive 98/37/EC).

2.2. Outdoor Directive 2000/14/EC (amended by the Directive 2005/88/EC)

The Directive 2000/14/EC of the European Parliament and of the Council, amended by the Directive 2005/88/EC sets out both limits and labelling requirements on noise emission for a number of machines intended for use outdoors. This directive only covers equipment that is placed on the market or put into service as an entire unit suitable for the intended use (see Articles 12 and 13 of directive 2000/14/EC, and Article 12 of directive 2005/88/EC).

The aim of this directive is to improve the control of noise emissions of equipment used outdoors, such as compressors, excavator-loaders, different types of saws, mixers and gardening equipment like lawn mowers, etc. (listed in Articles 12 and 13 of the directive and defined in Annex I).

The following shall be excluded from the scope of this Directive (see Article 2):

- Non-powered attachments that are separately placed on the market or put into service, except for hand-held concrete-breakers and picks, and for hydraulic hammers.
- All equipment primarily intended for the transport of goods or persons by public road or rail or by air or on waterways.
- Equipment specially designed and constructed for military and police purposes and for emergency services.

According to the Directive labelling is compulsory for all listed items of equipment. This includes:

- The CE marking visibly, legibly and indelibly affixed to each item of equipment;
- The value of the sound power level L_{wa} in dB(A) in relation to 1 pW.

In order to assess the impact of the Directive, a procedure for the collection of noise emission data was established. This information will serve as a basis for devising economic incentives and **eco-label** awards.

Noise Emissions for Outdoor Equipment:
http://ec.europa.eu/enterprise/mechan_equipment/noise/index.htm

Link to the EU Commission's database on noise emission values of machines covered by the Outdoor Directive 2000/14/EC:
http://ec.europa.eu/enterprise/mechan_equipment/noise/citizen/app/

2.3. Relationship between Health and Safety Directives and Machinery and Outdoor Directives

The diagram represented in Table 6.1, presents the interrelations between Directives 'Health and Safety of the workers' and Directives on 'Machinery-Safety' and on 'Noise of machines used outdoors'.

Directive 2003/10/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise), introduces in Article 3 'exposure limit values' and 'exposure action values' for both A-weighted average of the noise exposure levels for a nominal 8 hour working day and C-weighted peak sound pressure levels.

Extract from Annex I, § 1.7.4 of Directive 98/37/EC 'Instructions'

(a) All machinery must be accompanied by instructions including at least the following.

- *A repeat of the information with which the machinery is marked, except the serial number (see 1.7.3), together with any appropriate additional information to facilitate maintenance;*
- *Instruction for safe installation, use, handling, assembling, dismantling maintenance, training instructions, etc ;*

(d) Any literature describing the machinery must not contradict the instructions as regards safety aspects. The technical documentation describing the machinery must give information regarding the airborne noise emissions referred to in (f) and, in the case of hand-held and/or hand-guided machinery, information regarding vibration as referred to in 2.2 (essential health and safety requirements for certain categories of machinery);

(e) Where necessary, the instructions must give the requirements relating to installation and assembly for reducing noise or vibration (e.g. use of dampers, type and mass of foundation block, etc.);

(f) The instructions must give the following information concerning airborne noise emissions by the machinery, either the actual value or a value established on the basis of measurements made on identical machinery:

- *equivalent continuous A-weighted sound pressure level at workstations, where this exceeds 70 dB(A); where this level does not exceed 70 dB(A), this fact must be indicated;*
- *peak C-weighted instantaneous sound pressure value at workstations, where this exceeds 63 Pa (130 dB in relation to 20 µPa);*
- *sound power level emitted by the machinery where the equivalent continuous A-weighted sound pressure level at workstations exceeds 85 dB(A);*

In the case of very large machinery, instead of the sound power level, the equivalent continuous sound pressure levels at specified positions around the machinery may be indicated.

Where the harmonised standards are not applied, sound levels must be measured using the most appropriate method for the machinery.

The manufacturer must indicate the operating conditions of the machinery during measurement and what methods have been used for the measurement.

Where the workstation(s) are undefined or cannot be defined, sound pressure levels must be measured at a distance of 1 metre from the surface of the machinery and at a height of 1.60 metres from the floor or access platform. The position and value of the maximum sound pressure must be indicated.

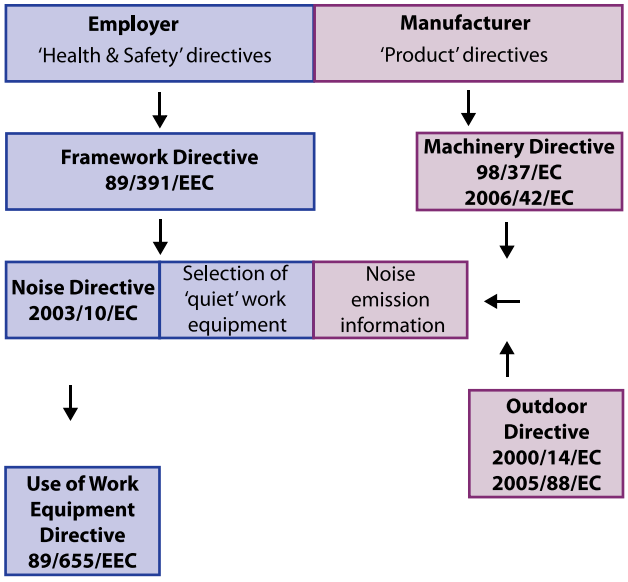


Table 6.1 Relationship between Health and safety Directives and Machinery and Outdoor Directives

The determination of the worker's effective exposure shall take into account all noise at the workplace, including the noise emitted by machinery. This is to reduce to a minimum the exposure to noise respecting the 'exposure limit values' and the 'exposure action values'. Therefore an appropriate choice of work equipment resulting from the 'risk assessment' is important. The exposure action values lead to concrete actions such as the requirement to tell workers about potential risks, the provision and wearing of hearing protectors, the checking of workers' hearing and the drawing up of a noise abatement programme, including a requirement to use adequate information for choosing quiet machines.

23.7.98 EN Official Journal of the European Communities L 207/19

1.7.4. Instructions

(a) All machinery must be accompanied by instructions including at least the following:

- a repeat of the information with which the machinery is marked, except the serial number (see 1.7.3) together with any appropriate additional information to facilitate maintenance (e.g. addresses of the importer, repairers, etc.),

- foreseen use of the machinery within the meaning of 1.1.2(c),

- workstation(s) likely to be occupied by operators,

- instructions for safe:

  - putting into service,
  - use,
  - handling, giving the mass of the machinery and its various parts where they are regularly to be transported separately,
  - assembly, dismantling,
  - adjustment,
  - maintenance (servicing and repair),

- where necessary, training instructions,

- where necessary, the essential characteristics of tools which may be fitted to the machinery.

Where necessary, the instructions should draw attention to ways in which the machinery should not be used.

(b) The instructions must be drawn up in one of the Community languages by the manufacturer or his authorised representative established in the Community. On being put into service, all machinery must be accompanied by a translation of the instructions in the language or languages of the country in which the machinery is to be used and by the instructions in the original language. This translation must be done either by the manufacturer or his authorised representative established in the Community or by the person introducing the machinery into the language area in question. By way of derogation from this requirement, the maintenance instructions for use by specialised personnel employed by the manufacturer or his authorised representative established in the Community may be drawn up in only one of the Community languages understood by that personnel.

(c) The instructions must contain the drawings and diagrams necessary for putting into service, maintenance, inspection, checking of correct operation and, where appropriate, repair of the machinery, and all useful instructions in particular with regard to safety.

(d) Any literature describing the machinery must not contradict the instructions as regards safety aspects. The technical documentation describing the machinery must give information regarding the airborne noise emissions referred to in (f) and, in the case of hand-held and/or hand-guided machinery, information regarding vibration as referred to in 2.2.

(e) Where necessary, the instructions must give the requirements relating to installation and assembly for reducing noise or vibration (e.g. use of dampers, type and mass of foundation block, etc.).

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(f) The instructions must give the following information concerning airborne noise emissions by the machinery, either the actual value or a value established on the basis of measurements made on identical machinery:

- equivalent continuous A-weighted sound pressure level at workstations, where this exceeds 70 dB(A); where this level does not exceed 70 dB(A), this fact must be indicated,

- peak C-weighted instantaneous sound pressure value at workstations, where this exceeds 63 Pa (130 dB in relation to 20 ìPa),

- sound power level emitted by the machinery where the equivalent continuous A-weighted sound pressure level at workstations exceeds 85 dB(A).

In the case of very large machinery, instead of the sound power level, the equivalent continuous sound pressure levels at specified positions around the machinery may be indicated.

Where the harmonised standards are not applied, sound levels must be measured using the most appropriate method for the machinery.

The manufacturer must indicate the operating conditions of the machinery during measurement and what methods have been used for the measurement.
Where the workstation(s) are undefined or cannot be defined, sound pressure levels must be measured at a distance of 1 metre from the surface of the machinery and at a height of 1,60 metres from the floor or access platform. The position and value of the maximum sound pressure must be indicated.

(g) If the manufacturer foresees that the machinery will be used in a potentially explosive atmosphere, the instructions must give all the necessary information.

(h) In the case of machinery which may also be intended for use by non-professional operators, the wording and layout of the instructions for use, whilst respecting the other essential requirements mentioned above, must take into account the level of general education and acumen that can reasonably be expected from such operators.

3. STANDARDS RELATED TO NOISE

A major decision taken in 1985 by the European Economic Community (EEC), now the European Union (EU), was the removal of technical barriers to trade. This was achieved by adopting a series of directives that would 'approximate the laws of Member States'.

These 'new approach' directives define legislative harmonisation in specific sectors where barriers to trade existed due to divergent national regulations. One example of this was in the assessment of machinery hazards. The basic principle is that the directives are written as a series of simple legal requirements (essential health and safety requirements) and leave to standards how to reach the objectives.

Although their use remains voluntary, the use of a harmonised standard is one way to achieve conformity to the related new approach directive.

Three types of standards

There are three types of standards supporting the Machinery Directive:

- **Type A standards** cover basic safety concepts;
- **Type B standards** cover horizontal issues (e.g. noise emission measurement in general) and are applicable to many different machines; and
- **Type C standards,** also denoted as machinery safety standards, deal with safety aspects (including hazards due to noise emission) of specific types of machinery.

As far as noise from machinery is concerned B-standards describe the basic measurement without providing any information about the specific operating, mounting and installation conditions for the respective machines. This important information together with recommendations on which B-standards should be used for the measurements is given in noise test codes. Such test codes have been prepared for a large amount of different families of machines by CEN and CENELEC working groups.

A noise test code is either a separate standard or a normative annex to a type C standard, that is a machinery safety standard. More than 500 are already published (**EN** or **ISO** or **EN-ISO**), others are still in preparation (**prEN**). They cover a large variety of machine families such as pumps (EN 12639:2000); printing, paper making and paper converting machinery (EN 13023:2003); agricultural machinery (EN 1553:1999 as frame noise test code for this wide family of machines), etc.

The procedures for measurement, declaration and verification of the sound emission quantities are defined in the following basic standards (B-standards):

- **EN ISO 3740** series and **EN ISO 9614-1-3** lay down methods for determining machinery sound power level in both special acoustic test rooms and in situ (i.e. at workplaces).
- **EN ISO 11200 – 11205** lay down methods for determining the emission sound pressure level at the workstation under various environmental conditions.
- **EN ISO 4871** deals with both noise emission declaration and verification (checking).

The use of a single noise emission measuring method (noise test code relevant to family concerned) by all manufacturers of a given machine family offers machine purchasers the opportunity to compare noise emission values for machines of the same family. Moreover, it allows the comparison of potential values and thus the option to choose comparatively quiet machines.

4. HOW TO REDUCE NOISE EMISSION FROM WORK EQUIPMENT

4.1. How to request information about the noise emission

To reduce noise at the workplace, purchasers of machines should request information on noise emission values from different machine manufacturers and compare these values to select the quietest machine offered by the different suppliers.

In order to assure that the requested noise emission values are comparable, it is suggested that the purchaser of machines should ask the manufacturer to provide a noise emission declaration based on European standards. Such a noise emission declaration provides reliable technical information on the noise emission values as their determination is based on machinery specific European Standards. Thus the measurement method, the operating and mounting conditions as well as the declaration and verification procedure are unambiguously defined for a large amount of very different machines. This is especially important for large and/or specific machinery [see Annex I, paragraph 1.7.4 (f) of directive 98/37/EC]:

'In the case of very large machinery, instead of the sound power level, the equivalent continuous sound

pressure levels at specified positions around the machinery may be indicated.'

See website:
http://www.cenorm.be/cenorm/aboutus/information/otherpublications/catalogueetc.asp to get a catalogue providing a list with standards supporting the 'Machinery' directive 98/37/EC.

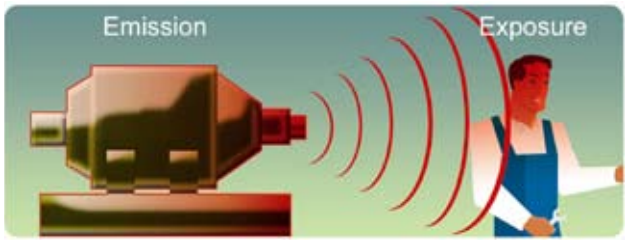


Figure 6.1 Lower machine noise emission results in lower worker exposure

4.2. Noise emission information

According to the 'Machinery' Directive 98/37/EC (and after 29 December 2009 the Directive 2006/42/EC) requirements, machine manufacturers are required to provide noise emission values which should be clearly distinguished from exposure values of workers.

Accordingly the machine manufacturer and/or authorised representatives established in the EU (distributors, importers, etc.) shall give:

- The A-weighted emission sound pressure level at workstations, where this exceeds 70 dB(A); where this level does not exceed 70 dB(A), this fact must be indicated;
- Peak C-weighted instantaneous sound pressure value at workstations, where this exceeds 63 Pa (130 dB in relation to 20 µPa);
- Sound power level emitted by the machinery where the A-weighted emission sound pressure level at workstations exceeds 85 dB(A).

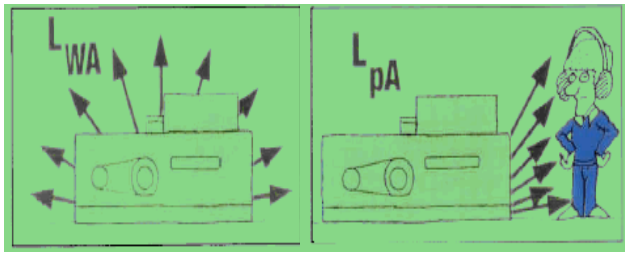


Figure 6.2 Emission values quoted in noise emission information
(© Courtesy of BAuA. Brochure 'Technik 1 – Geräuschangaben für Maschinen – Informationen für den Machineneinkauf', page 18)

Both the emission sound pressure level and the sound power level are quantities that are independent from the environment in which the machine is placed. Therefore they characterise the machine as a sound source.

Be aware, when reading 'decibel' that this can be related to very different types of noise characterising quantities, thus covering emission, immission or exposure. Therefore it is very important not to confuse **emission** sound pressure level L_{pA}, or sound power level L_{WA}, with sound pressure levels characterising **immission** (also denoted as L_{pA}) or **exposure** levels $L_{AEX,T}$. Although these levels are all expressed in dB(A), they describe totally different quantities (see Chapter 1, Section 3 of this guide).

5. HOW TO SELECT A QUIET WORK EQUIPMENT

5.1. Legal Obligation

An employer has the duty to take suitable action to prevent or reduce exposure of his employees to noise. To carry out the obligations laid down in Directive 2003/10/EC, Article 4 of Directive 89/655/EEC 'Rules concerning work equipment' lays down that:

1. Without prejudice to Article 3 (general obligations), the employer must obtain and/or use:
   (a) work equipment which, if provided to workers in the undertaking and/or establishment for the first time after 31 December 1992, complies with:
   - the provisions of any relevant Community directive which is applicable;
   - the minimum requirements laid down in the Annex, to the extent that no other Community directive is applicable or is so only partially;

   (b) work equipment, if already provided to workers in the undertaking and/or establishment by 31 December 1992, complies with the minimum requirements laid down in the Annex no later than four years after that date.

Machines can normally be considered as major sources of noise in the workplace, so design of low-noise machines by manufacturers and procurement of such machines by the employer (user) based on comparable noise emission values is of considerable significance to workplace noise reduction.

Employers (users) are not normally in a position to modify the basic design of machines. However, owing to the requirements of the 'Machinery' Directive 98/37/EC, manufacturers, and/or their authorised representatives established in the EU, must provide noise emission values in the instruction manual. According to the new 'Machinery' Directive 2006/42/EC, the same information on emissions must also be contained in any sales literature describing the performance characteristics

of the machinery. Furthermore, the manufacturer and/or authorised representatives established in the EU (distributors, importers, etc.) provides instructions to facilitate employers (users) to choose, to put into service, to use/operate, to maintain and to adjust the machine in order to contribute to a lower noise emission during its operation and consequently to reduce to a minimum the exposure of workers to noise respecting the 'Exposure limit values' and the 'Exposure action values' established by the 'Noise' Directive 2003/10/EC.

Thus knowledge about the noise emission, before choosing a new machine, could allow employers (users) to avoid or reduce the noise emission at workplace. This information must not be contradictory to other instructions as regards health and safety aspects.

Noise information allows potential machine purchasers to select the machine with the lowest noise emission from a range of different makes. At the same time, this makes it possible for the employer to fulfil the machine user's statutory duty to acquire, as far as possible, quiet work equipment according to Article 5 of Directive 2003/10/EC.

5.2. Differences between values given by manufacturers and real values at workplace

The noise emission declaration provided by a machine manufacturer is an important tool to help constructive dialogue between users and manufacturers in the selection of the best lower noise emission machinery. Employer/purchaser/user should therefore always request additional information from manufacturers and/or their authorised representatives established in the EU.

Under real conditions on site, an immission sound pressure level, that means the sound pressure level measured at the respective workplace, can differ by more than 10 dB from the declared emission sound pressure level, determined under free-field conditions, because of noise from other sources, reflections from walls, ceilings, floors or machine surfaces and operating conditions diverging from those given in standards. Confusion in these fundamentally different values quantifying emission and immission or even exposure, which includes the time of exposure, explains the many discussions and misunderstandings between machine manufacturers and customers.

It must be clear that exposure limiting values to be observed by employers, e.g. daily exposure action values given in the 'Noise' Directive 2003/10/EC, cannot be compared with noise emission values quoted by machine manufacturers. The latter however, provide a basis for selecting quiet machines and predicting noise exposure values sustained by employees in the workshop.

5.3. Why to compare the noise emission of different machinery

Noise emission information not only enables the selection of quiet machinery, it also offers the opportunity to estimate noise exposure of workers at the workplace.

Information on noise emission values (L_{WA}, L_{pA}) are required:

- to compare noise emission values for different machine brands to select the quietest model;
- to compare noise emission values with collected data on the corresponding machine group to check whether the state of the art has been achieved;
- to allow technical dialogue between the purchaser/user and the supplier;
- to estimate noise immission and exposure in the workplace by applying noise prediction (calculation) software;
- to permit assessment of compliance by the purchaser with guaranteed noise emission values.

The noise emission generated by the machine, i.e. the sound power, determines the machine's acoustic quality. The lower the sound power level, the better the acoustic quality and the quieter the machine. Thus, a machine with comparatively low noise emission values creates lower noise exposure for workers not only in its vicinity but also at other workplaces. The potential risk of hearing damage will therefore be reduced.

Noise emission values are a prerequisite for planning by forecasting the noise immission or exposure at workplaces. Therefore the noise emission values form a basis for planning new workplaces according to noise control requirements. In addition, they constitute an important aid to draw up noise reduction actions required for working areas exceeding the upper exposure action values laid down in Article 3 of Directive 2003/10/EC.

5.4. When to compare the noise emission of different machinery

In respecting the health and safety directives, in particular Article 6 of the Framework Directive 89/391/EEC, the employer in the context of his responsibilities and on the basis of the general principles of prevention shall avoid risks and if it is not possible shall evaluate the risks which cannot be avoided. If the result of this risk assessment shows that there is a risk of exposure of to the noise, the employer (user) who is purchasing work equipment, must be sure to have received in the instructions handbook the information required by the 'Machinery' Directive and if necessary ask for further information on noise from providers.

Making reference to this information on noise emission levels from machinery, the employer (user) must be select and choose the lower noise emission work equipment to respect the exposure limit values and exposure action values established by the Directive 2003/10/EC.

5.5. How to compare the noise emission of differents machinery

Some applications

To select state-of-the-art quiet machinery, it is necessary to know about the representative distribution of noise emission values for the relevant machine family.

Noise emission standards and noise emission declarations made by machine manufacturers establish the basis for potential purchasers to select the machine with the lowest emission values compared with noise emission declarations made by different machine suppliers. However, there is no guarantee, yet, that the selected machine is effectively one of the quietest on the market. A decision can only be reached if we know the noise emission of the state–of-the-art machine amongst this family of machines.

State-of-the-art machine noise emission can only be considered within a machine group used in the same application field. For this purpose, the term of 'actual state of noise emission' was coined (comparative emission data according to Standard EN ISO 12100-1:2004 'Safety of machinery – Basic concepts, general principles for design, Part 1 Basic terminology, and methodology', and EN ISO 11689:1997 'Procedure for the comparison of noise emission-data for machinery and equipment'). This actual state represents a range of emission values that are suitable for comparison; in other words, which were measured with comparable measuring methods laid down in standards.

Database

State-of-the-art in noise emission terms can be concluded from a representative range of emission values for comparable machines.

So far, actual state of noise emissions has only been included on a few databases and in certain German VDI-ETS guidelines.

As far as possible, a comparatively quiet machine should be selected based on a broad (wise) data search taking into account that studies have shown that a significant noise reduction is achievable (benchmarking).

Data about actual state of noise emission is available at the website:
http://ec.europa.eu/enterprise/mechan_equipment/noise/citizen/app/

and at the website:
http://ec.europa.eu/enterprise/mechan_equipment/noise/index.htm

Figure 6.3 illustrates an example of the typical noise emission distribution determined for a specific machine. These figures include emission values for a fairly representative selection of pneumatic screwdrivers on the market. The sound power level is given for the noise-related machine parameters maximum screw diameter.

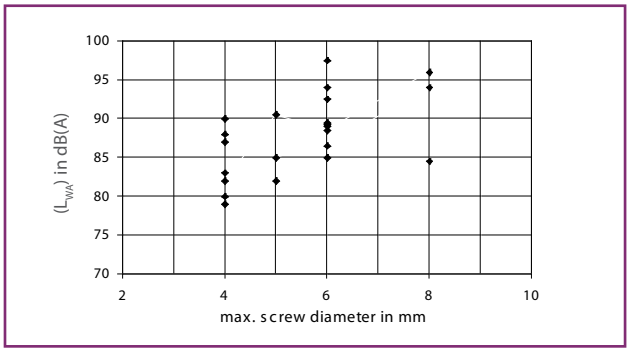


Figure 6.3 Sound power level (L_{WA}) of air cut-off pneumatic screwdrivers with respect to the maximum screw diameter

Verifying (checking) manufacturer's emission information

In some cases, the employer/purchaser/user of a machine may want to check whether machine noise emission values exceed those quoted by the machine manufacturer in the noise emission declaration or quoted in the sales contract. This normally happens if measured noise exposure values at the workplace are higher than expected after the installation of the new machine.

Immission values in a workroom can be approximately calculated by applying **EN ISO 11690-3**, which uses declared noise emission values as basic input data.

EN ISO 4871 provides methods of verifying (checking) noise emission information and how the manufacturer describes its.

6. ANNEX

The Table 6.2 illustrates an example of how noise emission information should preferably look, if it is provided by manufacturers and/or their authorised representatives established in the EU, applying the rules stated in **EN ISO 4871**. It shows measured values compared with the different required emission values and the relevant uncertainty of these measured values.

Machine description: Wood working machine; Tenoning machine, Type 990, 50Hz		
Dual-number noise emission values according to EN ISO 4871		
	Machine 'on' without load (idling)	Machine 'on' with load (working)
A-weighted sound power level L_{WA} in dB re 1 pW	94	98
Uncertainty K_{WA} in dB	2	2
A-weighted emission sound pressure level L_{pA} in dB re 20 µPa at workplace	80	86
Uncertainty K_{pA} in dB	2	2
The above values were determined according to the noise test code ISO 7960, applying basic standards EN ISO 3744 and EN ISO 11204		

Table 6.2 Example of suitable 'Machinery' directive-based noise emission information based on the EN ISO 4871 dual-value information to illustrate an example of how to use standards in the framework of the 'Machinery' Directive 98/37/EC

Example of a technical specification on noise emission description (machine, instalation device, additional unite).

EC Machinery Directive 98/37/EC requires the machine manufacturer and/or his authorised representative established in the EU to provide information on noise emission values.

Noise emission values must be determined based on machinery safety standards or separate machine-specific noise test codes. If this is not possible, basic standards like:

- EN ISO 3740 series or EN ISO 9614 Parts 1-3 must be applied for the determination of the A-weighted sound power level or
- EN ISO 11200–11205 for the determination of the A-weighted emission sound pressure level at the workplace and the C-weighted peak sound pressure level.

The information should be in accordance with EN ISO 4871 and shall be presented as a dual-value declaration featuring measured values and their respective uncertainties.

LIMIT VALUES	**IDLING**	**LOAD/WORKING**	**STANDARD APPLIED**
Sound power level L_{WA} (in dB re 1 pW) Uncertainty K_{WA}	_____dB _____dB	_____dB _____dB	
Emission sound pressure level at the workstation L_{pA} (in dB re 20 µPa) or other specified locations Uncertainty K_{Pa}	1._____dB 2._____dB 3._____dB _____dB	1._____dB 2._____dB 3._____dB _____dB	
1m-surface sound pressure level Lp_A,1m (in dB re 20 µPa)	_____dB	_____dB	
Peak sound pressure level L_{pCpeak} (in dB re 20 µPa) Uncertainty K_{pCpeak}	_____ dB _____dB	_____dB _____dB	

For particular and specific cases, the employer/purchaser/user of a machine may adopt these technical requirements to ascertain their particular needs.

Location of measuring point(s) at workstation and other defined positions:

_____

_____

_____

Operating conditions during noise emission measurement:

_____

_____

_____

Further acoustic details (e.g. tonality):

_____

_____

_____

Further noise control measures:

_____

_____

_____

Additional noise emission values, e.g. determined under specific operating conditions diverging from those described in standards:

_____

_____

_____

Additional information to experts

Considering these different emission quantities, the sound power level L_{WA} is determined by measurement of the sound pressure levels at measuring points located on a measuring surface that envelopes the machine, assuming that the machine is placed in an acoustic free-field.
The measuring surface is normally a parallelepiped or a hemisphere, which envelops the machine at a distance of about 1 metre from its external surface. The average of the measured sound pressure values $\overline{L_{pA}}$ allows us to calculate the sound power level using the following simple formula:

$$L_{WA} = \overline{L_{pA}} + 10\lg\left[\frac{S}{1m^2}\right] \; dB$$

where S is the enveloping measurement surface area.

The above formula can be abreviated to:

$$L_{WA} = \overline{L_{pA}} + L_S$$

This formula demonstrates clearly that the sound power level value of a sound source is always larger in dB than the average sound pressure level value at a distance of 1 metre from the machine surface. Moreover, this formula allows us to calculate the average sound pressure level around a machine, if the sound power level is known, by simply subtracting L_S from L_{WA}. Thus, if we consider for example a sound power level L_{WA} of 93 dB for a vacuum cleaner we can calculate approximately the sound pressure level at a distance of 1 metre around the machine by subtracting approximately 13 dB from the sound power level to give an $\overline{L_{pA}}$ of 80 dB. This requires us to assume that L_S is approximately 13 dB for a typical box-shaped enveloping measuring surface (e.g. a 2m x 2m x 2m cube giving an surface of 20m²).

EQUIPMENT NOISE: ABSTRACT SHEET

Sound power level L_{WA} and sound pressure level L_{pA}

NB: the definitions of these parameters are given in the Glossary.
The relation between these values may be roughly expressed by:

$$L_{pA} = L_{WA} - 10 \lg \left[\frac{S}{1 m^2} \right]$$

where L_{pA} is the average sound pressure level on a surface enveloping, at a distance of approximately 1 metre, a machine radiating omnidirectionally and **S** is the area of this surface.

- As stated in Chapter 1 of this Guide, L_{WA} gives the total amount of airborne noise generated by the source and L_{pA} is the sound pressure level measured at a single point on the enveloping surface.
- When considering **machine noise only** and **excluding environmental influence**, L_{pA} is the **emission** sound pressure level, if the workstation (workplace) is assumed to be located at the measurement surface distance from the source (machine).
- If the measuring point is the operator position, L_{pA} characterises machine noise emission as defined in standards and used as the declared machine emission value.
- Although L_{WA} and L_{pA} are quantities of different nature, both are expressed in dB(A).

However reflections from walls or noise from other machinery must be taken into account, when predicting the ultimate sound pressure level in typical workshops.

From emission sound pressure level L_{pA} to sound exposure level $L_{AEX,T}$

It is important not to confuse machine emission and worker exposure. The influence of various parameters may be expressed as the sum of the following adjustments:

$L_{AEX,T} = L_{pA}$	emission sound pressure level measured according a noise test code
$+ \Delta L_1$	contribution from sound reflections (room influence)
$+ \Delta L_2$	contribution due to operating condition diverging from the one in the noise test code
$+ \Delta L_3$	contribution from the sound power L_{WA} of other machinery in the room
	*(at this point, the resulting sum is the **immission**)*
$+ \Delta L_4$	worker exposure time **T**

CHAPTER 7
Hearing damage and health surveillance

1. DIRECTIVE PROVISIONS

Directive 2003/10/EC[39] lays down its requirements on health surveillance in Article 10:

1. Without prejudice to Article 14 of Directive 89/391/EEC[40], Member States shall adopt provisions to ensure the appropriate health surveillance of workers where the results of the assessment and measurement provided for in Article 4 (1) of Directive 2003/10/EC indicate a risk to their health. Those provisions, including the requirements specified for health records and their availability, shall be introduced in accordance with national law and/or practice.

2. A worker whose exposure exceeds the upper exposure action values shall have the right to have his/her hearing checked by a doctor or by another suitably qualified person under the responsibility of a doctor, in accordance with national law and/or practice. Preventive audiometric testing shall also be available for workers whose exposure exceeds the lower exposure action values, where the assessment and measurement provided for in Article 4(1) indicate a risk to health.

   The objectives of these checks are to provide early diagnosis of any loss of hearing due to noise, and to preserve the hearing function.

3. Member States shall establish arrangements to ensure that, for each worker who undergoes surveillance in accordance with paragraphs 1 and 2, individual health records are made and kept up to date. Health records shall contain a summary of the results of the health surveillance carried out. They shall be kept in a suitable form so as to permit any consultation at a later date, taking into account any confidentiality. Copies of the appropriate records shall be supplied to the competent authority on request. The individual worker shall, at his or her request, have access to the health records relating to him or her personally.

4. Where, as a result of surveillance of the hearing function, a worker is found to have identifiable hearing damage, a doctor, or a specialist if the doctor considers it necessary, shall assess whether the damage is likely to be the result of exposure to noise at work. If this is the case:
   (a) the worker shall be informed by the doctor or other suitably qualified person of the result which relates to him or her personally;
   (b) The employer shall:
   - review the risk assessment carried out pursuant to Article 4;
   - review the measures provided for to eliminate or reduce risks pursuant to Articles 5 and 6;
   - take into account the advice of the occupational healthcare professional or other suitably qualified person or the competent authority in implementing any measures required to eliminate or reduce risk in accordance with Articles 5 and 6, including the possibility of assigning the worker to alternative work where there is no risk of further exposure; and
   - arrange systematic health surveillance and provide for a review of the health status of any worker who may have been previously exposed.

1.1. Health surveillance

Workers must have appropriate health surveillance at all times. Results of assessing and measuring noise and other factors may signal a hearing risk (Article 10 of Directive 2003/10/EC).

- Hearing examinations must be provided when a worker is exposed above upper exposure action values [85 dB(A)].
- Hearing examinations are performed by a medical doctor or another suitably qualified person under the responsibility of a medical doctor.
- Preventive audiometric testing shall be available to workers, whose exposure exceeds lower exposure action values [80 dB(A)], to ensure early diagnosis of hearing loss due to noise.
- The objectives of these examinations are to ensure early diagnosis of any hearing loss due to noise and to preserve the hearing function.

1.2. Keeping health records

Health surveillance shall include keeping individual health records (according to national law and/or practice), which:

- Contain an up-to-date summary of past health surveillance.
- Are available for consultation at a later date.
- Are kept confidential (under a medical doctor's responsibility).
- Are supplied to the competent national authority on request.

39. Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003, on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise), O.J. n° L 42 of 15.02.2003, page 38.

40. 89/391/EEC Council Directive of 12 June 1989, on the introduction of measures to encourage improvements in the safety and health of workers at work, O.J. n° L 183 of 29.06.1989, page 1.

- Are accessible to the individual worker, to whom they relate personally.

Hearing damage shall be identified:

- A medical doctor or another qualified person specified by the doctor shall assess whether hearing damage is likely to be caused by exposure to noise at work. If this is indeed the case:
  - A medical doctor or another qualified person shall inform the worker of the result relating personally to him/her.
  - The employer must advise the worker of suitable preventive measures.

1.3. Employer's duties in the event of hearing damage caused by exposure to noise at work

The employer is required to:

- Review the risk assessment concerning noise exposure.
- Review measures for eliminating or reducing exposure risks and other factors detrimental to hearing.
- Implement measures necessary for eliminating or reducing risk, giving due consideration to the advice of an occupational healthcare professional or another suitably qualified person or competent authority. This includes the possibility of assigning the worker to alternative work, in which there is no risk of further exposure.
- Organise systematic health surveillance and undertake a review of the health status of any worker, who has been similarly exposed.
- Pay special attention to reducing the exposure risk of sensitive population groups such as pregnant women or young employees.
- All actions must be implemented in accordance with national law and/or practice.

2. STRUCTURE OF THE HUMAN EAR

The ear, an organ of the body enabling people to hear sounds, is extremely important for verbal communication in social interaction. The ear is divided into three major parts: the outer ear, the middle ear and the inner ear.

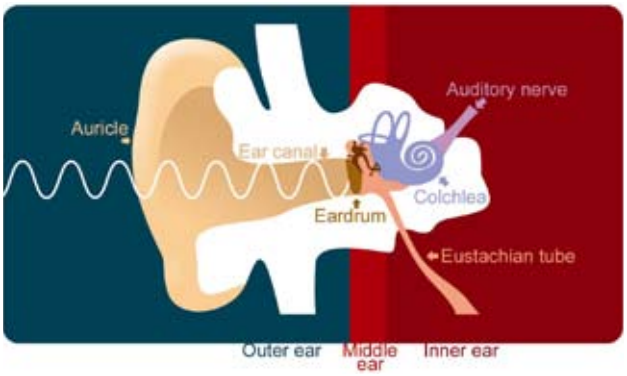


Figure 7.1 Structure of the ear

2.1. The outer ear

The outer ear is the part of the ear, which is commonly known as 'the ear'. The outer ear consists of flaps of skin and cartilage forming the auricle (pinna), the ear canal and the eardrum.

- The pinna collects and modifies incoming sound, which is important for perceiving the distance and direction of the sound source.
- The ear canal is an irregular cylinder, about 25 mm long and 7 mm wide, which conveys sound to the eardrum.

Example:

The ear canal operates as a resonator for frequencies in the 2000 to 5000 Hz range by amplifying the sound vibration by 10 to 15 dB. This means that the ear is most sensitive to high frequencies and is therefore very susceptible to damage from noise in the high-frequency range.

2.2. The middle ear

The outer ear terminates at the eardrum, which forms the beginning of the middle ear. The middle ear comprises a sequence of three small bones – the hammer, anvil and stirrup.

- The hammer pushes the anvil, which in turn pushes the stirrup to convert eardrum vibration into vibration of inner ear fluids.
- The middle ear acts as a sound amplifier. Vibration of the eardrum is very delicate and for high frequency soft sounds, eardrum movement is less that the diameter of a hydrogen molecule. The middle ear amplifies sound by about 20 to 30 dB mainly by modifying the area between the eardrum and the stirrup footplate.

Example:

Without the middle ear, over 99 % of acoustic energy would be reflected and unavailable for hearing sound.

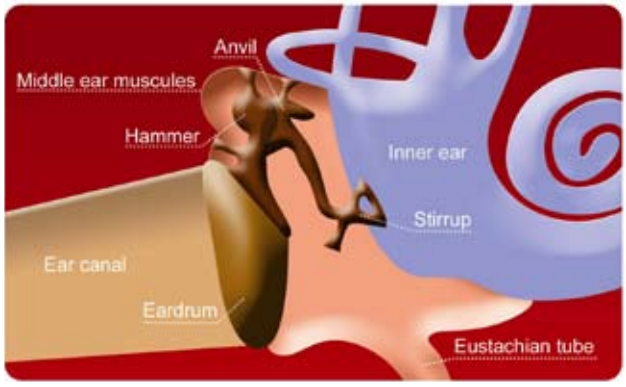


Figure 7.2 The middle ear

- The second role of the middle ear is to protect the hearing system from loud sounds. Middle ear muscles twist the bones and limit the vibration force transferred to the inner ear, when the sound level exceeds 80 – 87 dB. This effect, called the acoustic reflex, protects the hearing system against loud sounds of slowly increasing intensity only for a short time. The acoustic reflex does not intervene effectively for impulsive noise such as gunfire.

2.3. The inner ear

The inner ear, also called the cochlea, is the actual sound receptor and analyser. This organ is no bigger that a fingertip and its structures are so delicate that they are the first parts of the ear to be damaged by noise.

- Over 28,000 hair cells spaced along the cochlear duct are responsible for initiating neural impulses in response to the vibration generated by sound. These cells are of two types: inner hair cells and outer hair cells, which differ in their shape and function. The terms inner and outer hair cell refer to the cell position, which is nearer to the centre of cochlear turn for inner hair cells and is further from the centre of cochlear turn for outer hair cells.
- About 30 to 60 hairs, called stereocilia, project from the top of each inner hair cell and about 100 to 160 stereocilia project from the top of each outer hair cell. Their shearing motion gives rise to neuron discharge.
- About 31,000 neurons contribute to transferring neural spikes to and from the brain along the auditory nerve.

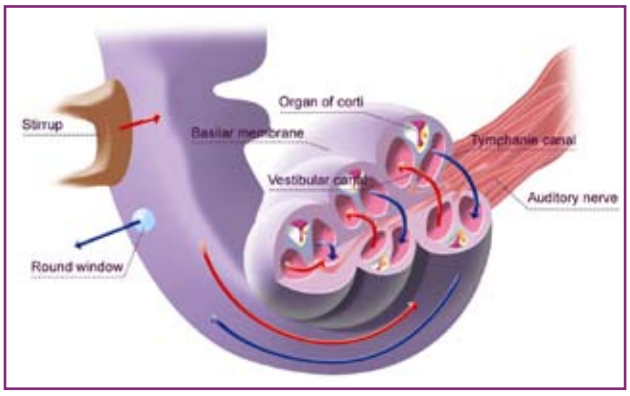


Figure 7.3 Structures of the inner ear

Example:

Displacement of hair cell stereocilia is very small – at the threshold of hearing (0 dB SPL), the movement is as little as 10^{-6} μm, while at the highest levels (approximately 120 dB), this movement amounts to 1 μm.

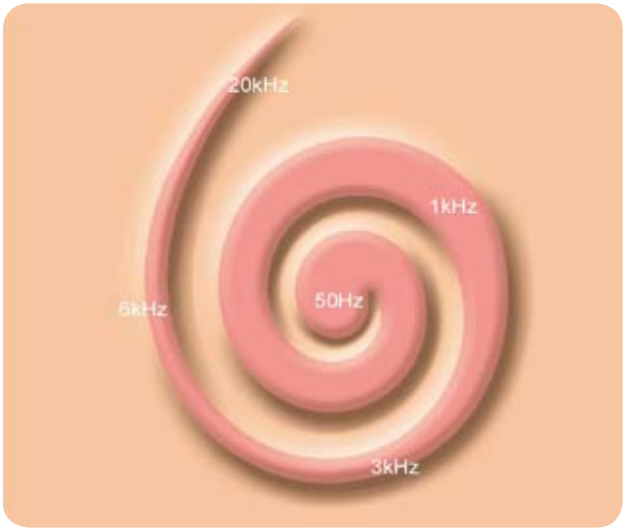


Figure 7.4 Frequency analysis along the cochlea

- Progression of vibration along the inner ear in response to acoustic waves allows us to hear different frequencies, represented by different pitches.
- Fluid vibration in the inner ear sets up a travelling wave, which shakes different groups of hair cells and excites different groups of neurons, depending on the sound frequency. A close relationship exists between frequency and distance within the cochlea, at which excitation is observed.
- The inner ear behaves as a mechanoneural acoustic frequency analyser. Hearing loss at a given frequency is therefore associated with hair cell damage in specific parts of the cochlea.

Example:

The ear is so accurate as a frequency analyser that, at 1000 Hz, we can differentiate sound pitches differing by only 0.1 Hz.

3. EXAMPLES OF DAMAGE TO HEARING SYSTEM

Exposure of the ear to high-level noise causes excessive stimulation of hearing cells, which in turn damages their structures. At sound levels exceeding 87 – 100 dB, hearing cell hairs suffer from fatigue or may break. Major biochemical and physiological changes occur, but these are reversible to some degree.

- Changes become permanent after prolonged exposure to noise at levels exceeding 80 dB (A) or sudden exposure to very high-level noise exceeding 120 dB.

Examples:

Damage to hair cells may kill them. Hair cell damage in a specific region of the inner ear is associated with loss of sensitivity to the sound frequencies received by this region of the ear.

Partial damage to hearing cells leads to the death of hair cells in various parts of the inner ear. This process is very dangerous because a destroyed cell may cause destruction and death of the neighbouring cells due to inflammation.

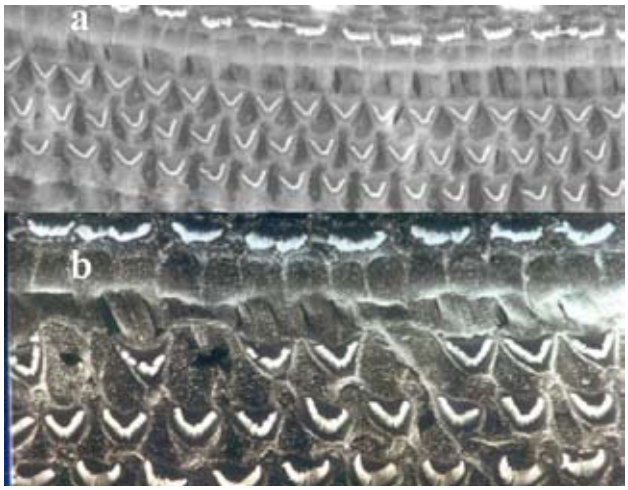


Figure 7.5 Undamaged control hair cells (above) and hair cells (below) damaged due to exposure to high sound level. The first row of outer hair cells is more seriously damaged than the second row. Stereocilia are damaged. Photo © INRS

Ringing in the ears (tinnitus)

- One of the first effects and signs of hearing damage is ringing in the ears (tinnitus). Tinnitus is hearing ringing noises and tones even when no sound is actually conveyed to the ear.

Temporary threshold shift (TTS)

- Over-stimulation of the hair cells results in so-called 'Temporary Threshold Shift' (TTS), which is elevation of the hearing threshold following over-stimulation; it disappears slowly once noise exposure is finished. Elevated threshold is experienced as a feeling of some hearing sensitivity loss and is the first sign of hearing system fatigue due to noise.

Example:

Threshold elevation starts at noise levels exceeding 80 dB. It is tens of minutes or even hours before the ear recovers.

Permanent threshold shift (PTS)

- After prolonged or repeated exposure to loud noise, the threshold elevation turns into a 'Permanent Threshold Shift' (PTS). Permanent hearing threshold elevation constitutes hearing loss.
- Total deafness, which occurs when both inner and outer hair cells disappear, also causes nerve fibre degeneration.

4. EXAMPLES OF DAMAGE TO HEARING SYSTEM BY OUTSIDE AGENTS

Chemicals, solvents, and medical drugs causing temporary or permanent hearing damage to hearing are called ototoxins.

- Many industrial solvents are ototoxic.
- Chemicals are usually inhaled or absorbed through the skin to reach the inner ear through the blood system.
- Damage to hearing occurs by damaging hair cells (especially outer hair cells) or neural pathways associated with hearing.
- Chemicals and solvents known to cause damage to hearing include: trichlorethylene, xylene, styrene, toluene, hexane, and carbon disulfide. Damage to the inner ear is also caused by carbon monoxide, which causes general hypoxia in the body.

The combined effect of ototoxic chemicals and noise exposure is particularly damaging to hearing. The presence of chemicals causes an abnormal condition of the inner ear, making it especially vulnerable to noise-related mechanical damage.

- Chemicals such as toluene, styrene, trichlorethylene, ethyl benzene, hydrogen cyanide and carbon monoxide interact synergistically with noise; they augment the damaging effect of noise on the hearing system. Exposure to solvent mixtures appears to potentiate the damaging effect on the auditory system.

The use of some medicines may also produce ototoxic effects.

- People taking medicines known to have a detrimental effect on hearing shall not be exposed to noise. Medicines affecting hearing include certain antibiotics, cancer treatment drugs, diuretics and quinines. Medicines and noise have no proven combined synergetic effect on hearing, although the individual effects of many medicines on hearing is well documented.

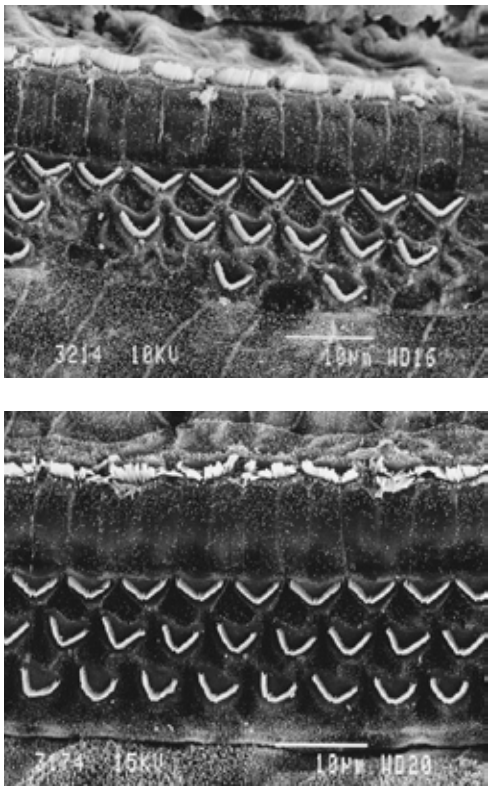


Figure 7.6 Undamaged control cells (above) and hair cells (below) damaged due to exposure to solvents (toluene). The third row of outer cells is more damaged than the second row. Stereocilia look the same as in their initial state. Photo © INRS

Example:

Chemical agents acting synergistically with noise to cause hearing loss and typical industries concerned (non-exhaustive list).

Chemical agent	Industry
Trichlorethylene	Industry metal degreaser
Xylene	Chemical, petroleum, transportation, painting
Styrene	Many manufacturing industries (especially food, chemical, rubber and plastics, etc.), trade, services, transportation, construction
Toluene	Painting industry, rubber and plastic, printing industry
Hydrogen cyanide	Extraction, electroplating, chemical, steel, metalwork, manufacturing (synthetic fibres, plastics, dyes, pigments, nylon)
Carbon disulfide	Textile, agriculture
Lead	Mining, electric
Carbon monoxide	Transport (combustion engines), fire fighting, steel, metalworking, pulp & paper

4.1. Interaction between noise and vibration

Scientific studies show that both hand-arm vibration and whole-body vibration cause interactions with noise. However, exact dose-response relations are not available for these interactions, and to ensure preventive measures the Directive 2002/44/EC[41] on 'Vibrations' established limit values and action values. [Further research is necessary to determine dose and response relations.]

For example, workplaces involving HGV drivers at construction sites featuring whole-body vibration exposures above the exposure limit value given by to ISO 2631-1:1997 (a_w = 0.8 m/s^2) cause interaction between noise and whole-body vibration and in turn a higher risk of hearing loss (approximately 3 dB) than noise exposition excluding whole-body vibration.

41. Directive 2002/44/EC of the European Parliament and of the Council of 25 June 2002, on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibrations), O.J. n° L 177 of 06.07.2002, page 13.

4.2. Provision for health surveillance based on interaction between noise and work-related ototoxic substances and vibration

To ensure prevention measures despite insufficient scientific knowledge of dose-response relations, some experts advise lowering health surveillance (audiometric tests) action values in the case of combined exposure to noise and ototoxic substances or to noise and vibration.

5. EFFECTS OF HEARING SYSTEM DAMAGE

Consequences of damage to the inner ear are numerous.

Elevation of hearing threshold

- Elevation of hearing threshold is loss of sensitivity to sounds at specific frequencies. There are various types of hearing loss. However, the most commonly observed hearing loss is experienced as a result of exposure to industrial noise in the 2 – 6 kHz frequency range; so-called 'high-frequency sloping hearing loss'.

Example:

Elevation of hearing threshold due to hearing loss.

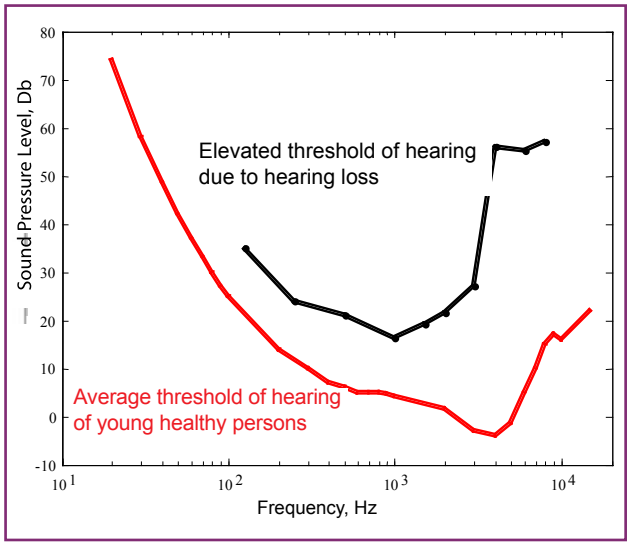


Figure 7.7 Elevation of hearing threshold due to hearing loss

Increase in loudness sensitivity

- Threshold elevation causes abnormal growth in the feeling of sound loudness. A person with normal hearing experiences loudness over a wide range (90 dB) of sound levels. Sound is barely audible at 10 dB SPL, but it is unpleasantly loud at 100 dB SPL. For a 50 dB hearing loss, this range will decrease to approximately 40 dB. In this case, 60 dB SPL sound is barely audible, but is unpleasantly loud at 100 dB as in the case of normal hearing.

Examples:

Increase in loudness sensitivity makes it very difficult to properly understand speech. It also causes a major distortion in music perception.

Decrease in frequency selectivity

- Hearing loss can cause a decrease in frequency selectivity – the ability to distinguish sounds of different frequencies. A normal ear behaves like a well-tuned frequency-receiver of different frequency sounds. Loss of frequency selectivity means that sounds or parts of sounds at various frequencies are mixed up. The sounds mask each other even when their frequency is very different.

Difficulty in following time-related sound variations

- Sound, especially speech, is dynamic, i.e. sound level varies continuously with time. Hearing loss is associated with the impaired ability to follow time-related sound variations. Sound perception is therefore blurred.

Example:

Mixing up different frequency sounds and impairment in following time-related sound variations makes speech comprehension very difficult. This is one reason why people with impaired hearing find it difficult to understand speech on social occasions, especially when many people are speaking simultaneously.

Difficulty in sound source localisation

- A decrease in frequency selectivity, difficulties in perceiving time-related sound variations and an increase in masking make it difficult to detect, identify and localise sound sources.

Ringing in the ears (Tinnitus)

- People with impaired hearing may experience ringing in their ears (tinnitus). This condition is caused by localised damage to inner ear structures, thereby altering auditory nerve activity. This means that sound is perceived, when none is being conveyed to the ear. Tinnitus is experienced through ringing noises and tones at mid- or high frequencies.

Example:

In extreme cases, subjective noise may last 24 hours a day, 7 days a week. Around 20 % of the population experience tinnitus to some degree, and 4 % experience this disorder permanently.

6. EXTRA-AURAL EFFECTS OF NOISE

Many undesirable effects of noise may be produced even at noise levels and exposures innocuous to the inner ear. These include the following:

- Interference with speech communication (misunderstanding leading to wrong decisions).
- Interference with task performance (decrease).
- Annoyance.
- Stress.
- Difficulty in detecting and recognising danger and warning signals.
- Interference with sleep and reduced sleep quality.

People differ drastically in the degree of annoyance they experience. Annoyance depends on the level and duration of single noise events as well as their pattern of intermittence or frequency content. Appearance of irritation and stress can vary between individuals depending on subjective conditions. Annoyance, irritation and stress cannot be measured and related to an exceeding of specified noise levels.

Noise levels may also produce certain physiological changes, including the following:

- Increased heart rate.
- Increased blood pressure.
- Narrowing of blood vessels (vasoconstriction).
- Eye pupil dilation.
- Adrenalin secretion.
- Startle effect.

Noise levels may affect safety because they are likely to interfere with warning information:

- Danger signals may be masked.
- Information provided by a colleague or loudspeaker may become incomprehensible.

7. AUDIOMETRIC TESTING

7.1. Air and bone conduction

The standard health surveillance aid to noise-induced hearing loss is audiometric testing, which can be used to detect early damage resulting from exposure to noise.

- Audiometric testing in a soundproof room is conducted on a worker, who has not been recently exposed to noise.
- The quiet rest period before testing shall last for at least 12 hours.
- Audiometric testing is conducted for a number of tone frequencies in the 125 – 8000 Hz range.
- Standard testing is carried out using an earphone (air conduction), corresponding to the normal method of sound conveyance to the ear. Another testing method involves using a bone vibrator (bone conduction), from which the sound is conveyed to the ear through skull tissues and bones.
- Comparing bone conduction with air conduction enables us to check the condition of the inner ear.

7.2. Speech audiometry

If significant hearing loss is detected, additional tests, such as speech recognition, may be conducted.

- Their role is to assess the ability of the person with impaired hearing to maintain normal social contact though speech.
- Difficulty in verbal communication usually occurs when hearing loss exceeds 40 dB.

7.3. Schedule for audiometric testing

People employed in environments in which there is a risk of hearing damage, shall be audiometrically tested (Article 10 of Directive 2003/10/EC), when starting employment and at suitable intervals during their working lives.

- Normally, this test is repeated after the first 12 months to determine whether an individual is highly susceptible to noise; it is then re-administered every three years.

- Hearing shall also be checked every time sudden hearing damage could occur, e.g. after explosions.

The frequency of the audiometric testing can be adjusted to the level of the exposure.

7.4. Indication of an impairment of hearing or an incipient amblyacousia

As a general rule, amblyacousia develops slowly extending over several years. Furthermore, the process of hearing is very complex and to a certain extent weaknesses of the sense organ 'ear' to transform audible signals into corresponding stimuli of the nerves can be compensated by the subsequent intelligent converting. Therefore, at the beginning, the development of amblyacousia normally proceeds unnoticed.

One of the first indications of an impairment of hearing or amblyacousia is called the 'party effect'. If it is it difficult for someone to follow a single conversation, for example at a party where there are many conversations held in parallel, this can be an indication of an incipient amblyacousia even if there should not be any problems yet with listening to a conversation which is held alone.

Further indications of an impairment of hearing or an incipient amblyacousia could be:

- to miss the ringing of the telephone or the door bell;
- to miss warning signals (e.g. forklift, bell of a bicycle);
- to listen to the radio or to watch the television on (nearly) full blast.

8. HEARING LOSS INDICATORS

Hearing level

- In clinical standards and practice, hearing loss is expressed in decibels HL (hearing level), which indicates the elevation of hearing threshold above normal hearing, a value determined for young healthy people.
- For instance, a hearing level of 40 dB HL at a frequency of 2,000 Hz means that the worker's hearing threshold is 40 dB higher than normal for this frequency.

Premature hearing loss

- In the early stages, hearing loss due to noise develops at frequencies of 4 – 6 kHz. Common practice therefore involves curtailing costs by recommending an audiometric test in a limited 1 – 6 kHz frequency range.
- Hearing loss greater than 40 dB HL usually requires medical treatment.
- Hearing loss greater than 60 dB HL is considered severe and the person will require a hearing aid for verbal communication.

The aging process

- When assessing noise-induced hearing loss, we must take into account the normal decrease of hearing sensitivity due to age (presbyacusis).
- For people over 50 years of age, more rapid deterioration in hearing than for younger people has been documented.
- Presbyacusis is gender-specific; it is normally more acute in men than in women.

Example:

Hearing loss.

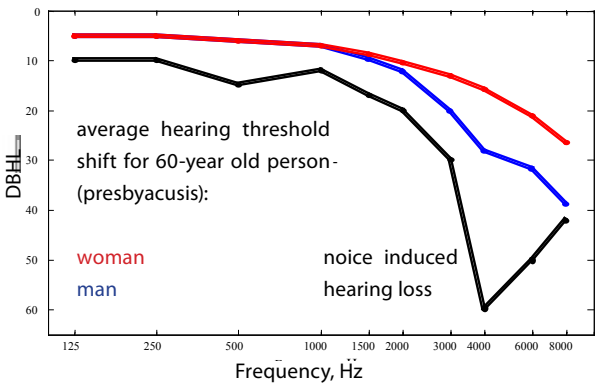


Figure 7.8 Age-related hearing loss and noise-induced hearing loss

Percentage hearing loss

- A percentage hearing loss is calculated for financial compensation purposes. Various methods exist, based on average hearing loss in dB HL for audiometric frequencies of 500, 1000 and 2000 Hz, which are usually applied to the better ear, but can be used for both ears. The above three frequencies are selected because of the significant influence of hearing loss on speech recognition in the frequency 500 – 2000 Hz frequency range.

CHAPTER 8
The Music and Entertainment Sectors

1. DIRECTIVE REQUIREMENTS

Article 14 of Directive 2003/10/EC[42] requests: **'***In the context of the application of this Directive Member States shall draw up in consultation with the social partners, in accordance with national law and practice, a code of conduct providing for practical guidelines to help workers and employers in the music and entertainment sectors to meet their legal obligations as laid down in this Directive*.**'**

It should be underlined that Directive 2003/10/EC lays down minimum health and safety requirements regarding the exposure of workers to the risks arising from noise within the meaning of Article 3 *'Definitions'* of the Framework Directive 89/391/EEC[43]:

(a) **'Worker'**: any person employed by an employer, including trainees and apprentices but excluding domestic servants' and

(b) **'Employer'**: any natural or legal person who has an employment relationship with the worker and has responsibility for the undertaking and/or establishment.'

2. OTHER CONSIDERATIONS

Due to the particular specificities of the music and entertainment sectors, many musicians/crew members work as freelance staff and can consider themselves self-employed. This group of workers are not covered by the Directive 2003/10/EC but Council Recommendation 2003/134/EC[44] concerning the improvement of the protection of the health and safety at work of the self-employed workers should be applicable to them. In this case the hereunder suggested measures can also be considered.

42. Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003, on the minimum health and safety requirements regarding the exposure of works to the risks arising from physical agents (noise), O.J. n° L 42 of 15.02.2003, page 38.

43. 89/391/EEC Council Directive of 12 June 1989, on the introduction of measures to encourage improvements in the safety and health of workers at work, O.J. n° L 183 of 29.06.1989, page 1.

44. 2003/134/EC Council Recommendation of 18 February 2003, concerning the improvement of the protection of the health and safety at work of self-employed workers, O.J. n° L 53 of 28.02.2003, page 45.

3. INTRODUCTION: WHY A SEPARATE CHAPTER? SPECIFIC RISKS AND PROBLEMS

The music and entertainment sectors are unique in that high sound levels and special effects loud enough to cause hearing damage are often regarded as elements essential to performance.

The speciality of sounds both live and recorded in this sector is that it is in essence the very own product that may be harmful. Relevant sound levels are not an unwanted secondary effect but to some degree are expected by the audience. Nevertheless, this special working product can directly put a risk on workers' and performers' most important tools – their ears.

The Noise Directive 2003/10/EC specifies the minimum requirements for the protection of workers from the risk to their health and safety arising, or likely to arise from exposure to noise at work. Risk assessments of the work activity should identify those workers who may be exposed; these will include musicians and other performers, technical staff and others working directly in the music and entertainment sectors (see Table 8.1). For example, ushers, security, front of house and catering staff, etc., depending on their location and length of time spent in the noisy entertainment.

4. A LIST OF WORKERS LIKELY TO BE AFFECTED IN THE MUSIC AND ENTERTAINMENT SECTORS

The 'Noise' 2003/10/EC Directive applies to **ALL** premises where workers are present, where live (whether amplified or not) or recorded music is being played for entertainment purposes. Where the exposure levels as set down in the Directive 2003/10/EC may be exceeded, the appropriate actions should be taken. Anyone whose activity may result in a noise hazard has a responsibility to him/herself or to anyone else who may be affected.

A combination of different measures may be required in order to find the best way to avoid or reduce sound exposure levels in the particular circumstances being encountered. When examining possible measures factors such as types of instruments being played, the number and positions of players, whether amplification is being used, whether workers are or have been working already at other premises that day (at home, in a rehearsal studio, teaching in class, etc.), the acoustics of the venues and the noise associated with stunts and effects should all be considered. Several different controls or a combination of measures may have to be tried to find the best way to avoid or reduce sound exposure levels as each measure may itself have implications for others in a variety of ways.

- Serious risks of hearing damage exist for workers in the music and entertainment sectors who regularly have to work in noisy environments such as clubs, discotheques or at live concerts. The scope of affected workers concerned include musicians and other performers, disc jockeys (DJs), service staff, technical staff, security staff, first-aid workers, cashiers and others.

These workers are often exposed to sound levels exceeding the *'exposure limit values'* indicated in Article 3 of Directive 2003/10/EC. Hence, what is a pleasure and almost harmless for consumers at a single event may be an occupational hazard for workers due to their repeated long-term exposure.

In the following situations:

- **In the case of orchestral musicians**:
  The most directly affected from music sound are musicians themselves.

  Depending on the instrument and the location and taking into account the additional exposure arising from individual's training, rehearsals or warm up sessions, a typical exposure level of an orchestral musician reaches 80-95 dB(A).

- **In the case of rock and pop musicians**:
  High sound pressure levels in rock and pop music are predominantly desired and expected by the audience. As a result significant on stage sound levels are commonplace. Sound pressure levels for rock and pop musicians are in the range of 95-110 dB(A).

- **In the case of jazz and folk musicians**:
  For musicians in the genre of jazz and folk music the sound pressure levels are usually a bit lower within a span of 90-98 dB(A).

- **In the case of other workers**:
  Similar noise exposures have been measured for sound engineers, security or other service staff at live concerts.

- **In the case of workers of discotheque and disk jockeys (DJs)**:
  The employees of discotheques or comparable live events are exposed to high sound levels as well. The sound pressure levels on dance floors are often over 100 dB(A). While disk jockeys (DJs) are exposed to levels of 95-100 dB(A), the sound pressure levels of the service staff are 90-95 dB(A). Despite working times of less than 20 hours per week, exposure levels of 96 dB(A) for DJs and 92 dB(A) for service staff have been assessed.

Noise induced hearing loss and other disorders not only affect the enjoyment of music, but may threaten a worker's career, for it first affects the precision of hearing. In addition to loss of hearing, other disorders may include tinnitus, hyperacusis and difficulties in pitch perception.

Workers in the music and entertainment sectors are expressly included in the Directive 2003/10/EC. Different personnel working in these sectors (i.e. employers, workers, supervisors in charge and in control of workplaces, etc.) shall be involved in avoiding risks arising from noise or reducing it to a minimum. The main challenges in doing this are adequate risk assessments and the implementation of appropriate noise prevention measures. Both require the application of suitable strategies as recommended in Chapter 8, Section 6 of this Guide.

5. WHO MAY BE AT RISK?

Table 8.1 below is not an exhaustive list of workers potentially exposed to noise in the music and entertainment sectors:

• Acrobats and gymnasts	• PA providers
• Actors	• Pit orchestras
• Aerobic instructors	• Opera singers
• Artistic directors	• Orchestra porters
• Audio engineers and assistants	• Piano technicians
• Backline technicians	• Producers
• Bar staff	• Production companies
• Child Performers	• Promoters
• Choirs	• Projectionists
• Choreographers	• Set designers
• Classical music ensembles	• Singers
• Composers	• Sound designers
• Conductors	• Sound engineers
• Crew	• Sound equipment operators/ suppliers
• Crowd Managers	• Special effects designers/ personnel
• Dance instructors	• Staff (including managers, bouncers and waiters/ waitresses)
• Dancers	• Stage bands
• Disc Jockeys (DJs)	• Stage crew/technicians
• Door supervisors	• Stage management
• Engagers	• Stage workers (such as carpenters, props builders, electricians and welders)
• Entertainers	• Stewards
• Event organisers	• Studio owners/operators
• Fixers	• Technical directors
• Front of house staff	• Musical education personnel
• Groups such as pop, rock, jazz, folk and country	• Ushers
• Instrument technicians	• Venue managers/owners
• Jazz musicians	• Video technicians
• Lighting designers	• Recording engineers
• Lighting crew/engineers/ technicians	• Refreshment staff
• Managers	• Riggers
• Marshals	• Security personnel
• Monitor engineers	• Vocalists
• Musical directors	• Service staff
• Musicians	
• Music instructors & those involved in musical education	

Table 8.1

6. STRATEGIES FOR REDUCING NOISE EXPOSURE LEVELS

This section describes some strategies for avoiding and/or reducing the exposure of workers to the risks arising from 'Noise' in the music and entertainment sectors. Taking into account the diversity of workplaces in these sectors, several strategies may have to be used according to individual situations and circumstances. In order to cope with this diversity this section distinguishes five basic strategies which cover most types of activities and workplaces in this field. The suitable procedure will depend on the role taken in the music and entertainment sectors and the nature of the respective activity. Different strategies could be applicable at the same time.

The main criteria for choosing a suitable strategy:

Are you an employer or a worker?

If you are an employer, are your workers performers or non performers (service, technical staff, etc.)?

The areas to be examined are:

- Place of work: one or more locations;
- Rehearsals: quieter overall level or reduced exposure to sound levels;
- Repertoire: mixture of repertoire, i.e. loud and quiet repertoire;
- Scheduling of performances: balanced scheduling of performances/rehearsals (loud and quiet repertoire);
- Layout: layout of performers in performance areas.

In the field of safety and health at work it is necessary to underline that Section II *'Employers' obligations'* of the Directive 89/391/EEC laid down employer's general obligations and to which explicit reference is made in Section II 'Obligations of employers' of the Directive 2003/10/EC which laid down the employer's obligations as follows:

- Art. 5 of Directive 89/391/EEC – *'General provision'*
- Art. 6 of Directive 89/391/EEC – *'General obligations on employers'*
- Art. 4 of Directive 2003/10/EC – *'Determination and assessment of risks'*
- Art. 5 of Directive 2003/10/EC – *'Provisions aimed at avoiding or reducing exposure'*
- Art. 6 of Directive 2003/10/EC – *'Personal protection'*
- Art. 7 of Directive 2003/10/EC – *'Limitation of exposure'*

Strategies for Occupational Groups					
Occupational Group	**Employers Venue operator**	**Employers Entertainment providers**	**Employers of service staff**	**Employers Provider or operator of sound amplification equipment**	**Workers**
Example	Operators, managers of bars, discotheques Theatre managers Concert organisers Promoters Event/Entertainment organisers Concert hall managers	Bandleaders Orchestra managers Ensemble leaders	Providers of: Catering Security Cashier services First aiders	Rental or retailer of sound systems Operators of sound equipment at an event	Musicians and other performers Music teachers Service staff (such as cashiers, security, first aiders) Technicians Catering
Strategy	**1**	**2**	**3**	**4**	**5**

Table 8.2 Noise management strategies for different occupational groups in the music and entertainment sector

- Art. 8 of Directive 2003/10/EC – *'Worker information and training'*
- Art. 9 of Directive 2003/10/EC – *'Consultation and participation of workers'*

The answers to these questions will help you choose an appropriate strategy from Table 8.2 *'Noise management strategies for different occupational groups in the music and entertainment sector' (see Table 8.2).*

Strategy 1: Employers – Venue operator

Who is concerned?

You are the employer, venue operator of a bar, discotheque, theatre or concert hall. You possibly employ service staff who are not directly involved in the musical performances, such as serving staff or cashiers.

or

You are a concert hall manager or event/entertainment organiser.

What to do?

As an employer, venue operator and according to the Section II of Directive 2003/10/EC *'Obligations of employers'*, you shall:

- Assess and, if necessary, measure the levels of noise to which workers are exposed.
- Develop and implement health and safety prevention measures to protect workers against risks from noise.
- Taking account of technical progress and of the availability of measures to control the risk at source, the risks arising from exposure to noise shall be eliminated at their source or reduced to a minimum.
- Be informed about regulations and technical standards.
- Be informed about the contents of this guide and make them available for information purposes to your workers and promoters, ensuring that they are involved at all levels. (See Article 14 of Directive 2003/10/EC *'Code of conduct'*).
- Involve all levels of the organisation so that they understand their obligations and comply with the health and safety policy. (See Article 9 of Directive 2003/10/EC *'Consultation and participation of workers'*).
- Provide part-time workers/casual workers or new staff with adequate information.
- Ensure that consultation and participation of workers and/or their representatives takes place in accordance with Article 11 of Directive 89/391/EEC on the matters covered by Directive 2003/10/EC, in particular:
  - The assessment of risks and identification of measures to be taken, referred to in Article 5 of Directive 2003/10/EC.
  - The actions aimed at eliminating or reducing risks arising from exposure to noise, referred to in Article 5 of Directive 2003/10/EC.
  - The choice of individual hearing protectors referred to in Article 6, paragraph 1 (c) of Directive 2003/10/EC.
  - Coordinate with entertainment providers, employers of service staff, providers or operators of sound equipment to ensure that workers from outside undertakings and/or establishments engaged in work in their undertaking and/or establishment have in fact received appropriate instructions regarding health and safety risks during their activities in their undertaking and/or establishment (Article 8 of Directive 2003/10/EC 'Worker information and training' referring to Article 12, paragraph 1 of Directive 89/391/EEC 'Training of workers').

Risk assessment and sound level

As an employer, venue operator you can apply the following procedures to identify harmful sound exposures:

- Establish the situations and areas where high sound levels may arise. As a rule of thumb if individuals at a distance of one metre can only communicate if they raise their voices, this will likely be the case.
- Be informed of the expected sound levels of the 'works' to be performed. When no data or information is available on the music to be played, have sound level measurements conducted by a skilled person during a typical event.
- Add the data of the expected sound levels of the works played during a day or week in order to be able to calculate the time-weighted exposure on the basis of the average eight-hours daily or five eight-hour weekly work.

Reduce exposure

If your workers' exposure levels are too high, consider reducing the sound levels by:

- Lowering the sound level of your performance as far as practicable (in consultation with promoters and health and safety specialists and safety representatives).
- Limiting the exposure time(s).
- Reducing the volume of individual instruments, e.g. percussion, trumpet, etc.
- Providing information available on noise exposure limit values and exposure action values to promoters and workers.
- Reducing the volume of the sound equipments, e.g. use of smaller amplifiers to lower the sound level on the stage.

Reduce the sound levels by technical measures and room acoustic improvements

- Wherever possible you can reduce the exposure to sound by increasing the distance between non-performing workers and the stage or by repositioning loudspeakers.
- Where there are arrays of loudspeakers, such as in discos or concerts, reduce as far as possible the sound level of those loudspeakers near to workers. Consider incorporating several loudspeakers directly above a dance floor (See Figure 8.1).
- Install sound level limiters in amplifier systems.
- Install appropriate acoustic shielding of service areas, such as offices, kitchen, recreation rooms and administrative zones by the use of walls and doors with adequate acoustic characteristics.
- Line doors to service areas with noise-insulating material. Raise the transmission losses by increasing the acoustic absorptive materials of rooms by fitting acoustic ceilings, walls and claddings (e.g. wall coating).
- By providing appropriately designed concert stages and orchestra pits, the sound level to which musicians are exposed can be reduced without affecting the sound quality in the auditorium.
- Use technical measures wherever possible to make changes to performance areas, e.g. orchestra pits.
- Seek specialist advice from acoustic engineers and architects.

NB: *When renovations are performed, devise a health and safety prevention plan with acoustic engineers and architects to ascertain how the acoustic characteristics of venues or rehearsal rooms can be properly optimised.*

Consider organisational measures to reduce noise exposure

- Identification and marking of areas with appropriate signs where 'upper exposure action values' $L_{EX,8h}$ = 85 dB (A) or ρ_{peak} = 140 Pa [peak levels of 137 dB(C)] are likely to be exceeded and prohibit access from people not wearing suitable hearing protectors.
- Reduce exposure levels by shortening the time in which workers are exposed to high sound levels; this can also be done by rotating service staff from noisy to quieter areas also point out to agencies their duty to take care of the health and safety of workers.

Obligations

In particular, employers, venue operators must fulfil the following obligations:

- After the risk assessment, provide prevention measures to avoid or reduce to a minimum the exposure of workers to high sound levels.
- Provide information, training and instructions on the preservation of hearing and on the availability and use of prevention measures such as collective measures or personal hearing protectors. Ensure that written information is available on these issues.
- Mark noise areas [if $L_{ex,8h}$ > 85 dB(A)] where workers are likely to be exposed to noise exceeding the 'upper exposure actions values' as requested in the Article 5 of Directive 2003/10/EC.
- A worker whose exposure exceeded the 'upper exposure action values' [$L_{ex,8h}$ > 85 dB(A)] shall have the right to have his/her hearing checked by a doctor or by another suitable qualified person under the

responsibility of a doctor, as requested in the Article 10 of Directive 2003/10/EC.
- Preventive audiometric testing shall also be available for workers whose exposure exceeds the 'lower exposure action values' [Lex,8h > 80 dB(A)], as requested in the Article 10 of Directive 2003/10/EC.
- If sound exposure cannot be reduced sufficiently by practicable technical and organisational measures, employers must provide appropriate hearing protectors to workers, taking into account that this applies both for musicians or other performers, technical and service staff, as requested in the Article 6 of Directive 2003/10/EC. There are special hearing protectors for musicians with a flat frequency response.
- Then you must provide instructions/training to workers on correct use of personal hearing protectors, as requested in the Article 8 of Directive 2003/10/EC.

Example: Discotheque

Problem: A discotheque presents recorded music by different disc jockeys (DJs) every night. Before the renovation, the sound system consists of two main loudspeakers near the dance floor and others throughout the room giving an extensive sound exposure to the DJs, bar and glass collection staff.

Solution: The owner (employer, venue operator) of the discotheque installed a sound ceiling with built in speakers suspended above the dance floor. This results in high sound levels on the dance floor while the sound propagation sideways into the rest of the room is lowered/reduced by around 10 dB(A). In order to maintain the reduced music level, a sound level meter is installed near the DJ´s desk to monitor and to record the sound levels. If a collective solution cannot be provided (i.e. isolated cabin), the owner must provide personal hearing protectors and implement an appropriate training programme for the staff concerned.

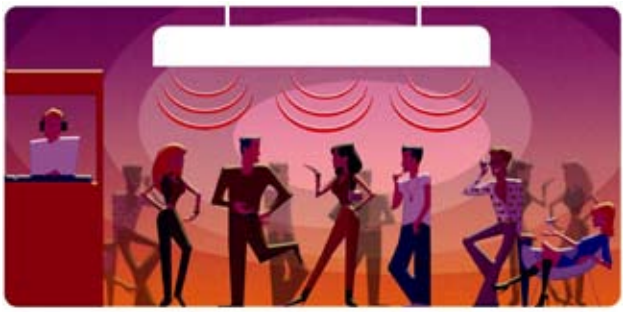


Figure 8.1 Discotheque with acoustic ceiling incorporating several loudspeakers instead of two main loudspeakers

Strategy 2: Employers – Entertainment providers

Who is concerned?

You are an employer, entertainment provider and for example:

- You manage a band, an orchestra or some other ensemble;
- You equally organise musical events, you employ musicians and other performers.

NB: *Musicians and other performers should refer to Strategy 5: 'Workers'.*

What to do?

In general, as an employer, entertainment provider, and according to Section II of Directive 2003/10/EC 'Obligations of employers', you shall:

- Assess and, if necessary, measure the levels of noise to which workers are exposed.
- Develop and implement health and safety prevention measures to safeguard band, orchestra and/or other ensemble against harmful sound exposure (noise).
- Taking account of technical progress and of the availability of measures to control the risk at source, the risks arising from exposure to noise shall be eliminated at their source or reduced to a minimum.
- Ensure that all workers involved and/or their representatives in the entertainment are informed relating to risks resulting from exposure to noise and on the health and safety prevention measures to be taken in order to eliminate or reduce to a minimum the risks from noise.
- Be familiar with statutory regulations and fulfil employer obligations with regard to worker protection against risks from noise exposure.
- Be familiar with the contents of the present guide and follow its recommendations.
- Communicate these matters to performers, technical staff and other workers involved.
- Ensure that all those involved in the entertainment are informed of the health and safety prevention strategy.

Risk assessment and sound level

As an employer, entertainment provider you can adopt the following procedure to identify workers' risks from exposure of workers to noise:

- Firstly, the employer, entertainment provider may identify the risk, and may assess whether the workers' levels of noise exposure during the performance is harmful. Rule of thumb: if individuals at a distance of one metre can only communicate if they raise their voices, this will likely be the case.
- If necessary, measure the exposure noise level of a typical performance under normal conditions. Note the relevant suggestions given in Chapter 2 'Risk assessment procedure' of this Guide. Also make contact with the venue operator and endeavour together to obtain measurements of the sound level, where relevant, to reduce noise.
- Determine the exposure noise level of performers and other staff.
- Carry out a new risk assessment if there are significant changes in the nature of the musical instrument(s) used, the sound equipment (e.g. amplifiers), or in the performance.
- Clarify with the venue operator whether a maximum sound level has been agreed and what sound level is desired. (See Article 3 of Directive 2003/10/EC 'Exposure limit values and exposure action values').
- Do not exceed this agreed sound level.
- Notify the venue operator before the event about the typical sound level of your performance.
- Monitor or record the sound level during the event.

Reduce exposure:

a) Acoustic screens

Employers need to take into account potential problems if they are considering installing screens, e.g.:

- Lack of space: screens can reflect sound back at the performers seated behind and nearby.
- Screens may produce distortion.
- Screens may make it difficult for performers to hear other instruments.

b) Use of screens

Acoustic screens should only be used in accordance with the risk assessment and on a collective basis.

In some circumstances musicians may be able to use acoustic shields to protect themselves from sounds made by other musicians. However, proper training should be given on the use of acoustic shields as misuse can cause more damage not only to the user but to other surrounding musicians.

Extreme care is required when positioning acoustic screens as they can double the noise exposure of the player to the ear, as well as increasing the risk of an overplaying injury. The protection afforded to the player in front may prove to be more psychological than acoustic although this may be worthwhile where the risks of hyperacusis or stress are significant. The indiscriminate use of personal screens can actually increase noise exposure for others, so screens need to be introduced on a collective basis. It is not acceptable to slightly reduce a medium risk (e.g. to the person in front of a screen) by doubling a high risk (e.g. the person playing into the screen).

Figure 8.2 Transparent acoustic screen for use by orchestras or major bands. Modern materials can be transparent and absorbing.
(© & courtesy by 'Kaefer Isoliertechnik', Germany)

There are currently two main types of screen construction, hard (acoustically reflective) and soft (acoustically absorbent). There is a hybrid third type which combines both the hard and soft types.

Hard screens are mostly made from plastic or similar transparent material to maintain visual contact. Soft screens comprise an acoustically absorbent material (e.g. mineral fibre, foam, foils, etc.) mounted on a panel and covered in a decorative finish.

Screens can be relatively small and discretely placed to deal with localised specific issues. Studio screens are usually 2m high and can be used to form enclosures. These are normally absorbent and can include transparent vision panels.

NB: *When using individual personal screens refer to Chapter 5 on 'Personal protective equipment (PPE): characteristics and selection of personal hearing protectors (PHP)' of this Guide.*

Exposure limitation

The following options can be used for reducing the sound exposure of workers:

- Reduce the sound level of your performance as far as possible.
- Reduce the sound amplification equipment on the stage to a practicable degree.
- Inform and train staff controlling the sound amplification equipment (for monitors and audience).
- Lower the volume of individual instruments (e.g. drums), or use smaller amplifiers to reduce the sound level on stage.
- Increase the distance between the performing workers and the loudspeakers.
- Areas in which workers and personnel are likely to be exposed to sound (noise) exceeding the 'upper exposure action' value [$L_{EX,8h}$ > 85 dB(A)] or exceeding the peak level [ρ_{peak} > 140 Pa ~ 137 dB(C)] shall be marked with appropriate signs. The areas in question shall also be delimitated and access to them restricted where this is technically feasible and the risk of exposure so justifies.
- Prohibit persons without appropriate hearing protectors from entering those areas.
- The rehearsal rooms/performing areas for musicians should be of an adequate/appropriate size and have suitable acoustic characteristics (See Strategy 1 'Employers – Venue operator').

Special personal hearing protectors

Custom made personal hearing protectors for musicians should be fitted by a qualified audiologist.

All ear plugs alter the listening experience and it can take a long time to get used to them. The acclimatisation process should be managed – if not, people will give up and their hearing will become increasingly damaged. Never wear earplugs for the first time in a performance.

There is a misconception amongst some woodwind and brass players that it is not possible to wear earplugs due to the build up of pressure and the risk of further damage to the ear canal. This has no basis in fact.

Occlusion effect

Players of reeded woodwind and brass instruments generally cannot use compressible earplugs because the resulting occlusion effect amplifies the natural jaw resonance when they play (vocalists also find compressible earplugs make the voice sound strange). There are two ways of dealing with the occlusion effect:

- Use deep-fitting custom made earplugs which reach into the inner boney portion of the ear canal and so reduce potential vibration and jaw resonance;
  or
- Use earplugs with vents that allow the trapped low-frequency sound to escape.

NB: *The provision of hearing protectors does not release you from your obligation to minimise the sound exposure by means of sound reduction measures. Regular risk assessments and ongoing monitoring and review is essential.*

Individual screens are available on the market and can be used as personal protective equipment.

Obligations

In particular, you as an employer, entertainment provider must fulfil the following obligations:

- After the risk assessment, provide prevention measures to avoid or reduce to a minimum the exposure of workers to high sound level.
- Provide information, training and instructions on the preservation of hearing and on the availability and use of prevention measures such as collective measures or personal hearing protectors. Ensure that written information is available on these issues.
- Mark noise areas [if $L_{ex,8h}$ > 85 dB(A)] where workers are likely to be exposed to noise exceeding the 'upper exposure actions values' as requested in the Article 5 of Directive 2003/10/EC.
- If sound exposure cannot be reduced sufficiently by practicable technical and organisational measures, employers must provide appropriate hearing protectors to workers, taking into account that this applies both for musicians or other performers, technical and service staff, as requested in the Article 6 of Directive 2003/10/EC. There are special hearing protectors for musicians with a flat frequency response.
- A worker whose exposure exceeds the 'upper exposure action values' [$L_{ex,8h}$ > 85 dB(A)] shall have the right to have his/her hearing checked by a doctor or by another suitably qualified person under the responsibility of a doctor, as requested in the Article 10 of Directive 2003/10/EC.
- Preventive audiometric testing shall also be available for workers whose exposure exceeds the 'lower exposure action values' [$L_{ex,8h}$ > 80 dB(A)], as requested in the Article 10 of Directive 2003/10/EC.

Strategy 3: Employers of service staff

Who is concerned?

You are an employer of security, cashiers, catering or first aid staff.

What to do?

In general, as an employer of security, cashiers, catering or first aid staff, and according to the Section II of Directive 2003/10/EC *'Obligations of employers'*, you shall:

- Be informed about national statutory regulations and technical standards, and about the obligations regarding the health and safety of workers at work.
- Be informed about the contents of the present guide and comply with its instructions and information.
- Assess and, if necessary, measure the level of noise to which workers are exposed.
- Develop and implement health and safety prevention measures to safeguard your service staff workers.
- Inform your workers of these matters.

For each venue

- Check with the event organiser if workers may be exposed to harmful noise.
- Find out who is responsible for noise prevention measures.
- Find out what noise prevention strategies are applied and follow their instructions.
- Consider the application of organisational noise reduction measures.

Obligations

In particular, you as an employer of service staff must fulfil the following obligations:

- After the risk assessment, provide prevention measures to avoid or to reduce to a minimum the exposure of workers to high sound level.
- Provide information, training and instructions on the preservation of hearing and on the availability and use of prevention measures such as collective measures or personal hearing protectors.
- Areas in which workers or personnel are likely to be exposed to sound exceeding the 'upper exposure action value' >85dB (A) or exceeding the peak level ρ_{peak} 137 dB(C) [140 Pa] shall be marked with appropriate signs as requested in the Article 5 of Directive 2003/10/EC. The areas in question shall also be delimitated and access to them restricted where this is technically feasible and the risk of exposure so justifies.
- If sound exposure cannot be reduced sufficiently by practicable technical and organisational measures, employers must provide appropriate hearing protectors to workers, taking into account that this applies both for musicians or other performers, technical and service staff, as requested in the Article 6 of Directive 2003/10/EC. There are special hearing protectors for musicians with a flat frequency response.
- Prohibit workers and personnel without appropriate hearing protectors from entering those areas.
- A worker whose exposure exceeds the 'upper exposure action values' [$L_{ex,8h}$ > 85 dB(A)] shall have the right to have his/her hearing checked by a doctor or by another suitably qualified person under the responsibility of a doctor, as requested in the Article 10 of Directive 2003/10/EC.
- Preventive audiometric testing shall also be available for workers whose exposure exceeds the 'lower exposure action values' [$L_{ex,8h}$ > 80 dB(A)], as requested in the Article 10 of Directive 2003/10/EC.

Strategy 4: Employers – Providers or operators of sound amplification equipment

Who is concerned?

You are an employer, provider or operator of sound equipment (e.g. for a nightclub, hotel, a concert hall or an open-air concert), or you operate such technical equipment at the venue. You employ staff to operate the equipment during the event.

What to do?

In general you as an employer, provider or operator of sound equipment, and according to Section II of Directive 2003/10/EC *'Obligations of employers'*, you shall:

- Be informed about national regulations and technical standards, and about the obligations regarding the health and safety of workers at work.
- Provide information on the safe use of the devices and working equipment you rent or sell.
- Assess and, if necessary, measure the level of noise to which workers are exposed.
- Develop and implement health and safety prevention measures to safeguard your workers.
- Inform your workers on these matters.
- Be informed about the contents of the present guide and comply with its instructions and information.

Information to be provided on delivery

Advise the employer, venue operator or organiser of the following:

- The use for which the equipment has been designed and tested.
- The safe operating procedures for the equipment.
- The circumstances which lead to hearing damage.
- Requirements to monitor sound levels during rehearsal or event.
- Access to areas where loudspeakers exceed the 'upper exposure action values' > 85 dB (A) or exceeding the peak level ρ_{peak} =137 dB(C) [140 Pa] shall be marked where technically feasible with appropriate signs. The areas in question shall also be delimitated and access to them restricted where this is technically feasible and the risk of exposure so justifies.
- Prohibit workers without appropriate hearing protectors from entering those areas.

NB: Information may be provided in verbal or written form or through warning signs fixed to the technical equipment.

Setting up

- Position loudspeakers as far away as possible or in such away that they are not directly pointing towards the areas where workers are located and work.
- Position loudspeakers so that it is possible to install access barriers to areas in which workers are likely to be exposed to sound exceeding the 'upper exposure actions values' > 85 dB (A) and exceeding the peak level ρ_{peak} =137 dB(C) [140 Pa]. Mark areas/barriers with appropriate signs.

Operation

- Collate information on the event organiser's or employer's noise prevention strategies.
- Collate information on the sound level required by the event organiser and agreements on maximum sound levels.
- Allow sound level monitoring/recording.

Obligations

In particular, as an employer, provider or operator of sound equipment, you must fulfil the following obligations:

- Assess and, if necessary, measure the levels of noise to which workers are exposed.
- After the risk assessment, provide a prevention plan of measures to avoid or to reduce to a minimum the exposure of workers to high sound levels.
- Provide information, training and instructions on the preservation of hearing and on the availability and use of prevention measures such as collective measures or personal hearing protectors.
- Document training by date, content and participants.
- If other collective measures cannot apply, provide appropriate personal hearing protectors [if $L_{ex,8h}$ > 80 dB(A)]. There are special hearing protectors for musicians with a flat frequency response.
- A worker whose exposure exceeds the 'upper exposure action values' [$L_{ex,8h}$ > 85 dB(A)] shall have the right to have his/her hearing checked by a doctor or by another suitably qualified person under the responsibility of a doctor, as requested in the Article 10 of Directive 2003/10/EC.
- Preventive audiometric testing shall also be available for workers whose exposure exceeds the 'lower exposure action values' [$L_{ex,8h}$ > 80 dB(A)], as requested in the Article 10 of Directive 2003/10/EC.

Example: in-ear monitoring

In-ear monitors consist of custom-fit moulded ear plugs with built-in miniature monitor speakers and a wireless transmitter receiver system you can wear on a belt. In-ear monitoring systems may substitute monitor loudspeakers and can help to reduce the exposure on the stage, particularly for 'pop' musicians. Take care of the volume setting and use systems with limiter function. Otherwise high sound levels of more than 110 dB may reach your ear drum. The moulded ear plugs must fit properly or they will allow background sound to leak in. An improper fit may cause the user to turn the monitors up to overcome the undesired background sound. Thus less expensive in-ear monitors with generic plugs are not recommended.

Figure 8.3 Custom-fitted ear plugs of an in-ear monitoring system

Strategy 5: Workers

Who is concerned?

You are, for example, a:

- Performer, artist or other performer, musician, music teacher, service personnel, or technician.
- Musician playing for a band and recruited for certain events.
- Worker of a catering facility.
- Worker at an event as technician, bar, service, security, first aid staff or catering.

What should you do?

- Collect information on and ask your employer whether you are exposed to hazardous sound levels.
- Consider whether your noise exposure might be extended by personal practice, additional non-professional music-making, teaching or leisure activities.
- Collate information on the risks and noise control strategies described in this guide.
- Consider what noise control measures are applicable in your area.

Obligations

In particular, you should fulfil the following obligations as laid down in Section III, Article 13 of Directive 89/391/EEC *'Workers' obligations'*:

- Follow your employer's relevant instructions on control strategies to be used to prevent the risk of exposure to excessive noise.
- Do not intentionally remove or damage any equipment provided for noise reduction purposes.
- During rehearsals, on stage and at home while practising, in accordance with your employer's requirements and when you cannot apply other noise reduction measures, the use of hearing protectors is necessary.
- Report new situations, in which harmful noise or hearing impairment arises, to your employer.
- Attend precautionary hearing checks.

Example: Silent Brass System

Sound reduction for brass players during individual exercise. It consists of a special damper and a microphone/headphone system which enables volume controlled exercises without the need to change intonation or strength of playing – from time to time pleasant for your neighbour and your ears.

Figure 8.4 Silent Brass System
(Photo © & courtesy by Yamaha Music)

Musician ear plugs

Musicians should opt for special earplugs, which provide uniform attenuation of all frequencies. This allows music to be heard with a natural sound characteristic.
These custom-fitted silicone earplugs are equipped with an interchangeable diaphragm filter available for attenuation levels of 9, 15 or 25 dB(A). Most musicians playing with earplugs, even with these special devices, need time to familiarise themselves with altered instrument perception.

Suggested choices for different sections of an orchestra are:

- Violins and violas – uniform attenuator earplugs most suitable, though some prefer amplitude sensitive – particularly if near to loud neighbours.
- Basses, celli and harps – vented/tuned earplugs.
- Reed woodwinds – uniform attenuator or amplitude-sensitive earplugs.
- Flutes ad piccolos – uniform attenuator or amplitude-sensitive earplugs.
- Brass – amplitude-sensitive earplugs or defenders (earmuffs).
- Percussion – amplitude-sensitive earplugs or defenders (earmuffs).

The table below gives an indication of the degree of protection that is likely to be suitable for different levels of noise. It is based on the single number rating (SNR) value provided with a hearing protection device. The information is intended as a guide rather than a substitute for assistance by a competent person.

Noise level in dB(A)	Select a protector with an SNR of
85 – 90	20 or less
90 – 95	20 – 30
95 – 100	25 – 35
100 – 105	30 or more

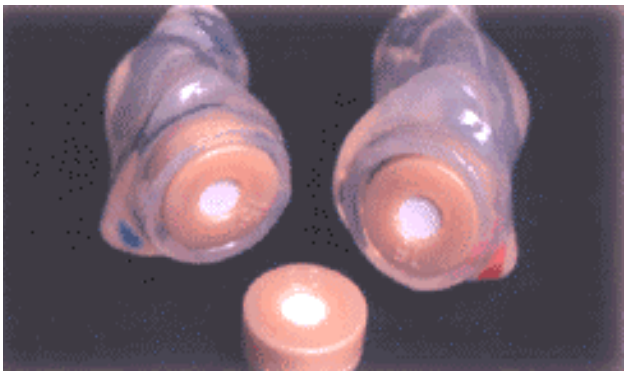


Figure 8.5 Musician ear plugs with interchangeable filters
(© & courtesy by Infield Safety Gmbh, Germany)

CHAPTER 9
Summary of the EU Noise Regulations

1. INTRODUCTION

This chapter summarises the legal duties and requirements for employers regarding the exposure of workers to the risks arising from noise. It describes:

- How Directives and supporting standards work together.
- The Safety and Health Directives that apply to the workplaces exposed to noise.
- The directives setting the essential requirements in relation to design, manufacture, quality level, testing and certification of equipment.
- Standards that give noise emission data for machinery, and the performance of personal hearing protection.

2. HOW THE NOISE DIRECTIVE RELATES TO OTHER DIRECTIVES

The Noise Directive 2003/10/EC[45], which is an individual Directive within the meaning of Article 16 of directive 89/391/EEC[46], defines the minimum health and safety requirements regarding the exposure of workers to the risks arising from noise. This Directive replaces the previous directive 86/188/EEC on the protection of workers from the risks related to exposure to noise at work.

In the Introduction of this guide, Table 0.1 compares the requirements of the Physical Agents 'Noise Directive' 2003/10/EC with those of previous Directive 86/188/EEC.

2.1. The Safety and Health Directives

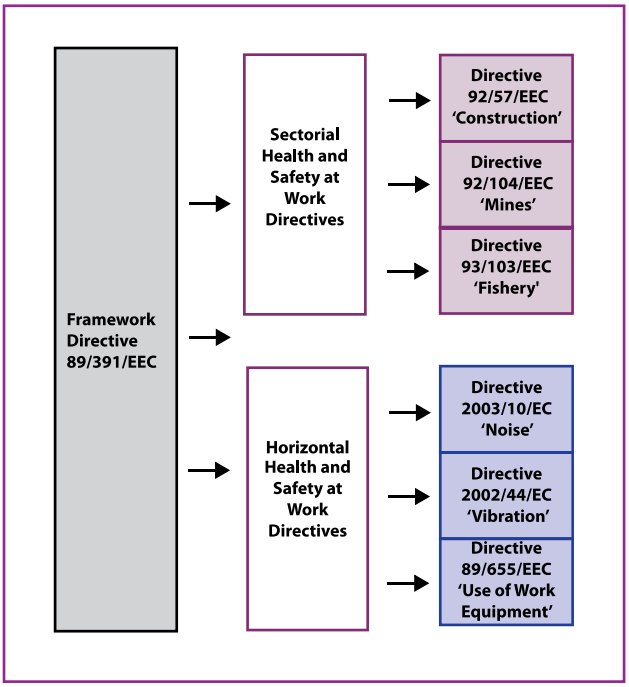


Table 9.1 The Noise Directive is one of several Directives arising from the Framework Directive

2.1.1. The Framework Directive 89/391/EEC

The objective of the Framework Directive is to encourage improvements in the safety and health of workers at work. The employer bears the duty to ensure the safety and health of workers in every aspect related to the work. For that the Framework Directive:

- Establishes the general principles of prevention of risks at work.
- Establishes the employers obligations.
- Requests the employer to take necessary measures to avoid risks and to evaluate the risks which cannot be avoided and to reduce these risks.
- Defines prevention services.
- Requires the employer to inform, consult and train workers ensure that they are subjected to adequate health surveillance.

Based on this so-called *'Framework Directive'*, a number of individual directives were adopted.

45. Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003, on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise), O.J. n° L 42 of 15.02.2003, page 38.

46. 89/391/EEC Council Directive of 12 June 1989, on the introduction of measures to encourage improvements in the safety and health of workers at work, O.J. n° L 183 of 29.06.1989, page 1.

2.1.2. Use of Personal Protective Equipment (PPE) Directive 89/656/EEC

The Noise Directive 2003/10/EC refers to the PPE Directive to define the minimum health and safety requirements in relation to a worker using personal protective equipment and, in particular, personal hearing protection.

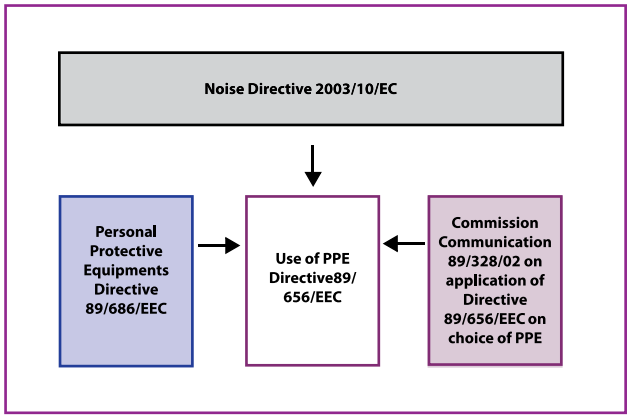


Table 9.2 The Noise Directive in relation with the PPE Directives

- The Use of PPE Directive (89/656/EEC) contains minimum requirements for the assessment, selection and correct use of personal protective equipment, including hearing protectors.

2.1.3. Directives for the protection of particularly sensitive groups:

Under the Framework Directive an employer is obliged to take account of the risks to workers who may be particularly sensitive to that risk. The 'Pregnant workers' directive 92/85/EEC[47] and 'Young people' directive 94/33/EC[48] provide some specific measures.

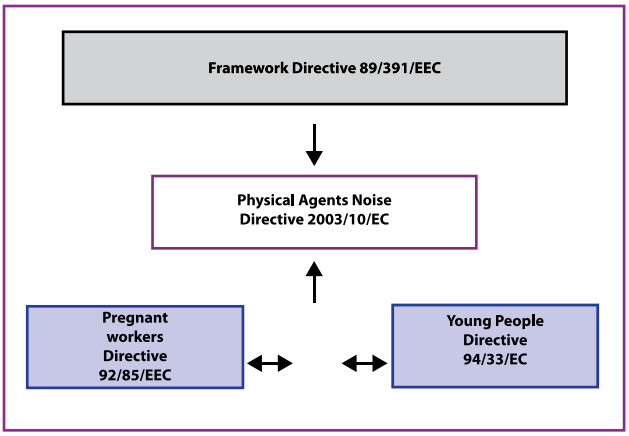


Table 9.3 The Noise Directive in relation with the particular sensitive groups Directives

2.2. Design and Manufacturing Directives

The above Directives are directives for the essential safety and health requirements of equipment. These include:

- The Machinery Directive 98/37/EC[49], which after 29th December 2009 should be replaced by the Directive 2006/42/EC[50];
- The Manufacturing of Personal Protective Equipment Directive 89/686/EEC[51];
- The Outdoor Noise Directive 2000/14/EC[52] amended by Directive 2005/88/EC[53].

2.2.1. Machinery Directive 98/37/EC (2006/42/EC) and Outdoor Noise Directive 2000/14/EC (amended by 2005/88/EC)

These Directives are supported by European Standards containing specific requirements and tests. Equipment assessed as conforming to these requirements is CE marked.

47. Council Directive 92/85/EEC of 19 October 1992, on the introduction of measures to encourage improvements in the safety and health at work of pregnant workers and workers who have recently given birth or are breastfeeding, O.J. n° L 348 of 28.11.1992, page 1.

48. Council Directive 94/33/EC of 22 June 1994, on the protection of young people at work, O.J. n° L 216 of 20.08.1994, page 12.

49. Directive 98/37/EC of the European Parliament and of the Council of 22 June 1998, on the approximation of the laws of the Member States relating to machinery. O.J. n° L 207 of 23.07.1998, page 1.

50. Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006, on machinery, and amending Directive 95/16/EC (recast), O.J. n° L 157 of 09.06.2006, page 24.

51. 89/686/EEC Council Directive of 21 December 1989, on the approximation of the laws of the Member States relating to personal protective equipment, O.J. n° L 399 of 30.12.1989, page 18.

52. Directive 2000/14/EC of the European Parliament and of the Council of 8 May 2000, on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors, O.J. n° L162, of 03.07.2000, page 1.

53. Directive 2005/88/EC of the European Parliament and the Council of 14 December 2005 amending Directive 2000/14/EC on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors, O.J. n° L344, of 27.12., page 44.

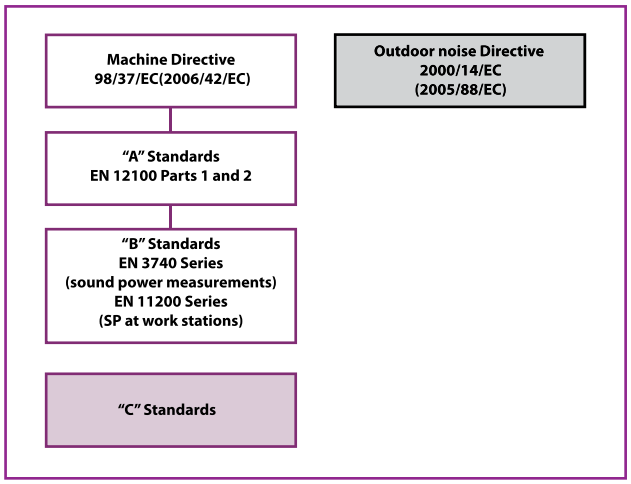


Table 9.4 The Machinery Directive, Outdoor Directive and the hierarchy of supporting European Standards

The 'Machinery' Directive lays down the essential safety and health requirements of machinery.

There are **'A'**, **'B'** and **'C'** standards supporting the essential requirements of the directive.

- Type '**A**' Standards (basic safety standards) give basic concepts that can be applied to all machinery.
- Type '**B**' Standards are on particular safety aspects. Measurement of the sound level at workstations is defined in EN 11200 series '**B**' Standards, measurement of the sound power level in EN 3740 series '**B**' Standards.
- Type '**C**' Standards detail the safety requirements for a particular machine or group of machines. The '**C**' Standards include information to enable a low-noise machine to be designed, and definition of the operating conditions for noise measurements and the appropriate '**B**' Standard procedure.

The Outdoor Noise Directive is concerned with the environmental impact of machinery noise. Limit values are placed on the sound power level of some machines, while the sound power of all machines must be reported. The Directive draws test codes for sound power assessment from **'B'** standards but specifies itself the operating conditions for individual machines rather than using **'C'** Standards.

Example:

An employer is considering buying a new power press. He is concerned that it should be as quiet as possible. He identifies presses with the capacity and features he requires. All are 'CE' marked confirming the noise emission has been measured using the standard procedure. He is able to compare the machine noise data for each machine.

2.2.2. Essential Requirements for Personal Protective Equipment Directive

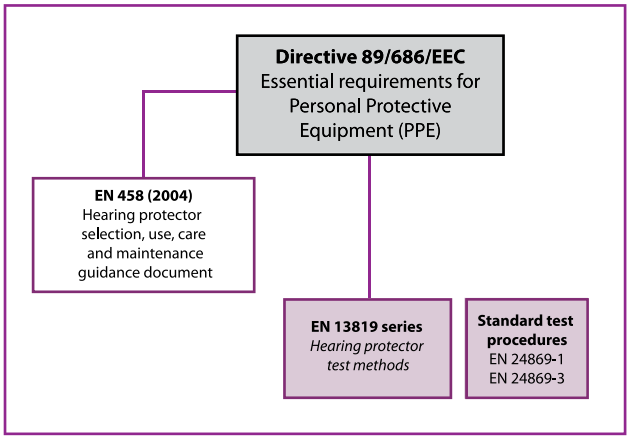


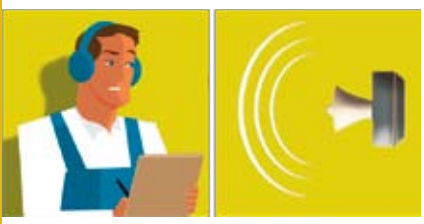
Table 9.5 Hierarchy of standards supporting the Essential Requirements of PPE Directive

The Essential Requirements of PPE Directive gives the first principles for the safe design of personal protective equipment. This Directive is supported by the following European standards:

- EN 13819 parts 1 and 2 define test plans and methods for the assessment of the physical and acoustic properties of hearing protectors;
- The EN 352 series of standards define safety requirements and test plans for individual types of hearing protector;
- EN 458 provides user guidance on how to use EN 352 series test data to select appropriate protectors and to use and maintain the protectors.

The CE mark is given to a hearing protector when it passes the tests against the supporting standard requirements. CE marked hearing protectors are assumed to conform to the Essential Requirements of PPE Directive.

CE certification mark



ANNEXES

Annex I

LIST OF KEYWORDS, LIST OF ABBREVIATIONS AND GLOSSARY

List of Keywords

Keywords	Chapter	Paragraph
Absorption (sound)	Ch 1 - Ch 3	5.3 - 2.1
Absorption coefficient α (sound)	Ch 3	4.2
Acoustic (Helmholtz) resonator	Ch 3	4.2
Acoustics	Ch 1	1
Audiometric testing	Ch 7	1 & 3
Audiometry	Ch 7	2
Averaging	Ch 2	5.1
Baffle	Ch 3	2.1 & 4.2
Bass	Ch 1	3.1
Bone conduction	Ch 7	7.1
Bone vibrator	Ch 7	7.1
Calibration	Ch 2	6.1
Daily exposure	Ch 1 - Ch 2	6.4 - 4.1 & 5.3
Damping	Ch 4	5.2
Decay rate	Ch 3	3.2.
Decibel	Ch 1	3.4
Diaphragm	Ch 3	4.2
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Exposure limit values	Ch 2	Summary page
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Loudness	Ch 7	5
Music and entertainment sector	Ch 8	all
Noise	Ch 1	2.2
Noise emission information	Ch 6	4.2
Noise exposure	Ch 1	6.4
Octave	Ch 1	4.2
Orchestras exposure level	Ch 8	6 (Strategy 2)
Otoplastics	Ch 5 - Ch 8	3 - 6 (Strategy 5)
Ototoxin	Ch 7	4
Outer hair cell	Ch 7	2.3 & 3 & 4
Peak sound pressure	Ch 1	6.1
Permanent threshold shift	Ch 7	3
Personal Hearing Protectors (PHP)	Ch 5	all
Personal Protective Equipment (PPE)	Ch 5	all
Propagation (of sound)	Ch 1 - Ch 3	2.3 - 3.1 & 3.2
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Reflection	Ch 1 - Ch 3	5.3 - 2.1
Reverberant field	Ch 3	2.2
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Room absorption area	Ch 3 – Ch 4	4.2 - 6.4
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Screen, barrier	Ch 4 - Ch 8	6.3 - 6 (Strategy 1)
Silencer	Ch 4	5.1
Sound	Ch 1	2.1
Sound analysis	Ch 1	4.1
Sound level meter	Ch 2	5.4
Sound power level	Ch 1	3.5
Sound pressure level	Ch 1	3.6
Sound source	Ch 1	2.3
Spectrum	Ch 1	4.1
Speech audiometry	Ch 7	7.2
Speech recognition	Ch 7	7.2 & 8
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Wave	Ch 1	2.1
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List of Abbreviations

Abbreviation	Means	Reference
α	Absorption factor	Ch 3 - § 4.2
A_{eq}	Absorption equivalent area	Ch 3 - § 3.2
DL_2	Rate of special decay per distance doubling	Ch 3 - § 3.2
DL_f	Room noise amplification	Ch 3 - § 3.2
$E_{A, 8h}$	A-weighted sound exposure in 8 hours	Ch 1 - § 6.4
f	Frequency	Ch 1 - § 3.1
HATS	Artificial head and torso simulator	Ch 1 - § 6.5
$LA_{eq, t}$	A-weighted sound pressure level in 8 hours	Ch 1 - § 6.4
$L_{Ex,8h}$	Daily noise exposure level (8 hours)	Ch 1 - § 6.4

Abbreviation	Means	Reference
$L_{Ex,d}$	Daily noise exposure level	Ch 1 - § 6.4
L_p	Sound pressure (p)	C 1 - § 3.3 & 3.4
L_{eq}	Equivalent continuous level	Ch 1 - § 5.1
L_w	Sound Pressure Level (SPL)	Ch 1 - § 3.4 & 3.5
MIRE	Microphone in real ear technique	Ch 2 - § 6.5
L_{wA}	Sound power level	Ch 1 - § 3.5
p	Sound pressure	Ch 1 - § 3.3
P	Sound power	Ch 1 - § 3.5
p_{peak}	Peak sound pressure	Ch 1 - § 6.6
PPE	Personal protective equipment	Ch 5
PHP	Personal hearing protectors	Ch 5
T_r	Reverberation time	Ch 3 - § 3.1

Glossary

ENGLISH	FRANÇAIS	DEUTSCH	Definition (EN)	Définition (FR)	Definition (DE)
Absorption (sound -)	Absorption acoustique	Schallabsorption	Sound energy loss inside a material or inside a dedicated system.	Diminution de l'énergie acoustique, obtenue par dissipation au travers d'un matériau ou par un système dédié.	Abnahme der Schallenergie innerhalb eines Materials oder durch eine geeignete Vorrichtung
Absorption coefficient α (sound -)	Coefficient d'absorption acoustique α	Schallabsorptionsgrad α	Ratio of the sound energy absorbed by a material or system to the incidental sound power (α goes from 0 to 1, 1 corresponding to total absorption).	Rapport entre la puissance acoustique absorbée par un matériau ou un système et la puissance acoustique incidente. α varie de 0 à 1, 1 correspondant à une absorption totale.	Verhältnis der von einem Material oder Vorrichtung absorbierten Schallenergie zur einfallenden Schallenergie. α kann Werte zwischen 0 und 1 annehmen, wobei der Wert 1 volle Absorption bedeutet.
Acoustical spectrum	Spectre acoustique	Schallspektrum	The distribution of sound pressures or intensities measured as a function of frequency or in specified frequency bands.	Répartition de la pression ou de l'intensité sonore en fonction de la fréquence, dans des bandes de fréquences données.	Die Verteilung eines Schalldrucks oder einer Schallintensität über der Frequenz oder deren Angabe für bestimmte Frequenzbänder
Acoustics	Acoustique	Akustik	The science of sound.	Science du son.	Die Wissenschaft des Schalls
Audiofrequency	Fréquence audible	Hörfrequenz	Frequency of audible sound.	Fréquence de son audible.	Die Frequenz hörbaren Schalls
Audiogram	Audiogramme	Audiogramm	A graph showing hearing sensitivity for different frequencies.	Graphe décrivant la sensibilité auditive en fonction de la fréquence.	Ein Diagramm, das die Hörschwelle abhängig von der Frequenz zeigt
Audiometer	Audiomètre	Audiometer	A device or software used to test hearing.	Instrumentation utilisée pour réaliser un test auditif.	Ein Gerät zur Messung der Hörfähigkeit
Audiometry	Audiométrie	Audiometrie	Measurement of hearing, usually performed using an audiometer.	Mesure de l'audition réalisée en principe avec un audiomètre.	Die Messung der Hörfähigkeit mit einem Audiometer
Averaging	Moyennage	Mittelung	Determination of the steady level that has equal sound energy to a varying sound (as for an L_{eq} indication).	Détermination d'une valeur constante ayant la même énergie qu'un son variable (à l'image d'une indication de L_{eq}).	Die Bestimmung eines konstanten Schallpegels mit derselben Schallenergie wie ein über die Zeit schwankender Schallpegel (zur L_{eq}-Angabe)
Background noise	Bruit de fond	Fremdgeräusch	Noise from all sources other than the noise from the source under test.	Bruit généré par toutes les sources en dehors de la source étudiée.	Geräusch von allen Quellen mit Ausnahme des Geräuschs der zu untersuchenden Quelle
Bass	Basse	Bass	Low frequency sound	Son en basses fréquences	Tieffrequenter Schall
Binaural	Binaural	Binaural	Relating to both ears.	Relatif aux deux oreilles.	Auf beide Ohren bezogen
Calibration	Calibration	Kalibrierung	Checking the accuracy of a sound-level meter against a calibrated sound source (calibrator).	Vérification de la précision d'un sonomètre par mesure d'une source sonore connue (calibrateur).	Überprüfung der Genauigkeit eines Schallpegelmessers durch Abgleich mit einer kalibrierten (Norm-)schallquelle.
Daily exposure	Exposition sonore quotidienne	Tagesexposition	The determination of an averaging level to which a person is exposed during a certain daily time period. In the field of work protection the averaging time is usually eight hours.	Niveau sonore moyen auquel est exposée une personne pendant une durée caractéristique de la journée (pour la protection des travailleurs, 8 heures de travail).	Die Bestimmung des gemittelten Schalldruckpegels, dem eine Person während einer festgelegten Zeit ausgesetzt ist. Im Arbeitsschutz wird üblicherweise über 8 Stunden gemittelt.
Damping	Amortissement	Dämpfung	The reduction of vibration energy by conversion into heat.	Dissipation d'énergie vibratoire en chaleur.	Die Verringerung von Schwingungsenergie durch Umwandlung in Wärme

ENGLISH	FRANÇAIS	DEUTSCH	Definition (EN)	Définition (FR)	Definition (DE)
Decay rate	Taux de décroissance	Pegelabnahme	The sound pressure level decay over a given time (e.g. reverberation time) or over a distance from a sound source (e.g. 6 dB per distance doubling in a free field).	Diminition du niveau de pression acoustique pendant une durée donnée (voir «Durée de réverbération») ou par rapport à l'éloignement d'une source (par exemple: 6 dB par doublement de distance en champ libre).	Die Schalldruckpegelabnahme über eine bestimmte Zeit (z. B. Nachhallzeit) oder eine Entfernung von einer Schallquelle (z. B. 6 dB pro Abstandsverdopplung im Freifeld)
Decibel	Décibel	Dezibel	A unit of measure of sound level: 10 times the common logarithm of the ratio of two quantities proportional to power or energy.	«Unité» de mesure du son correspondant à dix fois le logarithme du rapport entre deux quantités représentant une puissance ou une énergie.	Die Größenangabe für Schallpegel: das Zehnfache des dekadischen Logarithmus des Verhältnisses zweier energie- oder leistungsproportionaler (Schallfeld-)größen
Direct (acoustical) field	Champ direct	Direktes Schallfeld	Area around the source where the sound coming directly from the source dominates.	Zone proche de la source où le niveau sonore provenant directement de celle-ci est dominant.	Bereich, in dem der Schall von der Quelle dominiert
Ear-muff	Coquille (protecteur muni de —)	Kapselgehörschutz	Hearing protector consisting of cups pressed against each ear or against the head around each ear.	Protecteur contre le bruit constitué de coquilles enserrant les oreilles.	Zwei durch einen flexiblen Bügel verbundene schalldämpfende Kapseln, die über den Ohrmuscheln getragen werden
Ear-plugs	Bouchon d'oreille	Gehörschutzstöpsel	Hearing protector worn within the ear canal or against the entrance to each of the ear canals.	Protecteur contre le bruit introduit dans le conduit auditif ou la conque de l'oreille pour en obstruer l'entrée.	Schalldämpfende Stöpsel, die im äußeren Gehörgang oder an dessen Eingang getragen werden
Emission	Émission	Emission	The amount of sound radiated solely from a given source. The noise emission can be quantified either by a sound power level or by a sound pressure level.	Quantité de son rayonnée par une source et seulement par elle. L'émission sonore peut être quantifiée par un niveau de puissance acoustique ou de pression acoustique.	Der gesamte Schall, der von einer Quelle an die Umgebung abgestrahlt wird. Die Geräuschemission wird durch den Schallleistungspegel und/oder durch den Emissionsschalldruckpegel angegeben
Emission sound pressure level	Niveau de pression acoustique d'émission	Emissionsschalldruckpegel	Sound pressure level at a specified position, typically the work station near a machine, when the machine is in operation under defined operating conditions, excluding any reflected sound from walls or other sound reflecting surfaces.	Niveau de pression acoustique en une position donnée, en principe le poste de travail de la machine, lorsque celle-ci est en fonctionnement dans des conditions définies, en dehors de toute réflexion sur quelque surface que ce soit.	Der Schalldruckpegel an einer bestimmten Position (zugeordneter Arbeits- oder Bedienplatz) nahe einer Maschine, der sich einstellt, wenn die Maschine unter definierten Betriebsbedingungen betrieben wird. Umgebungsgeräusche, Geräusche anderer Maschinen oder Reflexionen von Decke oder Wänden werden dabei nicht berücksichtigt.
Equivalent level	Niveau équivalent	Äquivalenter Pegel	Constant sound pressure level which is energy equivalent to the fluctuating sound during the measurement.	Niveau de pression acoustique équivalent qui aurait une valeur constante pendant la durée de la mesure.	Konstanter Schalldruckpegel, der energieäquivalent ist zum schwankenden Geräusch während der Messung
Exposure	Exposition	Exposition	The noise a person is exposed to in various working situations over a given time period. It is usually quantified by an averaged sound pressure level.	Bruit auquel une personne est exposée pendant ses diverses activités de travail et pour une durée donnée. L'exposition est en principe quantifiée par un niveau de pression acoustique.	Schall, dem eine Person in einer bestimmten Situation für einen gegebenen Zeitraum ausgesetzt ist. Die Exposition wird üblicherweise als gemittelter Schalldruckpegel angegeben.
Exposure level	Niveau d'exposition	Expositionspegel	The averaged sound pressure level over the exposure time.	Niveau de pression acoustique moyen pendant la durée d'exposition.	Der gemittelte Schalldruckpegel über die Expositionszeit
Field (acoustical -)	Champ acoustique	Schallfeld	Space area including sound waves.	Zone spatiale dans laquelle se propagent des ondes sonores.	Der Bereich, in dem sich Schallwellen ausbreiten
Free field (acoustical -)	Champ acoustique libre	Freies Schallfeld	Sound field with no limits (no reflections), like an open space. In the free field, the sound decreases by 6 dB by doubling the distance from the noisy machine.	Champ acoustique sans limites (pas de réflexions), tel un espace ouvert. En champ libre, le son décroît depuis une machine de 6 dB par doublement de distance.	Der Bereich, in dem sich Schallwellen ungehindert ausbreiten
Frequency	Fréquence	Frequenz	The number of cycles of a periodic motion per second (given in Hz) and a measure of tone pitch.	Nombre de cycles par secondes d'un mouvement périodique.	Die Anzahl der Schwingungen pro Sekunde (angegeben in Hz) und ein Maß für die Tonhöhe
Hearing aid	Appareil de correction auditive	Hörhilfe	An instrument to help hearing, usually placed into the ear canal.	Appareil améliorant l'audition placé en général dans le conduit auditif.	Ein im äußeren Gehörgang getragenes Gerät zur Verbesserung der Hörwahrnehmung
Hearing threshold level	Seuil d'audition	Hörschwelle	Threshold of sound detection.	Seuil de détection du son.	Untere Wahrnehmungsgrenze für Schall
Hearing loss	Perte d'audition	Hörverlust	Elevation of threshold of hearing.	Élévation du seuil d'audition.	Verschiebung der Hörschwelle zu höheren Schallpegeln
Immission	Bruit ambiant (Immission)	Immission	The amount of sound that arrives at a specific measuring point (work station) including the various sound sources and the room reflections. It is usually quantified by a sound pressure level.	Quantité de son reçue en un endroit précis (poste de travail) prenant en compte l'ensemble des sources sonores et réflexions du local. Le bruit ambiant est en principe quantifié par un niveau de pression acoustique.	Der Schall, der an einem bestimmten Messpunkt (Arbeitsplatz) während einer festgelegten Zeitspanne auftritt. Die Geräuschimmission wird üblicherweise als Schalldruckpegel gemessen und angegeben.

ENGLISH	FRANÇAIS	DEUTSCH	Definition (EN)	Définition (FR)	Definition (DE)
Impact sound	Bruit de chocs	Anschlagsgeräusch	The sound produced by colliding objects.	Son produit par un choc entre objets.	Das Geräusch, das beim Zusammenprall zweier Objekte entsteht
Impulsive noise	Bruit impulsionnel	Impulsgeräusch	Rapidly arising noise lasting for less than one second followed by a period of quiet.	Niveau sonore surgissant très rapidement, durant moins d'une seconde et suivi d'un moment de «calme».	Kurzzeitige Geräuschspitzen von weniger als einer Sekunde Dauer gefolgt von einer Periode geringen Geräuschs
Insertion loss	Perte par insertion	Einfügungsdämmung	Difference between the sound power emitted by a source without and with a sound reduction device; this term is used to qualify silencers or enclosures.	Différence des puissances acoustiques émises par une source sans et avec un équipement de réduction du bruit; ce terme est utilisé pour qualifier les encoffrements et les silencieux.	Verminderung des Schallpegels durch Schallschutzeinrichtungen (Kapseln, Schallschirme, Schalldämpfer)
Intelligibility	Intelligibilité	Sprachverständlichkeit	Percentage of words, sentences or speech sounds making up words (phonemes) correctly identified by a listener or group of listeners.	Pourcentage de mots, phrases ou sons articulés (phonèmes) identifiés correctement par un auditeur ou un groupe d'auditeurs.	Der Prozentsatz von Wörtern, Sätzen oder Sprachlauten (Phonemen), der von einem Hörer oder einer Gruppe von Hörern korrekt identifiziert wird
$L_{A,eq}$	$L_{A,eq}$	$L_{A,eq}$	Equivalent continuous sound level in dB(A).	Niveau acoustique équivalent exprimé en dB(A).	Äquivalenter Dauerschalldruckpegel in dB(A)
$L_{Ex,d}$	$L_{Ex,d}$	$L_{Ex,d}$	Daily exposure level.	Exposition sonore quotidienne.	Tagesexpositionspegel
L_p	L_p	L_p	Sound pressure level.	Niveau de pression acoustique.	Schalldruckpegel
L_w	L_w	L_w	Sound power level.	Niveau de puissance acoustique.	Schalleistungspegel
Mapping	Cartographie	Kartierung	Drawing of the sound levels distribution over an area.	Représentation de la répartition des niveaux sonore sur une surface.	Grafische Darstellung der lokalen Verteilung des Schallpegels
Masking effect	Effet de masque	Verdeckungseffekt	Decrease of audibility of one sound by the presence of another (masking) sound. The amount by which the threshold of audibility for one sound is raised by the presence of another sound.	Diminution de la capacité à entendre un son du fait de la présence d'un autre son (qui «masque» le premier). Élévation du seuil d'audibilité d'un son générée par la présence d'un autre.	Einschränkung der Wahrnehmbarkeit eines Geräuschs durch Überlagerung eines anderen Geräuschs Anhebung der Hörbarkeitsgrenze für ein Geräusch bei Überlagerung durch ein anderes Geräusch
Noise	Bruit	Lärm	Any unwanted or unhealthy sound.	Tout son indésirable ou néfaste pour la santé.	Unerwünschter und/oder gesundheitsschädlicher Schall
Noise emission declaration	Déclaration bruit	Geräuschemissionsangabe	Declaration of the noise emission values like the emission sound pressure level or the sound power level as required according to the European machinery directive.	Déclaration de la valeur du niveau de pression ou du niveau de puissance acoustiques d'émission conformément aux prescriptions de la directive «Machine» européenne.	Kennzeichnung der Geräuschemission durch Emissionsschalldruckpegel oder Schallintensitätspegel gemäß den Anforderungen der europäischen Maschinenrichtlinie
Octave	Octave	Oktave	A band of the frequency where the upper cut-off frequency is equal to twice the lower cut-off frequency.	Bande de fréquence dont la fréquence supérieure est égale à deux fois la fréquence inférieure.	Frequenzintervall, bei dem die obere Grenze das Zweifache der unteren Grenzfrequenz beträgt
Peak sound pressure	Pression acoustique de crête	Spitzenschalldruck	The maximum value of the absolute instantaneous sound pressure level in a specific time interval.	Valeur maximale de la pression acoustique instantanée pendant une durée donnée.	Höchster momentaner Wert des Schalldruckpegels innerhalb eines Zeitintervalls
PHP (personal hearing protectors)	PICB	Gehörschutz	Devices worn to protect hearing against noise.	Équipement individuel porté par une personne pour se protéger contre le bruit.	Hilfsmittel zum Schutz des Gehörs vor Schalleinwirkung
PPE (personal protective equipment)	EPI	Persönliche Schutzausrüstung	Equipment which is worn or held by a person at work to protect against one or more risks to health.	Équipement individuel porté par une personne pour se protéger contre un ou plusieurs risques pour la santé.	Hilfsmittel, das vom Arbeitnehmer zum Schutz vor Gefahren getragen oder benutzt wird
Propagation (of sound)	Propagation (du son)	Ausbreitung (von Schall)	The spread of acoustical disturbance in an environment or given space.	Cheminement d'une perturbation acoustique dans un milieu ou un espace donnés.	Ausbreitung einer akustischen Druckschwankung
Radiation	Rayonnement	Abstrahlung	The conversion of the dynamic energy of a sound source into sound energy.	Conversion de l'énergie dynamique d'une source en énergie acoustique.	Die Umwandlung der Bewegungsenergie einer Schallquelle in Luftschall
Reflection	Réflexion (acoustique)	Schallreflexion	Bouncing of the sound wave from a surface (echo).	«Rebondissement» d'une onde sonore sur une surface.	Rückwurf einer Schallwelle an einer Oberfläche (Echo)
Reverberant field	Champ réverbéré	Hallfeld	In a closed space, the reverberant field is the area far from the source where the room amplification is almost constant.	Dans un espace fermé, zone éloignée de la source sonore dans laquelle l'amplification du local est quasiment constante.	Bereich eines Raums, wo der direkt von der Schallquelle kommende Schall in erheblichem Maße von reflektiertem Schall überlagert wird
Reverberation	Réverbération	Nachhall	Decay of sound in a closed room when a noise source is stopped.	Dans un local, persistance d'un son lorsque la source sonore est interrompue.	Abnahme des Schalls innerhalb eines Raums, nachdem die Schallquelle abgeschaltet wurde

ENGLISH	FRANÇAIS	DEUTSCH	Definition (EN)	Définition (FR)	Definition (DE)
Reverberation time	Durée de réverbération	Nachhallzeit	Time taken for the sound level to drop by 60 dB when the noise source is stopped.	Durée correspondant à une diminution du niveau de pression acoustique de 60 dB, lorsque une source sonore est interrompue dans un local.	Zeit, in welcher der Schallpegel nach Abschalten der Schallquelle um 60 dB abnimmt
Room absorption area A_{eq}	Absorption acoustique équivalente d'un local A_{eq}	Äquivalente Absorptionsfläche A_{eq}	For a room, the equivalent area if its surface would be completely absorbant ($\alpha = 1$).	Pour un local, surface équivalente qui serait totalement absorbante ($\alpha = 1$).	Fläche mit dem Absorptionsgrad $\alpha = 1$ (vollständige Absorption), die die gleiche Absorption hat wie die gesamte Oberfläche eines Raums
Room amplification	Amplification du local	Schallpegelanhebender Raumeinfluss	The increase of sound level from multiple reflections within the room.	Augmentation du niveau sonore générée par les multiples réflexions du local.	Anhebung des Schallpegels durch Vielfachreflexionen im Raum
Screen, barrier	Écran acoustlque	Schallschirm	Partition placed near a worker for noise protection.	Cloison placée à proximité d'un travailleur pour le protéger du bruit.	Stellwand zum Schutz des Arbeitnehmers vor Schalleinwirkung
Sound	Son	Schall	An oscillation of air pressure propagated as a wave through the air.	Oscillation de pression de l'air se propageant sous la forme d'une onde.	Schwingungen des Luftdrucks, die sich als Welle durch die Luft ausbreiten
Sound analysis	Analyse d'un son	Schallanalyse	Sound signal processing to obtain specific information.	Traitement d'un signal sonore pour en obtenir une information spécifique.	Bearbeitung von Schallsignalen, um spezifische Informationen zu erhalten
Sound attenuation	Affaiblissement du son	Schalldämpfung, Schalldämmung	Decrease of sound pressure from one position to another; term usually employed to characterise a PHP or a sound protection screen.	Diminution du niveau de pression acoustique entre deux points; terme utilisé pour caractériser un PICB ou un écran acoustique.	Schallpegelabnahme zwischen 2 Orten; Begriff, der üblicherweise zur Charakterisierung von Gehörschutz verwendet wird
Sound level meter	Sonomètre	Schallpegelmesser	Measurement instrument for the determination of the sound pressure level.	Instrument de mesure du niveau de pression acoustique.	Messinstrument zur Bestimmung des Schalldruckpegels
Sound power level	Niveau de puissance acoustique	Schalleistungspegel	The sound power level LWA of a machine describes the sound energy emitted by a machine per unit of time. It indicates how much airborne noise is generated by the source in total.	Le niveau de puissance acoustique LWA d'une machine décrit l'énergie sonore qu'elle émet par unité de temps. Il représente la quantité totale de bruit émise par la source.	Der Schallleistungspegel LWA einer Maschine beschreibt die von ihr pro Sekunde abgestrahlte Schallenergie. Er beschreibt, wie viel Luftschall insgesamt von der Quelle erzeugt wird.
Sound pressure level	Niveau de pression acoustique	Schalldruckpegel	Measure of the volume of sound expressed in decibels.	Mesure de la pression acoustique exprimée en décibel.	Ein Maß für die Lautstärke, ausgedrückt in dB
Sound proofing	Insonorisation	Schallminderung	All actions undertaken to reduce sound inside a room or from one room to another.	Toute action de réduction du bruit, que ce soit à l'intérieur d'un local ou entre deux locaux.	Lärmminderung nach Durchführung einer bestimmten Maßnahme
Sound propagation		Schallausbreitung	See 'Propagation of sound'.		Siehe Ausbreitung von Schall.
Sound reduction index	Indice d'affaiblissement acoustique	Schalldämmung	Ratio of the transmitted sound power to the incident sound power, in dB.	Rapport entre les puissances de bruit incidente et transmise, en dB.	Verhältnis zwischen einfallender und durchgehender Schallleistung, ausgedrückt, in dB
Sound source	Source sonore	Schallquelle	Origin or generating mechanism of sound.	Origine ou mécanisme générateur de bruit (ou de son).	Ursprung oder Erzeugungsmechanismus von Schall
Speed of sound	Vitesse du son	Schallgeschwindigkeit	The speed at which the sound waves travel.	Vitesse à laquelle les ondes sonores cheminent.	Ausbreitungsgeschwindigkeit von Schallwellen
Steady noise	Bruit stable	Stationäres Geräusch	Noise with fluctuations of sound pressure level of less than 5 dB during the period of observation.	Bruit dont les variations de niveau de pression acoustique sont inférieures à 5 dB pendant la durée d'observation.	Geräusch, dessen Schalldruckpegel sich innerhalb des Beobachtungszeitraums um weniger als 5 dB ändert
Threshold of hearing	Seuil d'audition	Hörschwelle	Level of sound at which a tone will just be detected.	Niveau sonore à partir duquel un auditeur moyen est capable d'entendre un son.	Schalldruckpegel, ab dem ein Ton gerade wahrgenommen wird
Transmission coefficient	Facteur de transmission	Schalltransmissionsgrad	See 'Sound reduction index', which is more suitable to use.	Voir «Indice d'affaiblissement acoustique», terme plus approprié.	Siehe Schalldämmung.
Ultrasound	Ultrason	Ultraschall	Any sound wave of frequency higher than the normal frequency range of hearing.	Toute onde sonore dont la fréquence est supérieure à 20 000 Hz.	Schallwelle mit einer Frequenz oberhalb des normalen Hörfrequenzbereichs
Wave	Onde	Welle	The pattern of disturbance travelling through the air caused by the sound source.	Allure de la propagation d'une perturbation sonore dans l'air.	Das Muster einer Störung, die durch eine Schallquelle hervorgerufen sich durch die Luft ausbreitet
Wavelength	Longueur d'onde	Wellenlänge	The distance the sound wave travels to complete one cycle.	Distance parcourue par une onde sonore pendant un cycle.	Die Wellenlänge ist der Abstand von sich wiederholenden Elementen des Wellenmusters.
Weighting curves	Courbes de pondération	Bewertungskurven	Frequency dependent correction of sound levels.	Correction du niveau acoustique en fonction de la fréquence.	Frequenzabhängige Korrektur des Schallpegels

Annex II

LEGISLATION, STANDARDS AND SOURCES OF FURTHER INFORMATION ON NOISE

EU DIRECTIVES

1. Directives on health and safety at work

Council Directive **89/391/EEC** of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work
OJ L 183, 29.6.1989, p. 1

Directive **2003/10/EC** of the European Parliament and of the Council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise)
OJ L 42, 15.2.2003, p. 38

Directive **2002/44/EC** of the European Parliament and of the Council of 25 June 2002 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibrations)
OJ L 177, 6.7.2002, p. 13

Council Directive **89/655/EEC** of 30 November 1989 concerning the minimum safety and health requirements for the use of work equipment by workers at work
OJ L 393, 30.12.1989, p. 13

Council Directive **89/656/EEC** of 30 November 1989 on the minimum health and safety requirements for the use by workers of personal protective equipment at the workplace
OJ L 393, 30.12.1989, p.18

Council Directive **92/85/EEC** of 19 October 1992 on the introduction of measures to encourage improvements in the safety and health at work of pregnant workers and workers who have recently given birth or are breastfeeding
OJ L 348, 28.11.1992, p. 1

Council Directive **94/33/EC** of 22 June 1994 on the protection of young people at work
OJ L 216, 20.8.1994, p.12

Council Recommendation **2003/134/EC** of 18 February 2003 concerning the improvement of the protection of the health and safety at work of self-employed workers
OJ L 53, 28.2.2003, p. 45

89/328/02: Commission communication for the implementation of Council Directive **89/656/EEC** of 30 November 1989 concerning the assessment of the safety aspects of personal protective equipment with a view to choice and use thereof
OJ C 328, 30.12.1989, p. 3

2. Directives on the single market

Directive **98/37/EC** of the European Parliament and of the Council of 22 June 1998 on the approximation of the laws of the Member States relating to machinery
OJ L 207, 23.7.1998, p. 1

Directive **2006/42/EC** of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast)
OJ L 157, 9.6.2006, p. 24

Directive **2000/14/EC** of the European Parliament and of the Council of 8 May 2000 on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors
OJ L162, 3.7.2000, p. 1

Directive **2005/88/EC** of the European Parliament and the Council of 14 December 2005 amending Directive 2000/14/EC on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors
OJ L 344, 27.12.2005, p. 44

Council Directive **89/686/EEC** of 21 December 1989, on the approximation of the laws of the Member States relating to personal protective equipment.
OJ L 399, 30.12.1989, p. 18

SELECTED STANDARDS

EU Standards

EN 458:2004 Hearing protectors — Provisions for selection, use, care and maintenance — Guidance document

EN 1746:1998 Safety of machinery — Guidance for the drafting of the noise clauses of safety standards

EN ISO 3740:2000 Acoustics — Determination of sound power levels of noise sources — Guidelines for the use of basic standards (Introduction to the series EN ISO 3741 to 3747 and EN ISO 9614)

EN ISO 4871:1996 Acoustics — Declaration and verification of noise emission values of machinery and equipment

EN ISO 9614 Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 1: Measurement at discrete points (1995); Part 2: Measurement by scanning (1996); Part 3: Precision method for measurement by scanning (2002)

EN ISO 11200:1996 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 (Introduction to the series EN ISO 11201 to 11205)

EN ISO 11546:1995 Acoustics — Determination of sound insulation performance of enclosures — Part 1: Measurements under laboratory conditions (for declaration purposes); Part 2: Measurements in situ (for acceptance and verification purposes)

EN ISO 11688 Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 1: Planning (1995), Part 2: Introduction to the physics of low-noise design (2001)

EN ISO 11689:1996 Acoustics — Procedure for the comparison of noise emission data for machinery and equipment

EN ISO 11690 Acoustics — Recommended practice for the design of low-noise workplaces containing machinery — Part 1: Noise control strategies (1996); Part 2: Noise control measures (1996); Part 3: Sound propagation and noise prediction in workrooms (1997)

EN ISO 11821:1997 Acoustics — Measurement of in situ attenuation of a removable screen

EN ISO 11957:1996 Acoustics — Determination of sound insulation performance of cabins — Laboratory and in situ measurements

EN ISO 12001:1996 Acoustics — Noise emitted by machinery and equipment — Rules for the drafting and presentation of a noise test code

EN ISO 14163:1998 Acoustics — Guidelines for noise control by silencers

EN ISO 14257:2001 Acoustics — Measurement and parametric description of spatial sound distribution curves in workrooms for evaluation of their acoustical performance

EN ISO 15667:2000 Acoustics — Guidelines for noise control by enclosures and cabins

International Standards

ISO 9612:1997 Acoustics – Guidelines for the measurement and assessment of exposure to noise in a working environment.

EU MEMBER STATES' NATIONAL REGULATIONS TRANSPOSING DIRECTIVE 2003/10/EC

(to the date of 31 December 2007)

BELGIQUE/BELGIË (Belgium)

Arrêté royal du 16 janvier 2006 relatif à la protection de la santé et de la sécurité des travailleurs contre les risques liés au bruit sur le lieu de travail
Moniteur belge du 15 février 2006, p. 8009-8016

БЪЛГАРИЯ/(Bulgaria)

Наредба № 14 от 7.08.1998 г. за службите по трудова медицина
Държавен вестник, бр. 95 от 14.08.1998 г.

Кодекс на труда
Държавен вестник, бр. 26 от 1.04.1986 г. и бр. 27 от 4.04.1986 г.; доп., бр. 6 от 22.01.1988 г.; изм. и доп., бр. 21 от 13.03.1990 г.; изм., бр. 30 от 13.04.1990 г., бр. 94 от 23.11.1990 г., бр. 27 от 5.04.1991 г.; доп., бр. 32 от 23.04.1991 г.; изм., бр. 104 от 17.12.1991 г.; доп., бр. 23 от 19.03.1992 г.; изм. и доп., бр. 26 от 31.03.1992 г.; доп., бр. 88 от 30.10.1992 г.; изм. и доп., бр. 100 от 10.12.1992 г.; Решение № 12 на Конституционния съд на РБ от 20.07.1995 г. — бр. 69 от 4.08.1995 г.; доп., бр. 87 от 29.09.1995 г.; изм. и доп., бр. 2 от 5.01.1996 г.; изм., бр. 12 от 9.02.1996 г.; изм. и доп., бр. 28 от 2.04.1996 г.; изм., бр. 124 от 23.12.1997 г.; доп., бр. 22 от 24.02.1998 г.; Решение № 11 на Конституционния съд на РБ от 30.04.1998 г. — бр. 52 от 8.05.1998 г.; доп., бр. 56 от 19.05.1998 г., бр. 83 от 21.07.1998 г., бр. 108 от 15.09.1998 г.; изм. и доп., бр. 133 от 11.11.1998 г., бр. 51 от 4.06.1999 г.; доп., бр. 67 от 27.07.1999 г.; изм., бр. 110 от 17.12.1999 г.; изм. и доп., бр. 25 от 16.03.2001 г.; изм., бр. 1 от 4.01.2002 г., бр. 105 от 8.11.2002 г.; изм. и доп., бр. 120 от 29.12.2002 г., бр. 18 от 25.02.2003 г.; изм., бр. 86 от 30.09.2003 г., в сила от 1.01.2004 г.; изм. и доп., бр. 95 от 28.10.2003 г., бр. 52 от 18.06.2004 г., бр. 19 от 1.03.2005 г., изм., бр. 27 от 29.03.2005 г.; доп., бр. 46 от 3.06.2005 г.; изм., бр. 76 от 20.09.2005 г.; изм. и доп., бр. 83 от 18.10.2005 г.; изм., бр. 105 от 29.12.2005 г.; изм. и доп., бр. 24 от 21.03.2006 г.; изм., бр. 30 от 11.04.2006 г., в сила от 12.07.2006 г.; изм. и доп., бр. 48 от 13.06.2006 г., бр. 57 от 14.07.2006 г.

Наредба № 5 от 11.05.1999 г. за реда, начина и периодичността на извършване на оценка на риска
Държавен вестник, бр. 47 от 21.05.1999 г.

Закон за здравословни и безопасни условия на труд
Държавен вестник, бр. 124 от 23.12.1997 г.; изм., бр. 86 от 1.10.1999 г., бр. 64 от 4.08.2000 г., бр. 92 от 10.11.2000 г., бр. 25 от 16.03.2001 г., бр. 111 от 28.12.2001 г.; изм. и доп., бр. 18 от 25.02.2003 г.; изм., бр. 114 от 30.12.2003 г.; изм. и доп., бр. 70 от 10.08.2004 г., бр. 76 от 20.09.2005 г.; изм., бр. 33 от 21.04.2006 г.; изм. и доп., бр. 48 от 13.06.2006 г.

Наредба № 6 от 15.08.2005 г. за минималните изисквания за осигуряване на здравето и безопасността на работещите при рискове, свързани с експозиция на шум
Държавен вестник, бр. 70 от 26.08.2005 г.

Наредба № 7 от 23.09.1999 г. за минималните изисквания за здравословни и безопасни условия на труд на работните места и при използване на работното оборудване
Държавен вестник, бр. 88 от 8.10.1999 г.; изм., бр. 48 от 13.06.2000 г., бр. 52 от 8.06.2001 г.; изм. и доп., бр. 43 от 13.05.2003 г.; изм., бр. 37 от 4.05.2004 г.; изм. и доп., бр. 88 от 8.10.2004 г.

ČESKÁ REPUBLIKA (Czech Republic)

Zákon č. 262/2006 Sb., zákoník práce, ve znění pozdějších předpisů
Sbírka zákonů č. 262/2006, strana 3146, částka 84, ze dne 7. 6. 2006

Zákon č. 309/2006 Sb., kterým se upravují další požadavky bezpečnosti a ochrany zdraví při práci v pracovněprávních vztazích a o zajištění bezpečnosti a ochrany zdraví při činnosti nebo poskytování služeb mimo pracovněprávní vztahy (zákon o zajištění dalších podmínek bezpečnosti a ochrany zdraví při práci), ve znění pozdějších předpisů
Sbírka zákonů č. 309/2006, strana 3789, částka 96, ze dne 22. 6. 2006

Nařízení vlády č. 11/2002 Sb., kterým se stanoví vzhled a umístění bezpečnostních značek a zavedení signálů, ve znění pozdějších předpisů
Sbírka zákonů č. 11/2002, strana 314, částka 6, ze dne 15. 1. 2002

Nařízení vlády č. 148/2006 Sb., o ochraně zdraví před nepříznivými účinky hluku a vibrací
Sbírka zákonů č. 148/2006, strana 1842, částka 51, ze dne 21. 4. 2006

Vyhláška č. 432/2003 Sb., kterou se stanoví podmínky pro zařazování prací do kategorií, limitní hodnoty ukazatelů biologických expozičních textů, podmínky odběru biologického materiálu pro provádění biologických expozičních testů a náležitosti hlášení prací s azbestem a biologickými činiteli
Sbírka zákonů č. 432/2003, strana 7210, částka 142, ze dne 15. 12. 2003

Nařízení vlády č. 361/2007 Sb., kterým se stanoví podmínky ochrany zdraví zaměstnanců při práci
Sbírka zákonů č. 361/2007, strana 5086, částka 111, ze dne 28. 12. 2007

Vyhláška Ministerstva pro místní rozvoj č. 137/1998 Sb., o obecných technických požadavcích na výstavbu
Sbírka zákonů č. 137/1998, strana 6594, částka 49, ze dne 1. 7. 1998

Vyhláška Ministerstva zdravotnictví č. 342/1997 Sb., kterou se stanoví postup při uznávání nemocí z povolání a vydává seznam zdravotnických zařízení, která tyto nemoci uznávají
Sbírka zákonů č. 342/1997, strana 7004, částka 113, ze dne 31. 12. 1997

Zákon č. 20/1966 Sb., o péči o zdraví lidu, ve znění pozdějších předpisů
Sbírka zákonů č. 20/1996, strana 74, částka 7, ze dne 30. 3. 1966

Zákon č. 258/2000 Sb., o ochraně veřejného zdraví a o změně některých souvisejících zákonů, ve znění pozdějších předpisů
Sbírka zákonů č. 258/2000, strana 3622, částka 74, ze dne 11. 8. 2000

ΚΥΠΡΟΣ (Cyprus)

Οι περί ασφάλειας και υγείας στην εργασία (προστασία από το θόρυβο) κανονισμοί του 2006
Επίσημη Εφημερίδα της Κυπριακής Δημοκρατίας, αριθ. 4124, 28.7.2006

DANMARK (Denmark)

Bekendtgørelse om besætningsmedlemmers udsættelse for støj (Støjbekendtgørelsen)
BEK nr. 18 af 9.1.2006
Lovtidende A, 24.1.2006

Bekendtgørelse om beskyttelse mod udsættelse for støj i forbindelse med arbejdet
BEK nr. 63 af 6.2.2006
Lovtidende A, 6.2.2006

Bekendtgørelse om beskyttelse mod udsættelse for støj i forbindelse med arbejdet på havanlæg
BEK nr. 54 af 31.1.2006
Lovtidende A, 10.2.2006

DEUTSCHLAND (Germany)

Verordnung zur Umsetzung der EG-Richtlinien 2002/44/EG und 2003/10/EG zum Schutz der Beschäftigten vor Gefährdungen durch Lärm und Vibrationen vom 6. März 2007
Bundesgesetzblatt Jahrgang 2007 Teil I Nr. 8 vom 8. März 2007 , S. 261-277.

EIRE (Ireland)

Safety, health and welfare at work (control of noise at work) regulations 2006
Statutory Instrument No 371 of 2006

EESTI (Estonia)

Töökeskkonna füüsikaliste ohutegurite piirnormid ja ohutegurite parameetrite mõõtmise kord – Vabariigi Valitsuse 25. jaanuari 2002. a määrus nr 54
RTI, 07.02.2002, 15, 83

Töötervishoiu ja tööohutuse nõuded mürast mõjutatud töökeskkonnale, töökeskkonna müra piirnormid ja müra mõõtmise kord – Vabariigi Valitsuse 12. aprilli 2007. a määrus nr 108
RTI, 27.04.2007, 34, 214

Ελλάδα (Greece)

Προεδρικό διάταγμα υπ᾽ αριθ. 149. Ελάχιστες προδιαγραφές υγείας και ασφάλειας όσον αφορά την έκθεση των εργαζομένων σε κινδύνους προερχόμενους από φυσικούς παράγοντες (θόρυβος) σε εναρμόνιση με την οδηγία 2003/10/ΕΚ
ΦΕΚ, Τεύχος Α, αριθ. 159, σ. 1657

ESPAÑA (Spain)

Real Decreto 286/2006, de 10 de marzo, sobre la protección de la salud y la seguridad de los trabajadores contra los riesgos relacionados con la exposición al ruido.
Boletín Oficial del Estado n° 60/2006, de 11 marzo de 2006, pp. 9842-9848

Corrección de errores del Real Decreto 286/2006, de 10 de marzo, sobre la protección de la salud y la seguridad de los trabajadores contra los riesgos relacionados con la exposición al ruido.
Boletín Oficial del Estado n° 62/2006, de 14 marzo de 2006, p. 10170

Corrección de errores del Real Decreto 286/2006, de 10 de marzo, sobre la protección de la salud y la seguridad de los trabajadores contra los riesgos relacionados con la exposición al ruido.
Boletín Oficial del Estado n° 71/2006, de 24 marzo de 2006, p. 11535

FRANCE

Décret n° 2006-892 du 19 juillet 2006 du ministère de l'emploi, de la cohésion sociale et du logement relatif aux prescriptions de sécurité et de santé applicables en cas d'exposition des travailleurs aux risques dus au bruit et modifiant le code du travail (deuxième partie: «Décrets en Conseil d'État»)
Journal officiel de la République française du 20 juillet 2006

Arrêté du 19 juillet 2006 du ministère de l'emploi, de la cohésion sociale et du logement pris pour l'application des articles R. 231-126, R. 231-128 et R. 231-129 du code du travail
Journal officiel de la République française du 29 juillet 2006

ITALIA (Italy)

Decreto legislativo n. 195, del 10 aprile 2006, Attuazione della direttiva 2003/10/CE relativa all'esposizione dei lavoratori ai rischi derivanti dagli agenti fisici (rumore)
Gazzetta ufficiale della Repubblica italiana, serie generale, n°124 del 30 maggio 2006, pag. 3.

LATVIJA (Latvia)

Ministru kabineta noteikumi nr. 66 "Darba aizsardzības prasības nodarbināto aizsardzībai pret darba vides trokšņa radīto risku"
Latvijas Vēstnesis Nr. 21, 2003. gada 7. februāris

LIETUVA (Lithuania)

Lietuvos Respublikos sveikatos apsaugos ministro įsakymas Nr. V-520 „Dėl Lietuvos higienos normos HN 33-1:2003 „Akustinis triukšmas. Leidžiami

lygiai gyvenamojoje ir darbo aplinkoje. Matavimo metodikos bendrieji reikalavimai“ patvirtinimo“
Valstybės žinios, 2003.09.12, Nr. 87

Lietuvos Respublikos socialinės apsaugos ir darbo ministro ir Lietuvos Respublikos sveikatos apsaugos ministro įsakymas Nr. A1-103/V-265 „Dėl darbuotojų apsaugos nuo triukšmo keliamos rizikos nuostatų patvirtinimo“
Valstybės žinios, 2005.04.26, Nr. 53

LUXEMBOURG

Règlement grand-ducal du 6 février 2007:
1) concernant les prescriptions minimales de sécurité et de santé relatives à l'exposition des travailleurs aux risques dus aux agents physiques (bruit)
2) portant modification du règlement grand-ducal du 17 juin 1997 concernant la périodicité des examens médicaux en matière de médecine du travail
Mémorial luxembourgeois du 2 mars 2007, A-n° 23, p. 527-532

MAGYARORSZÁG (Hungary)

Az egészségügyi miniszter 66/2005. (XII. 22.) EüM rendelete a munkavállalókat érõ zajexpozícióra vonatkozó minimális egészségi és biztonsági követelményekről,
Magyar Közlöny, 2005/12/22, 2005/166. sz., 10515–10524..

MALTA

L.N. 158 of 2006 Occupational Health and Safety Authority Act (CAP. 424) Work Place (Minimum Health and Safety Requirements for the Protection of Workers from Risks resulting from Exposure to Noise) Regulations, 2006
The Malta Government Gazette No. 17947, 28.7.2006, pp. 02873–02892

NEDERLAND (Netherlands)

Besluit van 25 januari 2006 tot wijziging van het Arbeidsomstandighedenbesluit, houdende regels met betrekking tot de blootstelling van werknemers aan de risico's van lawaai
Staatsblad van 9.2.2006, nr. 56.

ÖSTERREICH (Austria)

Verordnung der Landesregierung vom 16. Dezember 2003 über den Schutz der Bediensteten bei der Ausführung von Bauarbeiten (Bauarbeiterschutz-Verordnung – Bau-V)
Landesgesetzblatt (LGBl.) für Tirol Nr. 141 vom 30.12.2003, S. 491

Verordnung der Landesregierung vom 16. Dezember 2003 über den Schutz jugendlicher Bediensteter (Jugendbedienstetenschutz-Verordnung – JBed-V)
Landesgesetzblatt (LGBl.) für Tirol Nr. 140 vom 30.12.2003, S. 489

Verordnung der Landesregierung vom 16. Dezember 2003 über persönliche Schutzausrüstungen und Dienstbekleidung (Persönliche-Schutzausrüstungs-Verordnung – PSA-V)
Landesgesetzblatt (LGBl.) für Tirol Nr. 139 vom 30.12.2003, S. 487

Verordnung der Landesregierung vom 16. Dezember 2003 über den Schutz der Bediensteten vor Gefährdung durch bestimmte physikalische Einwirkungen am Arbeitsplatz (Verordnung über physikalische Einwirkungen – VPhE)
Landesgesetzblatt (LGBl.) für Tirol Nr. 138 vom 30.12.2003, S. 480

Verordnung der Landesregierung vom 16. Dezember 2003 über den Schutz der Bediensteten bei der Benutzung von Arbeitsmitteln (Arbeitsmittel-Verordnung – Am-V)
Landesgesetzblatt (LGBl.) für Tirol Nr. 135 vom 30.12.2003, S. 466

Verordnung der Landesregierung vom 16. Dezember 2003 über besondere Fachkenntnisse für bestimmte Tätigkeiten und ihren Nachweis (Fachkenntnisse-Verordnung – Fachk-V)
Landesgesetzblatt (LGBl.) für Tirol Nr. 134 vom 30.12.2003, S. 465

Verordnung der Landesregierung vom 16. Dezember 2003 über die Sicherheits- und Gesundheitsschutzkennzeichnung (Kennzeichnung-Verordnung – Kenn-V)
Landesgesetzblatt (LGBl.) für Tirol Nr. 133 vom 30.12.2003, S. 463

Verordnung der Landesregierung vom 16. Dezember 2003 über die Präventivfachkräfte, Sicherheitsvertrauenspersonen, Erst-Helfer und Brandschutzbeauftragten (Präventivdienst-Verordnung – PrävD-V)
Landesgesetzblatt (LGBl.) für Tirol Nr. 130 vom 30.12.2003, S. 455

Verordnung der Landesregierung vom 16. Dezember 2003 über die Sicherheits- und Gesundheitsschutzdokumente und sonstige Dokumentationspflichten (Dokum. Verord. -Dok-V)
Landesgesetzblatt (LGBl.) für Tirol Nr. 132 vom 30.12.2003, S. 461

Verordnung der Landesregierung vom 16. Dezember 2003 über die Gesundheitsüberwachung am Arbeitsplatz (Gesundheitsüberwachung- GÜ-V)
Landesgesetzblatt (LGBl.) für Tirol Nr. 131 vom 30.12.2003, S. 458

Gesetz vom 2. Juli 2003 über den Schutz der Bediensteten in den Dienststellen des Landes Tirol, der Gemeinden und der Gemeindeverbände (Tiroler Bedienstetenschutzgesetz 2003 – TBSG 2003)
Landesgesetzblatt (LGBl.) für Tirol Nr. 75 vom 2.9.2003, S. 275

Landesverfassungsgesetz und Gesetz vom 18. November 2004, mit dem die Kärntner Landesverfassung geändert wird und ein Gesetz über die Sicherheit und den Gesundheitsschutz der in den Dienststellen des Landes, der Gemeinden und Gemeindeverbände beschäftigten Bediensteten (Kärntner Bedienstetenschutzgesetz 2005 – K-BSG) erlassen wird
Kärntner Landesgesetzblatt (LGBl.) vom 3.2.2005, Nr. 7/2005

Verordnung der Oö. Landesregierung über den Schutz der Bediensteten vor Gefährdung durch bestimmte physikalische Einwirkungen (Oö. Verordnung über physikalische Einwirkungen PhysEV)
Landesgesetzblatt (LGBl.) für Oberösterreich vom 31.3.2005, Nr. 14/2005

Oberösterreichisches Dienstrechtsänderungsgesetz 2005
Landesgesetzblatt (LGBl.) für Oberösterreich vom 6.5.2005, Nr. 49/2005

Gesetz, mit dem die Landarbeitsordnung 2000 geändert wird
Landesgesetzblatt (LGBl.) vom 11.5.2005, Nr. 61/2005

Verordnung, mit der die Land- und forstwirtschaftliche Sicherheits- und Gesundheitsschutz-Verordnung geändert wird
Landesgesetzblatt (LGBl.) für Tirol Nr. 62/2005 vom 15.8.2005

Gesetz der Steiermärkischen Landesregierung vom 5. Juli 2005 , mit dem die Steiermärkische Landarbeitsordnung 2001 (STLAO 2001) geändert wird
Landesgesetzblatt (LGBl.), Land Steiermark, vom 18.10.2005, Nr. 102/2005

Oberösterreiche Gemeinde-Verordnung über physikalische Einwirkungen
Landesgesetzblatt (LGBl.) für Oberösterreich vom 30.11.2005, Nr. 121/2005

Oberösterreiche Gemeindebediensteten-Schutzgesetz – Novelle 2003
Landesgesetzblatt (LGBl.) für Oberösterreich vom 29.8.2003, Nr. 99/2003

Gesetz, mit dem die Kärntner Landarbeitsordnung 1995 geändert wird
Kärntner Landesgesetzblatt (LGBl.) vom 28.12.2005, Nr. 104/2005

Verordnung Lärm und Vibrationen – VOLV sowie Änderung der Bauarbeiterschutzverordnung und der Verordnung über die Gesundheitsüberwachung am Arbeitsplatz
Bundesgesetzblatt für die Republik Österreich (BGBl.) vom 25.1.2006, Teil II Nr. 22/2006

Gesetz vom 14. Dezember 2005, mit dem die Salzburger Landarbeitsordnung 1995 geändert wird
Landesgesetzblatt (LGBl.) vom 16.2.2006, Nr. 21/2006

Gesetz, mit dem die Wiener Landarbeitsordnung 1990 geändert wird
Landesgesetzblatt (LGBl.) für Wien vom 14.2.2006, Nr. 11/2006

Verordnung der Bundesregierung über den Schutz der Bediensteten vor der Gefährdung durch Lärm und Vibrationen (B-VOLV)
Bundesgesetzblatt für die Republik Österreich (BGBl.) vom 28.2.2006, Teil II Nr. 90/2006

Verordnung der Wiener Landesregierung über den Schutz der in Dienststellen der Gemeinde Wien beschäftigten Bediensteten vor der Gefährdung durch Lärm und Vibrationen und mit der die Verordnung der Wiener Landesregierung über die Gesundheitsüberwachung am Arbeitsplatz in Dienststellen der Gemeinde Wien geändert wird
Landesgesetzblatt (LGBl.) für Wien vom 13.3.2006, Nr. 22/2006

Gesetz vom 14. Februar 2006, mit dem die Steiermärkische Landarbeitsordnung 2001 (STLAO 2001) geändert wird
Landesgesetzblatt (LGBl.), Land Steiermark, vom 14.2.2006, Nr. 55/2006

NÖ Bediensteten-Schutzverordnung 2003 (NÖ BSVO 2003)
Landesgesetzblatt (LGBl.) für das Land Niederösterreich vom 22.5.2006, Nr. 2015/1-1

Gesetz vom 20. April 2006, mit dem die Burgenländische Landarbeitsordnung 1977 geändert wird
Landesgesetzblatt (LGBl.) für das Burgenland vom 16.6.2006, Nr. 27/2006

Verordnung der Wiener Landesregierung, mit der die Verordnung der Wiener Landesregierung über die Gesundheitsüberwachung in land- und forstwirtschaftlichen Betrieben geändert wird
Landesgesetzblatt (LGBl.) für Wien vom 23.6.2006, Nr. 38/2006

Verordnung der Wiener Landesregierung über den Schutz der Dienstnehmer und Dienstnehmerinnen in land- und forstwirtschaftlichen Betrieben vor der Gefährdung durch Lärm und Vibrationen (Wiener Verordnung Lärm und Vibrationen in der Land- undForstwirtschaft – Wr. VOLV Land- und Forstwirtschaft)
Landesgesetzblatt (LGBl.) für Wien vom 30.6.2006, Nr. 39/2006

Verordnung der Salzburger Landesregierung vom 30. Juni 2006 über den Schutz der Landes- und Gemeindebediensteten sowie der Dienstnehmer in der Land- und Forstwirtschaft gegen Gefährdung durch Einwirkungen von Lärm und Vibrationen (Lärm- und Vibrationenschutz-Verordnung – LäVib-V)
Landesgesetzblatt (LGBl.), Land Salzburg, vom 20.7.2006, Nr. 58/2006

Verordnung der Burgenländischen Landesregierung über den Schutz der Bediensteten vor der Gefährdung durch Lärm und Vibrationen (L-VOLV)
Landesgesetzblatt (LGBl.) für das Burgenland vom 22.9.2006, Nr. 48/2006

Verordnung vom 10. Oktober 2006 zum Schutz der DienstnehmerInnen vor der Gefährdung durch Lärm und Vibrationen (VOLV-Lufw)
Landesgesetzblatt (LGBl.), Land Steiermark, vom 30.10.2006, Nr. 127/2006

Verordnung der Landesregierung über den Schutz der Landes- und Gemeindebediensteten vor der Gefährdung durch physikalische Einwirkungen (Lärm und Vibrationen)
Landesgesetzblatt (LGBl.) vom 24.10.2006, Nr. 47/2006

Verordnung über die Gesundheitsüberwachung in der Land- und Forstwirtschaft
Landesgesetzblatt (LGBl.) vom 20.12.2006, Nr. 63/2006

Verordnung der Burgenländischen Landesregierung vom 6. Dezember 2006 über den Schutz der Dienstnehmerinnen und Dienstnehmer in der Land- und Forstwirtschaft vor der Gefährdung durch Lärm und Vibrationen
Landesgesetzblatt (LGBl.) für das Burgenland vom 20.12.2006, Nr. 62/2006

Verordnung über die Gesundheitsüberwachung in land-und forstwirtschaftlichen Betrieben
Landesgesetzblatt (LGBl.) für das Land Niederösterreich vom 27.11.2006, Nr. 9020/13-1

Verordnung über den Schutz der Dienstnehmer in der Land- und Forstwirtschaft vor Gefährdung durch Lärm und Vibrationen
Landesgesetzblatt (LGBl.) für das Land Niederösterreich vom 27.11.2006, Nr. 9020/16-0

Verordnung der Oö. Landesregierung über den Schutz der Dienstnehmerinnen und Dienstnehmer in der Land- und Forstwirtschaft

vor Gefährdung durch Lärm und Vibrationen
Landesgesetzblatt (LGBl.) vom 30.11.2006, Nr. 121/2006

Gesetz über eine Änderung des Landes- und Gemeindebediensteten-Schutzgesetzes
Landesgesetzblatt (LGBl.) vom 16.1.2007, Nr. 5/2007

Verordnung der Salzburger Landesregierung vom 22. Dezember 2006 über die Überwachung der Gesundheit von Bediensteten des Landes, der Gemeinden und Gemeindeverbände sowie der Bediensteten in der Land- und Forstwirtschaft (Salzburger Gesundheitsüberwachungs-Verordnung – S.GÜV)
Landesgesetzblatt (LGBl.), Land Salzburg, vom 25.1.2007, Nr. 3/2007

Verordnung über die Durchführung des Bedienstetenschutzes im Bereich der Dienststellen des Landes
Landesgesetzblatt (LGBl.) vom 21.11.2006, Nr. 135/2006

Verordnung der Kärntner Landesregierung über die Durchführung des Bedienstetenschutzes im Bereich der Dienststellen des Landes, der Gemeinden und Gemeindeverbände (K-BSDV)
Kärntner Landesgesetzblatt (LGBl.) vom 16.3.2007, Nr. 22/2007

Verordnung der Agrarbezirksbehörde Bregenz über den Schutz der land- und forstwirtschaftlichen Dienstnehmer vor der Gefährdung durch physikalische Einwirkungen (Lärm und Vibrationen)
Landesgesetzblatt (LGBl.) vom 24.3.2007, Nr. 12/2007

Verordnung der Kärntner Landesregierung über den Schutz der Dienstnehmer in der Land- und Forstwirtschaft vor der Gefährdung durch Lärm und Vibrationen
Kärntner Landesgesetzblatt (LGBl.) vom 16.3.2007, Nr. 21/2007

NÖ Landarbeitsordnung 1973
Landesgesetzblatt (LGBl.) für das Land Niederösterreich vom 30.12.2005, Nr. 9020-22

Verordnung der Oberösterreichischen Landesregierung über die Gesundheitsüberwachung in der Land- und Forstwirtschaft (Oö. VGÜ-LF)
Landesgesetzblatt (LGBl.) für Oberösterreich vom 30.4.2007, Nr. 31/2007

Kodex zur Lärmreduktion im Musik- und Unterhaltungssektor
Bundesgesetzblatt für die Republik Österreich (BGBl.) vom 1.2.2007

POLSKA (Poland)

Rozporządzenie Ministra Zdrowia z dnia 5 kwietnia 2001 r. zmieniające rozporządzenie w sprawie przeprowadzania badań lekarskich pracowników, zakresu profilaktycznej opieki zdrowotnej nad pracownikami oraz orzeczeń lekarskich wydawanych do celów przewidzianych w Kodeksie pracy
Dz. U. z 2001 r. Nr 37, poz. 451

Rozporządzenie Ministra Zdrowia i Opieki Społecznej z dnia 17 grudnia 1998 r. zmieniające rozporządzenie w sprawie przeprowadzania badań lekarskich pracowników, zakresu profilaktycznej opieki zdrowotnej nad pracownikami oraz orzeczeń lekarskich wydawanych do celów przewidzianych w Kodeksie pracy
Dz. U. z 1998 r. Nr 159, poz. 1057

Rozporządzenie Ministra Zdrowia i Opieki Społecznej z dnia 20 maja 1997 r. zmieniające rozporządzenie w sprawie przeprowadzania badań lekarskich pracowników, zakresu profilaktycznej opieki zdrowotnej nad pracownikami oraz orzeczeń lekarskich wydawanych do celów przewidzianych w Kodeksie pracy
Dz. U. z 1997 r. Nr 60, poz. 375

Rozporządzenie Ministra Zdrowia z dnia 16 stycznia 2003 r. zmieniające rozporządzenie w sprawie rodzajów dokumentacji medycznej służby medycyny pracy oraz sposobu jej prowadzenia i przechowywania
Dz. U. z 2003 r. Nr 37, poz. 328

Rozporządzenie Ministra Zdrowia i Opieki Społecznej z dnia 15 września 1997 r. w sprawie rodzajów dokumentacji medycznej służby medycyny pracy oraz sposobu jej prowadzenia i przechowywania
Dz. U. z 1997 r. Nr 120, poz. 768

Rozporządzenie Ministra Zdrowia i Opieki Społecznej z dnia 30 maja 1996 r. w sprawie przeprowadzenia badań lekarskich pracowników, zakresu profilaktycznej opieki zdrowotnej nad pracownikami oraz orzeczeń lekarskich wydawanych do celów przewidzianych w Kodeksie pracy
Dz. U. z 1996 r. Nr 69, poz. 332

Rozporządzenie Rady Ministrów z dnia 30 lipca 2002 r. w sprawie wykazu chorób zawodowych, szczegółowych zasad postępowania w sprawach zgłaszania podejrzenia, rozpoznawania i stwierdzania chorób zawodowych oraz podmiotów właściwych w tych sprawach
Dz. U. z 2002 r. Nr 132, poz. 1115

Ustawa z dnia 27 czerwca 1997 r. o służbie medycyny pracy
Dz. U. z 2004 r. Nr 125, poz. 1317

Rozporządzenie Ministra Gospodarki i Pracy z dnia 27 lipca 2004 r. w sprawie szkolenia w dziedzinie bezpieczeństwa i higieny pracy
Dz. U. z 2004 r. Nr 180, poz. 1860

Rozporządzenie Ministra Gospodarki i Pracy z dnia 28 czerwca 2005 r. zmieniające rozporządzenie w sprawie szkolenia w dziedzinie bezpieczeństwa i higieny pracy
Dz. U. z 2005 r. Nr 116, poz. 972

Rozporządzenie Ministra Pracy i Polityki Socjalnej z dnia 26 września 1997 r. w sprawie ogólnych przepisów bezpieczeństwa i higieny pracy
Dz. U. z 2003 r. Nr 169, poz. 1650

Rozporządzenie Ministra Gospodarki, Pracy i Polityki Społecznej z dnia 10 kwietnia 2003 r. w sprawie zasadniczych wymagań dla maszyn i elementów bezpieczeństwa
Dz. U. z 2003 r. Nr 91, poz. 858

Rozporządzenie Ministra Zdrowia z dnia 20 kwietnia 2005 r. w sprawie badań i pomiarów czynników szkodliwych dla zdrowia w środowisku pracy
Dz. U. z 2005 r. Nr 73, poz. 645

Ustawa z dnia 26 lipca 2002 r. o zmianie ustawy – Kodeks pracy oraz zmianie niektórych innych ustaw
Dz. U. z 2002 r. Nr 135, poz. 1146

Ustawa z dnia 24 sierpnia 2001 r. o zmianie ustawy – Kodeks pracy oraz o zmianie niektórych innych ustaw
Dz. U. z 2001 r. Nr 128, poz. 1405

Ustawa z dnia 14 listopada 2003 r. o zmianie ustawy – Kodeks pracy oraz o zmianie niektórych innych ustaw
Dz. U. z 2003 r. Nr 213, poz. 2081

Ustawa z dnia 26 czerwca 1974 r. Kodeks Pracy
Dz. U. z 1998 r. Nr 21, poz. 94

Rozporządzenie Ministra Gospodarki i Pracy z dnia 5 sierpnia 2005 r. w sprawie bezpieczeństwa i higieny pracy przy pracach związanych z narażeniem na hałas lub drgania mechaniczne
Dz. U. z 2005 r. Nr 157, poz. 1318

Rozporządzenie Rady Ministrów z dnia 24 sierpnia 2004 r. w sprawie wykazu prac wzbronionych młodocianym i warunków ich zatrudniania przy niektórych z tych prac
Dz. U. z 2004 r. Nr 200, poz. 2047

Rozporządzenie Rady Ministrów z dnia 30 lipca 2002 r. zmieniające rozporządzenie w sprawie wykazu prac wzbronionych kobietom
Dz. U. z 2002 r. Nr 127, poz. 1092

PORTUGAL

Decreto-lei n.º 182/2006 de 6 de Setembro que transpõe para a ordem jurídica interna a Directiva 2003/10/CE, do Parlamento Europeu e do Conselho, de 6 de Fevereiro, relativa às prescrições mínimas de segurança e de saúde em matéria de exposição dos trabalhadores aos riscos devidos aos agentes físicos (ruído)
Diário da República, I.ª série, n.º 172, de 6 de Setembro de 2006, p. 6584-6598

ROMÂNIA (Romania)

Hotărârea Guvernului nr. 493/2006 privind cerinţele minime de securitate şi sănătate referitoare la expunerea lucrătorilor la riscurile generate de zgomot
Monitorul Oficial al României nr. 380 din 3 mai 2006, pagina: 00011-00015.

Hotărârea Guvernului nr. 601/2007 pentru modificarea şi completarea unor acte normative din domeniul securităţii şi sănătăţii în muncă
Monitorul Oficial al României nr. 470 din 12 iulie 2007,
pagina: 00003-00006.

SLOVENIJA (Slovenia)

Pravilnik o varovanju delavcev pred tveganji zaradi izpostavljenosti hrupu pri delu
Uradni list RS št. 7/2001, str. 648–652

Pravilnik o varovanju delavcev pred tveganji zaradi izpostavljenosti hrupu pri delu
Uradni list RS št. 17/2006, str. 1536–1540

Popravek predpisa 2006-01-0643
Uradni list RS št. 18/2006, str. 1723

SLOVENSKÁ REPUBLIKA (Slovakia)

Nariadenie vlády Slovenskej republiky č. 115/2006 Z.z. o minimálnych zdravotných a bezpečnostných požiadavkách na ochranu zamestnancov pred rizikami súvisiacimi s expozíciou hluku
Zbierka zákonov č. 115/2006, strana 762, čiastka 47, zo dňa 1.3.2006.

Zákon č. 126/2006 Z.z. o verejnom zdravotníctve a o zmene a doplnení niektorých zákonov
Zbierka zákonov č. 126/2006, strana 860, čiastka 52, zo dňa 9.3.2006.

Zákon č. 355/2007 Z.z. o ochrane, podpore a rozvoji verejného zdravia a o zmene a doplnení niektorých zákonov
Zbierka zákonov č. 355/2007, strana 2402, čiastka 154, zo dňa 31.7.2007.

SUOMI (Finland)

Valtioneuvoston asetus (831/2005) terveystarkastuksista erityistä sairastumisen vaaraa aiheuttavissa töissä annetun valtioneuvoston asetuksen muuttamisesta, annettu Helsingissä 13 päivänä lokakuuta 2005 / Statsrådets förordning (831/2005) om ändring av statsrådets förordning om hälsoundersökningar i arbete som medför särskild fara för ohälsa, given i Helsingfors den 13 oktober 2005
(Suomen säädöskokoelma N:o 831, 26.10.2005, s. 4103).

Valtioneuvoston asetus (85/2006) työntekijöiden suojelemisesta melusta aiheutuvilta vaaroilta, annettu Helsingissä 26 päivänä tammikuuta 2006 / Statsrådets förordning (85/2006) om skydd av arbetstagare mot risker som orsakas av buller, given i Helsingfors den 26 januari 2006
(Suomen säädöskokoelma N:o 85, 2.2.2006, s. 303).

SVERIGE (Sweden)

Sjöfartsverkets föreskrifter och allmänna råd om arbetsmiljö på fartyg (SJÖFS 2005:23)

Arbetsmiljöverkets föreskrifter om buller (AFS 2005:16)

Arbetsmiljöverkets föreskrifter om arbetsplatsens utformning (AFS 2000:42)

Arbetsmiljöverkets föreskrifter om medicinska kontroller i arbetslivet AFS 2005:6)

Arbetsmiljöverkets föreskrifter om systematiskt arbetsmiljöarbete (AFS 2001:1)

Arbetsmiljöverkets föreskrifter om gravida och ammande arbetstagare (AFS 1994:32)

Arbetsmiljöverkets föreskrifter om användning av personlig skyddsutrustning (AFS 2001:3)

Lag (2004:175) om ändring i sekretesslagen (1980:100)

Lag (1998:531) om yrkesverksamhet på hälso- och sjukvårdens område

Arbetsmiljölag (1977:1160)

Patientjournallagen (1985:562)

Arbetsmiljöförordning (1977:1166)

UNITED KINGDOM

The control of noise at work regulations 2005
Statutory Instruments, 2005, No 1643, 28.6.2005

The control of noise at work regulations (Northern Ireland) 2006
Statutory Rules of Northern Ireland, 2006, No 1, 10.1.2006

The control of noise at work regulations 2006 (Gibraltar)
Gibraltar Gazette, No 3535, 1.6.2006

BIBLIOGRAPHY

European Union

PPE guidelines on the application of Council Directive 89/686/EEC of 21 December 1989 on the approximation of the laws of the Member States relating to personal protective equipment
European Commission, Directorate-General for Enterprise and Industry, 17 July 2006
Website: **http://ec.europa.eu/enterprise/mechan_equipment/ppe/guide.htm**

European Week for Safety and Health Work, 2005
European Agency for Safety and Health at Work
ISBN 92-9191-153-4

Expert forecast on emerging physical risks related to occupational safety and health
Risk Oservatory — Thematic report, 2005
European Agency for Safety and Health at Work
ISBN 92-9191-165-8

NoiseChem: a European Commission research project on the effects of exposure to noise and industrial chemicals on hearing and balance
D. Prasher, T. Morata, P. Campo, L. Fechter, A. Johnson, S. Lund, K. Pawlas, J. Starck, W. Sulkowski and M. Sliwinska-Kowalska
International Journal of Occupational Medicine and Environmental Health, 2002

Noise in figures
Risk Oservatory — Thematic report, 2005
European Agency for Safety and Health at Work
ISBN 92-9191-150-X

OSH in figures: Young workers — Facts and figures
European Risk Observatory Report 2006
European Agency for Safety and Health at Work
ISBN 92-9191-131-3

Prevention of risks from ocupational noise in practice — 2005
European Agency for Safety and Health at Work
ISBN 92-9191-153-4

Reducing the risks from occupational noise — European Week for Safety and Health at Work — 2005
European Agency for Safety and Health at Work
ISBN: 92-9191-167-4

Risk Observatory — Thematic report: Noise in figures — 2005
European Agency for Safety and Health at Work
ISBN: 92-9191-150-X

Code of good practice for implementing 'Council Directive 86/188/EEC on the protection of workers from the risks related to exposure to noise at work' in the underground workings of the extractive industries
Adopted by the SHCMOEI at the plenary meeting held on 20 December 1990
Doc. No 5025/7/89 [EN] of 20 December 1990

BELGIQUE/BELGIË (Belgium)

Bruit: stratégie d'évaluation et de prévention des risques
J. Malchaire, A. Piette et N. Cock, ministère fédéral de l'emploi et du travail, Belgique, 1998, 80 p.

ČESKÁ REPUBLIKA (Czech Republic)

Manual prevence v lekarské praxi, Souborne vydani, I. – V. dil, Statni zdravotni ustav

Praha, 1998, ISBN 80-7071-080-2.

Smetana, C. a kol., Hluk a vibrace, Sdělovací technika

Praha 1998, ISBN 80-90-1936-2-5.

ΚΥΠΡΟΣ (Cyprus)

DANMARK (Denmark)

Når hørelsen svigter: Om konsekvenserne af hørenedsættelse i arbejdslivet, uddannelsessystemet og for den personlige velfærd
Udført af Det Danske Socialforskningsinstitut
Danmark, 2003

Støj i landbruget — Er det et problem?
Tekst: Per Møberg Nielsen — Denmark AkustikNet A/S
Tryk: Centraltrykkeriet Skive A/S, 2004
ISBN: 87-91073-17

1. oplag: 10 000 — marts 2004
Websted: **www.akustiknet.dk**

Vejviser til de vigtigste arbejdsmiljøproblemer: Arbejdsmiljøvejviser 42
Arbejdstilsynet — Danmark — 16 s.

DEUTSCHLAND (Germany)

Akustische Gestaltung von Bildschirmarbeitsplätzen in Büros
BAuA, Technik, 2003
ISBN: 3-88261-402-1

Akustische Gestaltung von Bildschirmarbeitsplätzen in der Produktion
BAuA, Technik, 2003
ISBN: 3-88261-403- 27

Anwendungsbeispiele raumakustisch optimierter Fertigungsräume, HVBG, BGI 678

Aufgabenbezogene Beurteilung der beruflichen Belastungen mit Lärm und Vibrationen bei Forstarbeitern
R. Neitzel, M. Yost (2002)
AIHA J 63 (2002) 617-627/

Auswahl/Beschaffung leiser Maschinen FA
Informationsblatt Nr. 13, Fachausschuss Maschinenbau, Fertigungstechnik, Stahlbau (FA MFS), FA MSF 2005 – 6

Berufsbedingte Lärm- und Vibrationsexposition als Herz-Kreislauf-Risikofaktoren
B. Idzior-Walus (1987)
European Heart Journal, Band 8 (1987) S. 1040-1046)

Die kombinierte Wirkung des Lärms und der Ganzkörpervibration auf das Gehör des Landmaschinenfahrers
M. Schmidt (1992)
Zeitschrift für Lärmbekämpfung, Band 39 (1992) Nr. 2, S. 43-51 (Abb., Tab., 12 Lit.)

Der Mensch im Lärm (Lärm Teil 1)
Knoch/ Neugebauer.
Verlag Technik & Information, Bochum 2003
ISBN 3-928535-57-9

Druckluftdüsen – Anwendungsbeispiele aus der betrieblichen Praxis
HVBG, BGI 681

Einfluss beruflicher Lärm- und Vibrationsbelastung auf die Beschwerdenhäufigkeit
A.-M., Metz, A. Meister (1984)
Arbeitsmedizin-Information, Band 11 (1984) Nr. 1, S. 14-17

Einführung in die wichtigsten Grundlagen der Akustik
I. Veit, Vogel-Verlag Würzburg 1996

Extraaurale Wirkung von Erdbaumaschinenlärm unterschiedlicher Tonhaltigkeit – isoliert und in Kombination mit Ganzkörperschwingung (Abschlussbericht)
Bundesanstalt für Arbeitsschutz und Arbeitsmedizin
M. Schust, H. Seidel, H. Seidel u. a. (1997)
Dortmund: Schriftenreihe-Forschung-, Fb 775, Wirtschaftsverlag NW Bremerhaven, 1997, 224 S. (Abb., Tab., Lit.)
ISBN 3- 89701-009-7)

Extraaurale Wirkung von Erdbaumaschinenlärm unterschiedlicher Tonhaltigkeit – isoliert und in Kombination mit Ganzkörperschwingung (Forschungsbericht)
M. Schust, H. Seidel, H. Seidel, R. Blüthner
(1999)Fb 775 BAuA (1999)

Gehörschützer-Kurzinformation für Personen mit Hörverlust
Hauptverband der gewerblichen Berufsgenossenschaften
BGI 686

Grundlagen und Auswahlkriterien zur Schallabsorption
Hauptverband der gewerblichen Berufsgenossenschaften
BGI 674

Health surveillance for occupational noise exposure in Germany
Ausschuss Arbeitsmedizin, Arbeitskreis 2.1 „Lärm“
HVBG c/o Berufsgenossenschaft Metall Süd, Mainz
Issue May 2004
Website: **www.hvbg.de/d/bgz/praevaus/amed/index.html**

Hinweise zur Beschäftigung von hochgradig und an Taubheit grenzenden Schwerhörigen und Gehörlosen sowie ihrem Einsatz in Lärmbereichen
Hauptverband der gewerblichen Berufsgenossenschaften 2004
BGI 896

Hinweise zur Gestaltung von Kapseln einfacher Bauart
Hauptverband der gewerblichen Berufsgenossenschaften
BGI 789

Hypothese über die Einschätzung der Belästigung durch gleichzeitig auftretende Geräusche und Erschütterungen in Räumen an Bord von Schiffen
J.-H. Janssen (1981)
Noise control engineering, Band 16 (1981) Nr. 3, S. 145-150)

Lärmwirkungen: Gehör, Gesundheit, Leistung
H. Ising, Ch. A. Sust, P. Plath
BAuA-Schriftenreihe Gesundheitsschutz 4.
BAuA 2004.
3-88261-434-X
10 Auflage

Katalog lärmmindernder Maßnahmen in der Fertigung – Metallverarbeitung
H. Horns, R. Wettschurek
NW Verlag 1989
ISBN: 3-88-341-909-8
Fa 17

Kombinationswirkung von Sinus-Ganzkörperschwingungen und Lärm verschiedener Bandbreite und Intensität auf die vorübergehende Hörschwellenverschiebung beim Menschen
O. Manninen (1983)

International archives of occupational and environmental health, Band 51 (1983) Nr. 3, S. 273-288)

Komplexe physische und psychische Reaktion des Organismus auf Erdbaumaschinen – Lärm unterschiedlicher psychoakustischer Charakteristik isoliert und in Kombination mit arbeitsplatztypischer stochastischer Ganzkörperschwingung
Projektnummer: F 5113 BAuA (geplantes Ende 31. Dezember 2003)

Kreislaufveränderungen und Hörschwellenverschiebungen bei Männern unter einer komplexen Exposition gegenüber Lärm, Ganzkörperschwingungen, Temperaturen und einer psychischen Belastung durch Konkurrenzsituation (International archives of occupational and environmental health
O. Manninen(1985)
Herz, Band 56 (1985), Nr. 4, S. 251-274)

Kriterien für die betriebliche Lärmprognose – Berechnung des Schalldruckpegels in Arbeitsräumen
W. Probst
NW Verlag 1999
ISBN 3-89701-341-X
Fb 841

Lärm am Arbeitsplatz in der Metallindustrie
Hauptverband der gewerblichen Berufsgenossenschaften
BGI 688

Lärm, Impulslärm und andere physikalische Faktoren: Kombinierte Wirkung auf das Hörvermögen
J. Pekkarinen (1995)
Occupational medicine, Band 10 (1995) Nr. 3, S. 545-559)

Lärm und Vibrationen am Arbeitsplatz Messtechnisches : Taschenbuch für den Betriebspraktiker
IfaA 2000.

Lärmarm konstruieren XVIII – Systematische Zusammenstellung maschinenakustischer Konstruktionsbeispiele
P. Dietz, F. Gummersbach
NW Verlag 2000.
ISBN 3-87901525-0
Fb 883

Lärmminderung am Arbeitsplatz (IV) – Beispielsammlung
U. J. Kurze et al.
NW Verlag 1992
ISBN: 3-88-314-703-6
Fa 14

Lärmmessung im Arbeitsschutz (Lärm Teil 2)
G. Neugebauer, B. Morys
Verlag Technik & Information 2003

Lärmschutz an Maschine und Arbeitsplatz: Vorschriften, technische Regeln, Gefährdungsbeurteilung (Rw 30)
W. Parthey, H. Lazarus, P. Kurtz
NW Verlag 2001

Occupational exposure to noise: evaluation, prevention and control
World Health Organization
Berenice Goeltzer, Colin H. Hansen und Gustav A. Sehrndt 2001
ISBN 3-89701-721-0

0 Dezibel + 0 Dezibel = 3 Dezibel
Jürgen H. Maue.
Erich Schmidt, Berlin 2003
ISBN 3-503-0747-08

Präventive Arbeitsschutzstrukturen für Klein- und Mittelbetriebe am Beispiel Lärmminderung und Ergonomie
C. Barth, W. Hamacher, R. Stoll
NW Verlag 2001
3-89701-658-3
Fb 916

Schwerhörig durch Arbeitslärm – Hörbeispiele Die Welt mit den Ohren eines Schwerhörigen erleben. Audio-CD verdeutlicht Lärmschwerhörigkeit und ihre Folgen
BAuA
BAuA 1999
Website: **www.baua.de/news/archiv/pm_99/pm106_99.htm**

Taschenbuch der technischen Akustik
Gerhard Müller, Michael Möser (Hrsg.)
Springer Verlag, Berlin 2003
ISBN 3-540-41242-5
3. und erw. Auflage

Technischer und organisatorischer Lärmschutz
BGIA-Handbuch Sicherheit und Gesundheitsschutz am Arbeitsplatz
Eberhard Christ
Berufsgenossenschaftliches Institut für Arbeitsschutz, Sankt Augustin
Erich Schmidt Verlag Bielefeld Loseblatt-Ausgabe 36. 1999
Lfg. XII

EIRE (Ireland)

Guidelines to the noise regulations
UK, HSA ,1990, 8
Website: **http://www.hsa.ie/eng/Publications_and_Forms/**

EESTI (Estonia)

ΕΛΛΑΔΑ (Greece)

ESPAÑA (Spain)

Confort acústico: el ruido en oficinas
Ana Hernández Calleja.– Spain.– INSHT.
Website: **http://www.mtas.es/insht/ntp/ntp_503.htm**

Conocimiento, evaluación y control del ruido
Pedro Miguel Lanas Ugarteburu; Asociación para la Prevención de Accidentes (APA).– Spain.– APA 2000.– 176 p.
ISBN: 978-84-95270-21-4

El ruido en el ambiente laboral. Monografía nº 2
Instituto de Seguridad y Salud Laboral de la Región de Murcia (ISSL).– Spain.– ISSL.– 125 p.
Website: **http://www.carm.es/issl**

Guía técnica para la utilización por los trabajadores en el trabajo de los equipos de protección individual
INSHT.– Spain.– INSHT.– 52 p.

Evaluación de la exposición al ruido. Determinación de niveles representativos
Antonio Gil Fisa; Pablo Luna Mendaza.– Spain.– INSHT.
Website: **http://www.mtas.es/insht/ntp/ntp_270.htm**

Hipoacusia laboral por exposición a ruido: Evaluación clínica y diagnóstico
Eduardo Gaynés Palou; Asunción Goñi González.– Spain.– INSHT.
Website: **http://www.mtas.es/insht/ntp/ntp_287.htm**

Protocolos de vigilancia sanitaria específica. Ruido (2000)
Comisión de Salud Pública. Consejo Interterritorial del Sistema Nacional de Salud.– Spain.– Ministerio de Sanidad y Consumo.
ISBN: 978-84-7670-578-0
NIPO: 351-00-020-X
Depósito legal: M-50330-2000

Régimen jurídico del ruido: una perspectiva integral y comparada
Estanislao Arana García; María Asunción Torres López.– Spain– Comares 2004.– 560 p.
ISBN: 978-84-8444-895-2
Estudios de Derecho Administrativo, núm. 14

Régimen jurídico de la contaminación acústica: con comentarios a la Ley 37/2003, de 17 de noviembre, del ruido
Antonio Cano Murcia.– Spain.– Editorial Aranzadi (2004), 12435 0.– 1242 p.
ISBN: 978-84-9767-355-6

Ruido industrial y urbano
Manuel Rejano de la Rosa.– Spain.– Editorial Paraninfo (2000).– 240 p.
Website: **http://www.frigorista.com/**

Ruido: vigilancia epidemiológica de los trabajadores expuestos
Neus Moreno Sáenz, Francisco Marqués Marqués, Mª Dolores Solé Gómez, José Luis Moliné Marco.– Spain.– INSHT.
Website: **http://www.mtas.es/insht/ntp/ntp_193.htm**

Ruido y estrés ambiental
Clara Martimportugués Goyenechea.– Spain.– Ediciones Aljibe.
Website: **http://www.80mundos.com/familia.asp?IDFAMILIA=3511**

Videoterminales: evaluación ambiental
Paulino Domingo de la Osa.– Spain.– INSHT.
Website: **http://www.mtas.es/insht/ntp/ntp_196.htm**

FRANCE

Acoustique appliquée — Aide-mémoire
M. Val, L'Usine nouvelle-Dunod, France, 2002

Acoustique industrielle et aéroacoustique
S. Lévy, Hermès, France, 2001

Agents ototoxiques et exposition au bruit
INRS, France, 2001
TF 103

Bruit: synthèse des données réglementaires
J.-J. Barbara, Techniques de l'ingénieur, France, 2002, 16 p.
Environnement G 2790 + Doc G 2790

Bruit: prévention, maîtrise et contrôle des nuisances sonores
Direction des Journaux officiels, n° 34852, France, 470 p.
Brochure 1383

Décibels en sourdine
Vidéo, INRS, France, 1990
VM 0273 — 80,5

Effet du bruit sur l'homme
J. Jouhaneau, Techniques de l'ingénieur, France, 2001, 15 p.
Environnement G 2790 + Doc G 2720

Entre les oreilles, la vie
Vidéo, INRS, France, 2000
VS 0289/DV 0289 — 48

Étude du niveau d'exposition sonore quotidienne des salariés dans quatre activités: travaux de plasturgie, travaux sur machines à bois en atelier, vente de matériels hi-fi, vidéo, son, collecte des ordures ménagères (ripeur-éboueur)
Groupe «Ergonomie» du département «Action scientifique en médecine du travail» (ASMT) du Centre interservices de santé et de médecine du travail en entreprise (CISME), Docis, France, 1999, 155 p.
ASTM 18/1999

Inutile de crier
Vidéo, INRS, France, 1987
VS 0185 — 48

Le bon usage du silencieux pour la réduction du bruit: machines, installations, véhicules — Senlis, 21-22 mai 1996, recueil de conférence
Centre technique des industries mécaniques (CETIM), France, 1997, 260 p.

Le bruit: passeport santé
Caisse centrale de la mutualité sociale agricole, France, 2000, 17 p.

Le bruit: évaluation du risque
Comité technique régional du textile, 14 juin 1995
R. Jayat, CRAM Nord-Picardie, France, 1995, 5 p.

Le diagnostic vibro-acoustique: une étape fondamentale de la réduction à la source du bruit des machines
INRS, France, 1998
ND 2082

Les équipements de protection individuelle de l'ouïe
INRS, France, 2001
ED 868

L'oreille cassée
CD-ROM, centre régional d'imagerie cellulaire, France, 2002

L'oreille interactive
CD-ROM, pôle de compétence «Bruit», DDASS Savoie, France, 1996

Manuel d'acoustique fondamentale
M. Bruneau, Hermès, France, 1998

Matériaux acoustiques pour l'industrie
X. Carniel, B. Corlay et M. Bockhof, Centre technique des industries mécaniques (CETIM), France, 2003

Mediacoustic
CD-ROM, 01dB Company, France

Méthodologie et réduction du bruit en milieu professionnel: environnement G 2760
J.-M. Mondot et A.-M. Ondet, Techniques de l'ingénieur, France, 2000, 12 p.

Panorama des normes d'acoustique industrielle élaborées dans le cadre de la nouvelle approche
INRS, France, 1996
ND 2018

Réduire le bruit dans l'entreprise
INRS, France, 1997
ED 808

Réussir un encoffrement acoustique
INRS, France, 2003
ED 107

Tintamarre: trois spots sur le bruit
Vidéo, INRS, France, 1994
VS 0220 — 48

Traitement acoustique des locaux de travail
INRS, France, 1997
ED 68 et ED 69

Vibrations, propagation, diffusion
M. Soutif, Dunod, France, 1970

Vos gueules les décibels!
Vidéo, INRS, 1990
VS 0229 — 48

ITALIA (Italy)

Attuazione della valutazione del rischio rumore nei cantieri temporanei o mobili
P. Nataletti, A. Callegari, O. Nicolini. – Italy, Ispesl 1998.
Fogli di informazione Ispesl, n. 1

Dal rumore ai rischi fisici: valutazione, prevenzione e bonifica in ambiente di lavoro; rischio ex art. 40 D.lgs. 277/91: un bilancio indicativo dei primi cinque anni di applicazione e proposta normativa, in *Atti del Congresso Nazionale AIDII, Faenza 1997*
F. Merluzzi. – Italy, Regione Emilia-Romagna - Az. USL - Ispesl, 1998.

I rapporti di valutazione del rumore e vibrazioni negli ambienti di lavoro: dalla valutazione alla bonifica
P. Nataletti, A.Pieroni, R. Sisto, M. Nesti. – Italy, Regione Emilia-Romagna - Az. USL - Ispesl - AIA-GAA, 1999.

Il rumore negli ambienti di vita e di lavoro
S. Curcuruto, P. Nataletti, O. Nicolini. – Italy, EPC Libri, 2001.

La misure dell'esposizione al rumore in agricoltura contenuti, interpretazione e applicazione del D.lgs 277/91
Conama. – Italy, Conama, 1999. – 82 pagg.
Volumetto per i tecnici agricoli

Linee guida per la valutazione del rischio rumore negli ambienti di lavoro. Gruppo di lavoro nazionale per la predisposizione di procedure operative standardizzate per la valutazione del rischio da rumore e vibrazioni in ambienti di lavoro
Ispesl. – Italy, Ispesl, 2003. – 102 pagg.
Aggiornate al 1 aprile 2003
Website: **www.ispesl.it/linee_guida/fattore_di_rischio/lineeguidarumore.pdf**

Linee guida per l'applicazione dell'art. 41 del Decreto legislativo 277/91
Ispesl. – Italy, Ispesl.
Website: **www.asl.bergamo.it**

Manuale di acustica
R. Spagnolo. – Italy, UTET, Torino 2001.

Rumore: rischi e prevenzione. Protezione dei lavoratori contro i rischi di esposizione durante il lavoro
R. Dubini. – Italy, IPSOA, 1999.
ISL, Igiene & sicurezza del lavoro, n. 5

Rumore e vibrazioni. Linee guida per la corretta applicazione della legislazione negli ambienti di lavoro
O. Nicolini, P. Nataletti, A. Peretti
Italy, Regione Emilia-Romagna - Az. USL - Ispesl - AIA-GAA, 1999.

Rumore, vibrazioni, microclima, illuminazione, onde elettromagnetiche - Valutazione, prevenzione e bonifica negli ambienti di lavoro
O. Nicolini, P. Nataletti, A. Peretti, D. Ferrari.
Italy, Regione Emilia-Romagna - Az. USL - Ispesl - INAIL, 2002.

LATVIJA (Latvia)

Ar darba vides troksni saistīto risku novērtēšanas un novēršanas vadlīnijas
Latvia, Valsts darba inspekcija. Rīga, 2003, 47 lpp.

LIETUVA (Lithuania)

LUXEMBOURG

MAGYARORSZÁG (Hungary)

MALTA

NEDERLAND (Netherlands)

ÖSTERREICH (Austria)

Gehörschützer
Sicherheitsinformation der AUVA
AUVA, 13 S.
HUB - M 700 - 0502 Aktualisierte Auflage

Gesetzliche Bestimmungen für Lärmbetriebe
Sicherheitsinformation der AUVA
AUVA, 24 S.
M 019 Sicherheit Kompakt

Lärm Gefahren ermitteln & beseitigen
Sicherheitsinformation der AUVA
AUVA, 9 S.
HUB E 8 1103 Auflage Evaluierung

POLSKA (Poland)

Dźwięk i jego percepcja. Aspekty fizyczne i psychoakustyczne
E. Ozimek
Poland, PWN, Poznań 2002

Metody aktywnej redukcji hałasu
Z. Engel, G. Makarewicz, L. Morzyński, W. Zawieska
Poland, CIOP-PIB 2001

Ochrona środowiska przed drganiami i hałasem
Z. Engel
Poland, PWN, Warszawa 2001

Ocena ryzyka zawodowego. Podstawy metodyczne
Poland, CIOP-PIB 2004

Percepcja dźwięku przy prawidłowym i uszkodzonym funkcjonowaniu ucha wewnętrznego
J. Zera
Poland, CIOP-PIB 2001

Zasady użytkowania ochronników słuchu na hałaśliwych stanowiskach pracy
E. Kotarbinska
Poland, CIOP-PIB 2001

PORTUGAL

SLOVENIJA (Slovenia)

SLOVENSKÁ REPUBLIKA (Slovakia)

SUOMI (Finland)

SVERIGE (Sweden)

För utbildning och praktisk bullerdämpning (cd-rom)
Prevent, Art. Nr 772; ISBN: 91-7522-919-6

Fight the noise: examples of methods and solutions within companies and institutions in Sweden / The Swedish Work Environment Fund – Sweden.
The Swedish Work Environment Fund, 1990

Farligt buller i jordbruket / Kurt Öberg, Claes Jonsson, Olle Norén – Sweden.
JTI – Institutet för jordbruks- och miljöteknik 2003 – 40 s.
JTI-rapport, Lantbruk & Industri, 317

Farligt buller i jordbruket – Enkätundersökning och Pilotstudie för bullermätning. Citera oss gärna, men ange källan.
Kurt Öberg – Claes Jonsson – Olle Norén.
Sweden JTI – Institutet för jordbruks- och miljöteknik, 2003.
ISSN: 1401-4963

Noise, analysis and solutions (CD-ROM English and Swedish)
PREVENT – Sweden. PREVENT.
SEK 295

Buller och bullerbekämpning
Arbetsmiljöverket, best. nr H3
ISBN 91-7464-414-9
http://www.av.se/webbshop/produktlista.asp?kID=9&skID=51

UNITED KINGDOM

Acoustics and noise control
B. J. Smith, R. J. Peters and S. Owen.
UK, Longman, 1995

Acoustics for you
J. Prout, and G. Bienvenue
UK, Robert E. Krieger Publishing Co., 1990

A guide to exposure to noise in the entertainment industry
HSA
UK, HSA, 8 pp.
Website: **http://publications.hsa.ie/index.asp?locID=12&docID=106**

Controlling noise at work — The control of noise at work regulations 2005
Guidance on regulations, L 108
HSE, 2005
Available from HSE Books
ISBN 0 7176 6164 4

Engineering noise control theory and practice (second edition)
D. A Bies and C. H. Hansen.
UK, E. and F. N. Spon Ltd, 1996

Foundations of engineering acoustics
F. Fahy
UK, Academic Press, 2000

Fundamentals of acoustics
L. Kinsler, A. Frey, A. Coppens and J. Sanders
UK, Wiley, 1999

Noise at work: guidance for employers on the control of noise at work regulations 2005
Leaflet INDG362(rev1)
HSE, 2005
Available from HSE Books
ISBN 0 7176 6165 2

Noise control in industry
Sound Research Laboratories
UK, E. and F. N. Spon Ltd

Perceptual consequences of cochlear damage
B. C. J. Moore
UK, Oxford 1995

Proposal for new control of noise at work
Regulations implementing the physical agents (noise) directive (2003/10/EC)
Consultative document 2004
CD196 C50 04/04
Website: **www.hse.gov.uk/condocs/**

Protect your hearing or lose it!
Pocket card (INDG363(rev1))
HSE, 2005
Available from HSE books
ISBN 0 7176 6166 0

Sound solutions — Techniques to reduce noise at work
HSE Books
UK, HSE Books, 1995
ISBN 0717607917

Woods practical guide to noise control
Ian Sharland
UK, Wood Acoustics, 1979

Other non-EU countries

CANADA

Réduire le bruit en milieu de travail
Commission de la santé et de la sécurité au travail (CSST), Canada, 2002
DC 300-304

SWITZERLAND

Call centres — A measurement headache
Institute of Acoustics Publication
Institute of Acoustics Publication 2003
No 1178

Chemical exposure as a risk factor for hearing loss
T. Morata
Journal of the Occupational and Environmental Medicine, 45, 2003, pp. 675–682

Dangers du bruit pour l'ouïe à l'emplacement de travail
Caisse nationale suisse d'assurance en cas d'accidents-SUVA, Suisse, 1997

Engineering noise control
D. A. Bies and C. H. Hansen
1998

Industrielle Raumakustik
W. Lips.
Schweizerische Unfallversicherungsanstalt
(SUVA) 1989.

Musique et troubles de l'ouïe: 13e édition
SUVA, Suisse, 2001, 15 p.
84001.f.

The role of otoacoustic emission in screening and evaluation of noise damage
D. Prasher and W. Sulkowski
Am. J. Ind. Med., 37(1), 2000, pp. 112–120

USA

An Introduction to psychology of hearing
B. C. J. Moore
Academic Press, 2003

Handbook of noise control
C. M. Harris
USA, McGraw-Hill, 1979

Handbook of acoustical measurements and noise control — Third edition
C. Harris
USA, Acoustical Society of America, 1998

Noise and hearing conservation manual
E. Berger, W. Ward, J. Morrill and L. Royster
USA, American Industrial Hygiene Association, 1986

Noise and vibration control
Leo Beranek
USA, Institute of Noise Control Engineering, 1988

Noise and vibration control
L. L. Beranek
USA, Institute of Noise Control Engineering, 1998

Sound and hearing
S. S. Stevens and F. Warshofsky
Life Science Library, 1972

The noise manual — Fifth edition
E. Berger, L. Royster, J. Royster, D. Driscoll and M. Layne
USA, American Industrial Hygiene Association, 2000.

International institutions

World Health Organisation

Occupational exposure to noise: evaluation, prevention and control
B. Goelzer, C. Hansen and G Sehrndt
World Health Organisation/Federal Institute for Occupational Safety Health, 2001

Concawe

Factors potentially affecting the hearing of petroleum industry workers
P. Hoet, M. Grosjean and C. Somaruga
Concawe's Health Management Group
Concawe, Brussels, 2005.

WEBSITES

European Union

Website of the Directorate-General for Employment, Social Affairs and Equal Opportunities
Health, Safety and Hygiene at Work Unit:
http://ec.europa.eu/employment_social/health_safety/index_en.htm

Website of the Directorate-General for Enterprise and Industry:
http://ec.europa.eu/enterprise/mechan_equipment/ppe/index.htm

European Agency for Safety and Health at Work (EU):
http://osha.europa.eu/

Statistics and figures:
http://ec.europa.eu/employment_social/health_safety/statistics_en.htm

EUR-Lex (EU):
http://eur-lex.europa.eu/

Documents and publications:
http://ec.europa.eu/employment_social/health_safety/docs_en.htm

Accidents at work and work-related health problems:
http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1073,46587259&_dad=portal&_schema=PORTAL&p_product_code=KS-BP-02-002-3A

Data on accidents at work and occupational diseases:
http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1996,45323734&_dad=portal&_schema=PORTAL&screen=welcomeref&open=/&product=EU_MASTER_health&depth=2

Accidents at work in the EU 1998–99:
http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1073,46587259&_dad=portal&_schema=PORTAL&p_product_code=KS-NK-01-016

Work-related health problems in the EU 1998–99:
http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1073,46587259&_dad=portal&_schema=PORTAL&p_product_code=KS-NK-01-017

European Acoustics Association (EU)
http://www.eaa-fenestra.org/

Hear-it (EU):
http://www.hear-it.org

BELGIQUE/BELGIË (Belgium)

Institut pour la prévention, la protection et le bien-être au travail (Prevent)
http://www.prevent.be/

Le ministère fédéral de l'emploi et du travail
http://www.meta.fgov.be/

Comité national d'action pour la sécurité et l'hygiène dans la construction (CNAC)
http://www.cnac.be/

Institut national de recherche sur les conditions de travail (INRCT)
http://www.iph.fgov.be/

ČESKÁ REPUBLIKA (Czech Republic)

Výzkumný ústav bezpečnosti práce - VUVB (CZ)
http://www.vubp.cz

Centrum hygieny prace e memoci z povolani (CZ)
http://www.szu.cz/chpnp/

Centrum informaci a vzdelavani ochrany prace - CIVOP (CZ)
http://www.civop.cz

Statni zdravotni ustav - SZU (CZ)
http://www.szu.cz

Statni zdravotni ustav/Centrum pracovniho lekarstvi
http://www.szu.cz

Vyzkumny ustav bezpecnosti práce
http://www.vubp.cz

Oborovy portal bezpecnosti a ochrany zdravi při praci
http://www.bozpinfo.cz

Ceska akusticka spolecnost
http://www.czakustika.cz

ΚΥΠΡΟΣ (Cyprus)

DANMARK (Denmark)

Arbejdstilsynet (DK)
http://www.arbejdstilsynet.dk/

Arbejdsulykker (DK)
http://www.arbejdsulykker.dk/

Arbejdsmiljøinstituttet — AMI (DK)
http://www.ami.dk

DEUTSCHLAND (Germany)

Aktion „Schluss mit Lärm!"
www.schluss-mit-laerm.de

Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA)
http://www.baua.de

Bürgerportal Arbeitsschutz NRW
http://www.arbeitsschutz.nrw.de/

Hauptverband der gewerblichen Berufsgenossenschaften (HVBG)
http://www.hvbg.de/
http://www.bg-laerm.de

Informationen der Bundesländer
http://lasi.osha.de/de/gfx/index.php
http://bb.osha.de/de/gfx/good_practice/gefaehrdungskategorien.php

Jugend will sicher leben
http://www.jugend-will-sich-erleben.de/

Berufsgenossenschaftliches Forschungsinstitut für Arbeitsmedizin - BGFA
http://www.bgfa.ruhr-uni-bochum.de

Berufsgenossenschaftliches Institut für Arbeitsschutz - BGIA
http://www.hvbg.de/d/bia/index.html

EIRE (Ireland)

Health and Safety Authority (HSA) (IE)
http://www.hsa.ie

EESTI (Estonia)

ΕΛΛΑΔΑ (Greece)

Ελληνικό Ινστιτούτο Υγιεινής και Ασφάλειας της Εργασίας — ΕΛ.ΙΝ.Υ.Α.Ε. (GR)
http://www.elinyae.gr

ESPAÑA (Spain)

Instituto Nacional de Seguridad e Higiene en el Trabajo (INSHT). (ES)
http://www.mtas.es/insht/

Instituto de Acústica (ES)
http://www.ia.csic.es/
http://www.ruidos.org/

Asociación de Mutuas de Accidentes de Trabajo (AMAT). (ES)
http://www.amat.es/

Asociación para la Prevención de Accidentes (APA). (ES)
http://www.apa.es/

Recursos sindicales de Comisiones Obreras — ISTAS. (ES)
http://www.istas.net/

Unión General de Trabajadores (UGT). (ES)
http://www.ugt.es/

FRANCE

Institut national de recherche et de sécurité (INRS)
http://www.inrs.fr/

Société française d'acoustique
http://www.sfa.asso.fr/

Centre d'information et de documentation sur le bruit
http://www.infobruit.org/

Audition-infos
http://www.audition-info.org/

Association de prévention des traumatismes auditifs
http://audition-prevention.org/site/sommaire.html

Agence nationale pour l'amélioration des conditions de travail (ANACT)
http://www.anact.fr/

Organisme professionnel de prévention du bâtiment et des travaux publics (OPPBTP)
http://www.oppbtp.fr/

ITALIA (Italy)

Istituto superiore per la prevenzione e la sicurezza del lavoro. (Ispesl) (IT)
http://www.ispesl.it

Associazione professionale italiana ambiente e sicurezza (AIAS) (IT)
http://www.aias-sicurezza.it

Istituto nazionale per l'assicurazione contro gli infortuni sul lavoro (INAIL) (IT)
http://www.inail.it

LATVIJA (Latvia)

LIETUVA (Lithuania)

SODRA (LT)
http://www.sodra.lt

LUXEMBOURG

Association d'assurance contre les accidents (AAA) (LU)
http://www.aaa.lu

MAGYARORSZÁG (Hungary)

Munkavédelmi Kutatási Közalapítvány – MKK (HU)
http://www.mkk.org.hu

MALTA

NETHERLAND (Nederlands)

Nederlands Centrum voor beroepsziekten — NCVB (NL)
http://www.beroepsziekten.nl

TNO Arbeid (NL)
http://www.nia.tno.nl
http://www.tno.nl

ÖSTERREICH (Austria)

Allgemeine Unfallversicherungsanstalt (AUVA):
http://www.auva.or.at

Bundesministerium für Wirtschaft und Arbeit (BMWA):
http://www.bmwa.gv.at/

POLSKA (Poland)

Centralny Instytut Ochrony Pracy – CIOP (PL)
http://www.ciop.pll

PORTUGAL

Centro Nacional de Protecção Contra os Riscos Profissionais — CNPRP (PT)
http://www.seg-social.pt

Instituto para Segurança, Higiene e Saúde no Trabalho — ISHST (PT)
http://www.idict.gov.pt

Instituto Superior Técnico — IST (PT)
http://www.ist.utl.pt

SLOVENIJA (Slovenia)

Zavod Republike Slovenije za varstvo pri delu – ZVD (SI)
http://www.zvd.si

SLOVENSKÁ REPUBLIKA (Slovakia)

SUOMI (Finland)

Työterveyslaitos/Arbetshälsoinstitutet (Finnish Institute of Occupational Health, FIOH) (FI)
http://www.occuphealth.fi/
http://www.ttl.fi

SVERIGE (Sweden)

Arbetslivsinstitutet – NIWL (SE)
http://www.niwl.se
http://www.arbetslivsinstitutet.se

Arbetsmiljöverket – Swedish Work Environment Authority (SE)
http://www.av.se

UNITED KINGDOM

Health and Safety Executive (HSE) (UK)
http://www.hse.gov.uk

Health and Safety Laboratory (HSL) (UK)
http://www.hsl.gov.uk

Health and Safety Executive — Northern Ireland (HSENI) (UK)
http://www.hseni.gov.uk/

RNID (UK)
http://www.rnid.org.uk/

Office of Public Sector Information (OPSI) (UK)
http://www.opsi.gov.uk/

Centre for Occupational and Environmental Health (University of Manchester)
http://www.medicine.manchester.ac.uk/coeh/teachinglearning/resources/nihl

Department for Trade and Industry — Noise emission standards for outdoor machinery
http://www.berr.gov.uk/files/file11305.pdf

TUC (UK)
http://www.tuc.org.uk/

Association of Noise Consultants
http://www.association-of-noise-consultants.co.uk

Faculty of Occupational Medicine
http://www.facoccmed.ac.uk

Other non-EU countries

SWITZERLAND

Schweizerische Unfallversicherunganstalt — SUVA (CH)
http://www.suva.ch

Cercle bruit
http://www.cerclebruit.ch/

International institutions

International Labour Organisation
http://www.ilo.org/
http://www.ilo.org/public/english/publication.htm

World Health Organisation
http://www.who.int/en/

Fast noise and vibration information
http://www.noisenet.org/

Audition-infos
http://www.audition-info.org/

Organisation mondiale de la santé — Bureau régional de l'Europe — Programme «Bruit et santé»
http://www.euro.who.int/Noise

Concawe
http://www.concawe.org/Content/Default.asp?PageID=3

Annex III

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European Commission

How to avoid or reduce the exposure of workers to noise at work – Non-binding guide to good practice for the application of Directive 2003/10/EC

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This good practice guide explains how workers' exposure to noise at work can be reduced or avoided. Targeted at Member States, industries and other interested bodies, it describes how to follow Directive 2003/10/EC on the minimum safety and health requirements regarding workers' exposure to the risks arising from noise. In addition, a specific chapter presents practical and specific provisions to help workers and employers in the music and entertainment sectors, where workers are particularly exposed to very high noise levels.

This publication is available in printed format in English, French and German and in electronic format in all other EU official languages.

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