

PROTECTION OF WORKERS AGAINST

NOISE



AND

VIBRATION

IN THE WORKING ENVIRONMENT

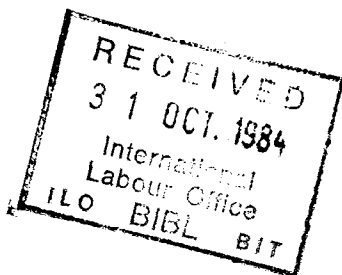
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The International Programme for the Improvement of Working Conditions and Environment (PIACT) was launched by the International Labour Organisation in 1976 at the request of the International Labour Conference and after extensive consultations with member States. PIACT is designed to promote or support action by member States to set and attain definite objectives aiming at "making work more human". The Programme is thus concerned with improving the quality of working life in all its aspects: for example, the prevention of occupational accidents and diseases, a wider application of the principles of ergonomics, the arrangement of working time, the improvement of the content and organisation of work and of conditions of work in general, a greater concern for the human element in the transfer of technology. To achieve these aims, PIACT makes use of and co-ordinates the traditional means of ILO action, including:

- the preparation and revision of international labour standards;
 - operational activities, including the dispatch of multidisciplinary teams to assist member States on request;
 - tripartite meetings between representatives of governments, employers and workers, including industrial committees to study the problems facing major industries, regional meetings and meetings of experts;
 - action-oriented studies and research; and
 - clearing-house activities, especially through the International Occupational Safety and Health Information Centre (CIS) and the Clearing-house for the Dissemination of Information on Conditions of Work.
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**Protection of workers
against noise and vibration in the working environment**



ILO Codes of Practice

**Protection of workers
against noise and vibration
in the working environment**

International Labour Office Geneva

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Introduction

At its 192nd Session, early in 1974, the Governing Body of the International Labour Office decided to convene a meeting of experts on noise and vibration at the workplace as part of the Organisation's activities aimed at improving the working environment. The meeting duly took place,¹ and the experts adopted the present code of practice, publication of which was approved by the Governing Body in March 1975.

This code provides guidance for governments, employers and workers. It sets out the principles that should be followed for the control of workplace noise and vibration, and contains the information required for the establishment of control programmes for individual plants.

It has no compulsory character; it does not lay down minimum requirements but is rather intended to stimulate, guide and promote noise control at the national level. The technical standards that it lays down are objectives which can be attained by successive stages.

The experts emphasised the importance of noise and vibration control. Noise and vibration were regarded as being two important factors among the many that contributed to the pollution of the working environment, having a detrimen-

¹ At the International Vocational and Technical Training Centre in Turin, from 2 to 10 December 1974. It was attended by the following experts:
Dr. A. Darabont (Romania), Chief of the Noise and Vibration Laboratory, Scientific Research Institute for Occupational Protection, Bucharest.

Dr. E. Denisov (USSR), Senior Scientific Officer, Noise and Vibration Laboratory, Occupational Safety and Health Institution, Academy of Medical Science, Moscow.

Prof. G. Gerhardtsson (Sweden), Industrial Medicine and Hygiene Office, Swedish Employers' Confederation, Stockholm.

Dr. F. Groenewold Alexandry (Mexico), Confederation of Chambers of Industry of the United States of Mexico, General Manager, Phone S.A., Acoustic consultancy, Mexico City.

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tal effect on the worker's health and comfort and constituting a burden on the economy in every country. Owing to the growth of industry and transport, there had been a significant increase in the number and power of noise sources over the past two decades. Statistical studies had shown that when noise and vibration exceeded certain thresholds, they impaired health and working capacity; the effects they produced ranged from mere mental and physical inconvenience to severe organic disorders.

From the human point of view, there has been a rapid rise in the number of persons exposed to the deleterious action

Mr. H. O. Hansen (Norway), Secretary, Norwegian Federation of Trade Unions, Oslo.

Mr. L. Heard (Canada), Safety Director, United Steel Workers of America, Canadian Regional Office, Toronto.

Dr. G. Hübner (Federal Republic of Germany), Head of the Laboratory for the Control of Machinery Noise, Siemens A.G., Berlin.

Dr. Franca Merluzzi (Italy), Lecturer in Occupational Medicine, Italian General Confederation of Labour (CGIL), Milan.

Mr. M. El Meccawi Mustafa (Sudan), President, Sudan Employers' Consultative Association, Khartoum.

Mr. H. J. Schulte (United States), Deputy Assistant Secretary of Labor for Occupational Safety and Health, US Department of Labor, Washington.

Dr. J. M. Vasiliev (USSR), Chief of Laboratory, Central Scientific Research Institute of Labour Protection, All-Union Council of Trade Unions, Moscow.

Dr. G. Wolff-Zurkühlen (Federal Republic of Germany), Director, Pollution and Radiation Control, Institute for Occupational Protection and Medicine, Karlsruhe; accompanied by Prof. Dr. H. Dupuis, Max Planck Institute for Agricultural Labour and Technology, Bad Kreuznach.

The following international organisations were represented at the meeting: World Health Organisation, International Organisation for Standardisation, International Electrotechnical Commission, Permanent Commission and International Association on Occupational Health, International Organisation of Employers, International Social Security Association, Commission of the European Communities.

of noise and vibration. No matter what the causes and the circumstances, noise and vibration are also ultimately responsible for economic losses due to reduced physical and intellectual working capacity, and even for the temporary or permanent elimination from the workforce (through sick leave or early retirement) of many workers affected by occupational disease or accidents caused by noise or vibration.

The elimination of noise and vibration at source when buildings, machines and equipment are being designed is fundamental for effective control. As a first step, manufacturers should be required to provide with each machine or piece of equipment that is a potential noise or vibration source a data sheet giving all the necessary information about the level of noise and vibration emitted. Subsequently, maximum noise and vibration levels could be laid down for these items of equipment and it would be desirable for the purchasers to specify the maximum noise and vibration levels for the equipment in question.

Other group control methods are the isolation of noise and vibration sources (by enclosure, by the use of materials that absorb noise and vibration and by location at a distance), and the prevention of the propagation of noise and vibration or the isolation of workers (e.g. on soundproof premises or anti-vibration platforms). Only when such collective measures cannot be applied should other types of control be used, such as the reduction of exposure duration and the use of personal protective equipment.

The cost of technical safety measures was mentioned on several occasions by some of the experts; others pointed out that it was also necessary to consider the cost of not taking such measures. The experts arrived at the conclusion that the lack of protective measures and supervision was generally more expensive than a suitable safety and medical supervision programme.

The importance of the medical supervision of workers exposed to noise and vibration was emphasised, but the

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experts drew attention to the shortage of trained personnel and the cost of such supervision. As far as noise was concerned, in particular, it was therefore advisable to start with an audiometric screening examination and then concentrate on any abnormal and pathological findings requiring more detailed medical examination.

Definitions

This code deals with noise and vibration as physical phenomena that may affect the human body and have a deleterious effect on the worker's health and a negative effect on occupational safety.¹

The words "noise" and "vibration" are in common use and are to be found in any general dictionary; more precise definitions from the physical and physiological points of view may be found in specialised dictionaries and in textbooks of physics and medicine. These terms, like many others, have been defined internationally and nationally. For the purposes of this code the experts, instead of adopting new definitions, have used those already in existence, making suitable reference to the sources used.² Asterisks are inserted in the text on the first occurrence of terms included in the following list.

¹ General principles of preventive action in these respects are laid down in the Working Environment (Air Pollution, Noise and Vibration) Convention, 1977 (No. 148), and Recommendation, 1977 (No. 156). Article 3 of the Convention contains the following definitions of "noise" and "vibration": "For the purpose of this Convention —

-
- (b) the term 'noise' covers all sound which can result in hearing impairment or be harmful to health or otherwise dangerous;
 - (c) the term 'vibration' covers any vibration which is transmitted to the human body through solid structures and is harmful to health or otherwise dangerous."

For further details, see Appendix 1.

² All published in Geneva. In addition to the sources specifically cited in this list of definitions, reference should be made to International Standard ISO 1925-1981: *Balancing — Vocabulary* of the International Organisation for Standardisation.

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*Audiometer, pure-tone, for general diagnostic purposes*³

A device using pure tones designed for general diagnostic use and for determining the hearing threshold levels of individuals by (a) monaural air-conduction earphone listening, and by (b) bone conduction. The apparatus should provide at least eight tones of frequencies: 250, 500, 1,000, 2,000, 3,000, 4,000, 6,000, and 8,000 Hz for air conduction; for bone conduction it should meet the requirements of IEC Publication 177.

—, *pure-tone screening*⁴

A device designed for screening purposes by monaural air-conduction earphone listening using pure tones. The ap-

³ International Electrotechnical Commission (IEC), Publication 177: *Pure tone audiometers for general diagnostic purposes* (1965), entries 1, 3.1 and 4.1. Superseded by IEC Publication 645: *Audiometers* (1979). For details, see footnote 4.

⁴ IEC Publication 178: *Pure-tone screening audiometers* (1965), entry 3.1. Superseded by IEC Publication 645: *Audiometers* (1979). This standard specifies requirements for audiometers designed primarily for use in determining hearing threshold levels in comparison with a chosen standard reference threshold level. A pure-tone audiometer is defined as an instrument for measurement of the hearing of pure tones and in particular the auditory threshold. Publication 645 no longer divides audiometers for diagnostic and screening purposes. It states that "audiometers can be classified in the following ways: according to the type of test signal they generate (i.e. pure tone or speech or both), according to the mode of operation or according to their complexity or the range of auditory functions they test (i.e. diagnostic, screening, etc.). However, in order to rationalise the classification of audiometers, five types are defined. Audiometers with which it is possible to make a diagnostic assessment (i.e. having as a minimum both air and bone conduction facilities) are classified as Types 1, 2 and 3. Instruments with air conduction facilities only are classified as Types 4 and 5." Type 4 would correspond to the previous screening audiometer and should provide tones of frequencies 500, 1,000, 2,000, 4,000 and at least one of the frequencies 3,000 and 6,000 Hz. The frequencies given for the previous pure-tone audiometer for general diagnostic purposes correspond to the Type 3 audiometer, whereas Types 1 and 2 also cover frequencies 125, 750 and 1,500 Hz for air conduction. IEC Publication 645 contains further specifications.

Definitions

paratus should meet the specifications of IEC Publication 178, and provide at least five tones of frequencies: 500, 1,000, 2,000, 4,000 and 6,000 Hz.

*Decibel A slow response [dB(A)]*⁵

Sound level is defined as

$$20 \log_{10} \frac{P_n}{P_o}$$

where P_n is the r.m.s. sound pressure due to the sound being measured, weighted in accordance with the curve A of IEC Publication 179, and P_o is the reference pressure (2×10^{-5} Pa = 2×10^{-5} N/m² = 2×10^{-4} μ bar). This sound level is measured using the precision sound level meter's dynamic characteristic "slow".

⁵ IEC Publication 179, Second edition, 1973: *Precision sound level meters*, entries 3.2 and 6.7. Superseded by IEC Publication 651: *Sound level meters* (1979). The most important aspect is the use of the weighted sound pressure level. "Weighted sound pressure level in decibels (dB) is 20 times the logarithm to the base ten of the ratio of a weighted sound pressure to the reference sound pressure. The sound pressure is weighted in accordance with one of the frequency weightings A, B or C, and is time weighted in accordance with characteristics S, F, I, or Peak, the frequency and time weightings being as specified in this standard. The reference sound pressure is 20 μ Pa (20 μ N/m²) and does not depend on the frequency or time weighting. When quoting the weighted sound pressure level, the frequency weighting and time weighting shall be indicated. (The term 'weighted sound pressure level', used throughout this standard, is often abbreviated to 'weighted sound level' or 'sound level' in English-speaking countries)."

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*Decibel A impulse response [dB(AI)]*⁶

The impulse-weighted sound level A is defined by

$$L_{AI} = 20 \log_{10} \frac{P_{AI}}{P_o} \text{ dB}$$

where P_{AI} is the A-weighted sound pressure measured with an apparatus having the characteristics specified in IEC Publication 179A, and P_o is the reference sound pressure: 2×10^{-5} Pa. Impulse sound levels are expressed in decibels (dB) and the weighting used should always be stated, as well as the dynamic characteristic "impulse".

*Environment, working*⁷

(1) All places of work as well as all the sites and areas where work is carried out including not only the permanent, indoor, stationary places of work which immediately come to mind such as factories, offices, kitchens and shops, but also temporary places of work such as civil engineering sites, open-air places such as fields, forests, roads and oil refineries and mobile ones such as cabs of trucks, seats of tractors and excavators, ships' galleys, flight decks of aircraft, and so on without exception.

(2) Places where workers are found as a consequence of their work (including canteens, and living quarters on board ship).

⁶ IEC Publication 179A: *First supplement to Publication 179 (1973): Precision sound level meters: Additional characteristics for the measurement of impulsive sounds*, entry 3.4. Superseded by IEC Publication 651: *Sound level meters* (1979). See footnote 5.

⁷ ILO: *Noise and vibration in the working environment*, Occupational Safety and Health Series, No. 33 (1976), p. 4.

Frequency band analysis

Noise and vibration analysis using octave, half-octave and third-octave band filters as defined in IEC Publication 225.⁸

Hearing impairment

Hearing loss exceeding a designated criterion (commonly 25 dB, averaged from the threshold levels at 500, 1,000 and 2,000 Hz).⁹ The hearing loss is the difference between the audibility threshold and the standard reference zero at each frequency as defined in International Standard ISO 389-1975.¹⁰

*Infrasound*¹¹

Acoustic oscillation whose frequency is too low to affect the sense of hearing.

*Noise*¹²

(1) Any disagreeable or undesired sound.

(2) A class of sounds, generally of a random nature, which do not exhibit clearly defined frequency components.

⁸ IEC Publication 225: *Octave, half-octave and third-octave band filters intended for the analysis of sounds and vibrations* (1966, second impression 1982).

⁹ International Standard ISO 1999-1975 (*Acoustics — Assessment of occupational noise exposure for hearing conservation purposes*) defines an "impairment of hearing for conversational speech" in the following manner (entry 3.4): "The hearing of a subject is considered to be impaired if the arithmetic average of the permanent threshold hearing levels of the subject for 500, 1,000 and 2,000 Hz is shifted by 25 dB or more compared with the corresponding average given in ISO 389."

¹⁰ International Standard ISO 389-1975: *Acoustics — Standard reference zero for the calibration of pure-tone audiometers*.

¹¹ IEC Publication 50 (08): *International electrotechnical vocabulary*, Group 08: *Electro-acoustics* (second edition, 1960), entry 08-05-040.

¹² *ibid.*, entry 08-05-025.

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—, *ambient*

Noise of a measurable intensity which is normally present.

—, *impulsive* ¹³

A noise consisting of one or more bursts of sound energy, each of a duration less than about 1 s.

—, *non-steady* ¹⁴

A noise whose level shifts significantly during the period of observation; a distinction is made between fluctuating noise, intermittent noise and impulsive noise.

—, *steady* ¹⁵

A noise with negligibly small fluctuations of level within the period of observation.

Sound, pure ¹⁶

Sound produced by a sinusoidal acoustic oscillation.

— *level, equivalent continuous* ¹⁷

That sound level — in dB(A) — which, if present for 40 hours in one week, produces the same composite noise exposure index as the various measured sound levels over one

¹³ International Standard ISO 2204-1979: *Acoustics — Guide to International Standards on the measurement of airborne acoustical noise and evaluation of its effects on human beings*, entry 3.2.2.3.

¹⁴ *ibid.*, entry 3.2.2.

¹⁵ *ibid.*, entry 3.2.1.

¹⁶ IEC Publication 50 (08), *op. cit.*, entry 08-05-015.

¹⁷ International Standard ISO 1999-1975, *op. cit.*, entry 3.3 (including tables 1 and 2).

week. For the two degrees of noise exposure to be equivalent, it is necessary that, if the sound intensity increases by 3 dB(A), the duration of exposure be reduced by a half.

*Ultrasound*¹⁸

Acoustic oscillation whose frequency is too high to affect the sense of hearing.

*Vibration*¹⁹

The variation with time of the magnitude of a quantity which is descriptive of the motion or position of a mechanical system, when the magnitude is alternately greater and smaller than some average value or reference.

*—, hand-transmitted*²⁰

Intensive vibration can be transmitted from vibrating tools, vibrating machinery or vibrating workpieces to the hands and arms of operators. Such situations occur, for example, in the manufacturing, mining and construction industry when handling pneumatic and electrical hand tools and in forestry work when handling chain saws. These vibrations are transmitted through the hand and arm to the shoulder. Depending on the work situation they can be transmitted to one arm only or to both arms simultaneously. In principle, these hand-transmitted vibrations are in the frequency range of 8-1,000 Hz.

¹⁸ IEC Publication 50 (08), op. cit., entry 08-05-045.

¹⁹ International Standard ISO 2041-1975: *Vibration and shock — Vocabulary*, entry 2.001.

²⁰ International Organisation for Standardisation: *Principles for the measurement and the evaluation of human exposure to vibration transmitted to the hand*, document ISO/DIS 5349, entries 1 and 2.

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—, *whole-body* ²¹

Vibration transmitted to the body as a whole through the supporting surface, namely the feet of a standing man, the buttocks of a seated man or the supporting area of a reclining man. This kind of vibration is usual in vehicles, in vibrating buildings and in the vicinity of working machinery. In principle, International Standard ISO 2631-1978 applies to vibration transmitted from solid surfaces to the human body in the frequency range 1-80 Hz. Vibration in the frequency range below about 1 Hz is a special problem, associated with symptoms such as kinetosis (motion sickness), which are of a character different from the effects from higher frequency vibrations. The appearance of such symptoms depends on complicated individual factors not simply related to the intensity, frequency or duration of the provocative motion.²²

²¹ International Standard ISO 2631-1978: *Guide for the evaluation of human exposure to whole-body vibration*, entries 0, 1 and 1 note 2.

²² The range of frequencies between 0.1 and 0.63 Hz has been covered by Addendum 2 to the International Standard ISO 2631-1978: *Evaluation of exposure to whole-body z-axis vertical vibration in the frequency range 0.1 to 0.63 Hz*.

1. General

1.1. Duties of employers

1.1.1. The employer should be responsible for action to reduce by all appropriate means the exposure of workers to noise * and vibration *.¹

1.1.2. The employer should be responsible for the organisational arrangements required to prevent the risks due to noise and vibration in the undertaking.

1.1.3. The employer should establish and publicise (preferably in writing) a general policy emphasising the importance of prevention, and should take the decisions and the practical steps required to give effect to national regulations and to this code of practice.

1.2. Duties of the workers

1.2.1. (1) The workers should abide by instructions given and recommendations made to them concerning the prevention of noise and vibration.

(2) In particular, workers should —

- (a) make use of noise and vibration control devices and techniques;
- (b) indicate whenever such devices are faulty or are in need of maintenance;
- (c) be willing to undergo the prescribed medical surveillance; and
- (d) use the personal protective equipment provided.

¹ Asterisks are inserted in the text on the first occurrence of terms included in the preliminary list of definitions.

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1.3. Co-operation

1.3.1. The employer should secure the workers' co-operation in action to protect their health and eliminate noise and vibration hazards, and should establish by joint agreement instructions and recommendations for the prevention of noise and vibration.

1.3.2. (1) The employer should co-operate with the workers in devising and implementing programmes for the prevention and control of noise and vibration.

(2) This co-operation should be especially close within any existing joint safety and health committees at the plant level.

1.3.3. Co-operation should be established between manufacturers and buyers of machinery and equipment with a view to reducing the noise and vibration emission of such machines and equipment.

1.4. Inspection by official services

1.4.1. Inspectors called upon to supervise compliance with the regulations should also take into consideration the provisions of this code of practice.

1.4.2. Inspectors should ensure that an effective prevention programme is evolved and put into effect whenever and wherever there is a special risk due to noise and vibration.

1.4.3. (1) Inspectors should attach special importance to proper briefing of workers, and to co-operation between employer and workers in the prevention of noise and vibration.

(2) Inspectors should ensure that the joint safety and health committees, whenever such committees are established, receive the information they need to be effective.

2. Organising principles of prevention

2.1. Aims

2.1.1. The aim of noise and vibration prevention programmes should be to eliminate those risks or to reduce them to the lowest feasible levels by all appropriate means.

2.1.2. The noise and vibration to which workers are exposed, and the time during which they are exposed, should not exceed the established limits.

2.2. Control

2.2.1. Appropriate measures should be taken at the source to prevent generation, transmission, amplification and reverberation of noise and vibration when machinery and equipment are being designed; and noise and vibration levels are factors to be taken into account when machinery and equipment are to be ordered.

2.2.2. (1) An endeavour should be made to ascertain at which locations, if any, noise or vibration will exceed the established limits.

(2) Such locations should be identified, marked out, and suitably indicated.

2.2.3. Technical measures should be taken to control noise and vibration with a view to reducing their levels below the maximum permissible levels.

2.2.4. When this proves impossible, provision should be made by a reorganisation of work, personal protective equipment or any other suitable means to reduce the exposure below the permissible levels.

2.2.5. The health of workers likely to be exposed to noise or vibration, or both, at levels exceeding the permissible

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maxima, including workers whose exposure is limited by personal protective equipment or by administrative arrangements which reduce exposure time, should be appropriately supervised.

2.2.6. (1) The monitoring of the working environment * should be systematic, and repeated as often as needed to ensure that noise and vibration risks are kept under control.

(2) Health supervision data should be used to ascertain that the workers involved remain in good health and hence that the prevention programme is achieving its aim.

2.3. Implementation

2.3.1. Every enterprise or department thereof should implement a general prevention programme that takes due account of its own specific features.

2.3.2. (1) Advice for the implementation of a prevention programme should be provided by the safety service, the occupational health service, or an external adviser or body.

(2) The employer should define and assign technical responsibilities in this connection.

2.3.3. If the enterprise is large enough, competent departments, branches or persons with certain responsibilities should have special duties in connection with noise and vibration prevention in —

- (a) the design of new buildings and equipment or studies of new processes;
- (b) the purchase of machinery or equipment;
- (c) contracts entered into with contractors;
- (d) the information and training given to workers; and
- (e) the purchase of personal protective equipment and the provision of instructions in regard to its use.

Organising principles of prevention

2.3.4. Noise and vibration control should preferably be achieved by collective measures with the assistance of a qualified person; improvements that are recommended should be made forthwith by the competent service.

2.3.5. The personnel responsible for monitoring noise and vibration in the working environment should —

- (a) have received appropriate training in the measurement and control of noise and vibration; and
- (b) be equipped with suitable instruments.

2.3.6. The medical supervision of the workers should be carried out —

- (a) under the responsibility of a qualified physician competent to interpret the results of the special tests which are made; and
- (b) with the assistance of qualified auxiliary staff that has received appropriate training concerning the special tests to be made (including audiometric tests) and the use of personal protective equipment.

2.3.7. (1) New building, equipment and plants should be designed, and new equipment ordered, with due consideration to the advice given by technically and medically qualified persons.

(2) The service responsible for monitoring the working environment, the medical service and the workers should be kept informed about any change in plant, equipment or process likely to bring about any substantial alteration in the noise and vibration levels.

3. Noise measurement and assessment

3.1. General

3.1.1. Procedures to measure and evaluate noise exposure depend on the goal to be attained. This applies in particular to —

- (a) assessment of the risk of hearing impairment *;
- (b) assessment of the degree of interference to communications essential for safety purposes; and
- (c) assessment of the risk of nervous fatigue, with due consideration to the work to be done.

3.1.2. Noise measurements should be carried out according to standardised methods appropriate for the specific goal and using standards adopted at the international level or their national equivalent.¹

3.1.3. The provisions of sections 3.2 to 3.4 are useful if —

- (a) standards concerning noise and vibration are being prepared; or
- (b) doubt arises whether, or in what manner, a certain standard should be used.

3.2. Hearing conservation

3.2.1. Noise measurements should be made in a manner which will show the noise exposure as accurately as is necess-

¹ The present national standards for noise measurements are not fully harmonised at the international level. For the same industrial noise level determined for the same purpose, it is possible to obtain different values by applying different national standards. This is the reason why standards

ary, so that the figures obtained may be compared with the noise limits given in paragraph 4.2.2.

3.2.2. When noise is measured, both normal working conditions and conditions involving the highest noise levels should be taken into consideration.

3.2.3. For steady noise *, the sound pressure level at the workplace (working environment) and equivalent continuous acoustic level should be determined in dB(A) according to international and national standards.² Frequency analysis³ should be made in accordance with standardised methods.

3.2.4. (1) For non-steady impulsive noise *,⁴ the additional effects of rapid fluctuations should be taken into account by appropriate standardised measurement methods.

(2) In order to assess the actual noise exposure for non-steady, impulsive noise, whichever of the following methods gives the higher readings should be used:

adopted at the international level, or such provisions incorporated into national standards, should be preferred. If not, the use of certain limit values can result in workers' being exposed, in their working environment, to different conditions according to the countries concerned. Existing international standards are described in Appendix 1.

² International Standard ISO 1999-1975, op. cit., entry 4: "Noise measurements", and entry 5: "Calculation of equivalent continuous sound level for non-impulsive sound that is intermittent or fluctuating". By applying this standard it is possible to determine, first, under entry 4, the sound level for steady noise which is almost unchanged within a week or varies in a regular manner among a few clearly distinguishable levels, and secondly, under entry 5, equivalent continuous sound levels for non-steady intermittent or fluctuating noise.

³ See preliminary definition of "frequency band analysis".

⁴ For non-steady impulsive noise, the actual noise exposure is higher than would be indicated by noise levels measured in accordance with existing international or national standards. Non-steady impulsive noise is said to exist if there is more than 3 dB(A) between the "slow" response and "impulse" readings of an impulse sound meter as defined by IEC Publication 179A.

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- (a) measurement with the sound level meter using the impulse response ⁵ and calculation of the mean value for an eight-hour daily exposure on an energy basis; or
 - (b) the use of a rule by which a certain (positive) correction factor (usually 3 to 10 dB) should be added to the "slow" response ⁶ values determined in accordance with international or national standards.⁷ The value of this correction should depend on the magnitude of the non-steadiness (impulsivity) of the noise to be measured.
- (3) Other special measurement methods which are proved to be appropriate should be used for rapid fluctuating noises.

3.3. Oral communications

3.3.1. Measurements of noise should be made in noisy working areas where —

- (a) it is important, for safety reasons, that a worker should be able to hear a message or other signal; or
- (b) the worker would be subjected to extra strain, and the work possibly hindered, by difficulties in oral communication.

3.3.2. Consideration should be given to defining the maximum distance at which speech intelligibility is preserved at normal voice loudness.

⁵ See "Decibel A impulse response" among the preliminary definitions.

⁶ See "Decibel A slow response" among the preliminary definitions.

⁷ International Standard ISO 1999-1975, op. cit., entry 6: "Calculation of equivalent continuous sound level of quasi-stable impulsive noise": "For impulsive noise consisting of series of noise bursts of approximately equal amplitudes (for example, noise from rapidly repeated hammering or riveting) an approximation to the partial noise exposure index may be based on a value 10 dB(A) higher than the measured sound level."

3.4. Fatigue

3.4.1. Measurements of noise should be made in noisy working areas where —

- (a) it is important for safety reasons that a worker should not be exposed to extra strain and fatigue resulting from noise; and
- (b) the nature of the work performed by the worker is such that the noise is likely to hinder it and to make it more difficult or arduous.

3.4.2. Maximum noise levels should be established as necessary, with due regard to the work performed.

3.5. Measuring instruments

3.5.1. The manufacturers of measuring and analysing instruments should provide full information about such instruments and in particular about their use, calibration, maintenance, margins of error and sensitivity, the interpretation of results and accessories.

3.5.2. Measuring and analysing instruments should be used in accordance with the manufacturer's instructions.

3.5.3. The measuring and analysing instruments used should meet the relevant international and national standards.

3.6. Instrument accuracy and calibration

3.6.1. All measuring and analysing equipment should be kept in good condition and calibrated every day it is used. The required calibration equipment should be accurate to within ± 1 dB.

3.6.2. Measuring and analysing instruments should be tested at suitable intervals, and a qualified person should

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complete a certificate of calibration to be kept with the instrument.

3.6.3. The persons responsible for the maintenance and testing of measuring and analysing instruments should be specially trained, and it should be their responsibility to ensure that those instruments are kept in good condition.

3.7. Recording of data

3.7.1. When noise is measured in the working environment, adequate data should be collected, especially regarding —

- (a) the location, nature, dimensions, and other distinctive features of the place of work where measurements are made;
- (b) the source or sources of the noise, the location of the source in the plant and the type of work being performed;
- (c) the instrument used, its accessories, the results of calibration tests, and the values indicated;
- (d) the location at which measurements were made, and the direction of the microphone;
- (e) the number of workers exposed to noise;
- (f) the duration of workers' exposure; and
- (g) the date and time, and the name of the observer.

3.7.2. The collected data should be suitably recorded. It would be advisable to have a special form for this purpose.

4. Noise limit levels

4.1. General

4.1.1. Noise limits should be laid down as a function of the goal to be attained,¹ in particular —

- (a) to prevent a risk of hearing impairment;
- (b) to prevent interference with communications essential for safety purposes; and
- (c) to eliminate nervous fatigue, with due regard to the work to be done.

4.1.2. The noise limit levels should be reviewed from time to time so as to keep abreast of scientific knowledge, technical developments and possibilities of prevention.

4.2. Hearing impairment

4.2.1. Depending on the degree of protection wanted, the following limit values should be determined —

- (a) a warning limit value that sets the noise level under which there is very little risk of hearing impairment to an unprotected ear for an eight-hour exposure; and
- (b) a danger limit value that sets the noise level above which hearing impairment and deafness may result from an eight-hour daily exposure of an unprotected ear.

4.2.2. In the light of present knowledge, the following values may be recommended —

- (a) a warning limit value of 85 dB(A); and
- (b) a danger limit value of 90 dB(A).

These values are equivalent continuous sound levels * and

¹ See Appendix 2, and Appendix 1, section 4.

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should be related to noise measurements made in accordance with the relevant procedures outlined in Chapter 3.

4.3. Special provisions

4.3.1. During emergencies, or because of unforeseen technical imperatives, a worker may be temporarily authorised to exceed the daily dose, provided that the next day he recuperates so that the maximum weekly dose (as determined on the basis of paragraph 4.2.2) is respected.

4.3.2. No matter for how short a time, a worker should not, without appropriate ear protection, enter an area in which the noise level is 115 dB(A) or more.

4.3.3. If there are single isolated bursts of noise which can go above 130 dB(A) "Impulse" or 120 dB(A) "Fast", personal protective equipment should be worn.

4.3.4. No worker should enter an area where the noise level exceeds 140 dB(A).

4.4. Ultrasound and infrasound

4.4.1. A survey should be made to find out if any workers are exposed to ultrasound * or infrasound * in their place of work.

4.4.2. Levels of exposure to ultrasound and infrasound should be reduced to and kept at a reasonable value, due account being taken of up-to-date technical information available.²

² See Appendix 2 and, for an example of national provisions along these lines on ultrasound, Appendix 3.

4.5. Oral communications

4.5.1. The noise limits expressed in dB(A), at places of work concerned and for the kind of oral communications envisaged, should be determined with regard to the current technical material available.

4.6. Fatigue and comfort

4.6.1. (1) Hearing conservation should be an important stage in the improvement of the working environment.

(2) The noise levels laid down should be such that work can proceed normally with a minimum of fatigue and discomfort.

(3) In defining these noise levels due account should be taken of the kind of work being done and the available knowledge.

4.6.2. The noise levels determined should ensure adequate comfort, and should be considered as objectives to be aimed at.

5. Vibration measurement

5.1. General

5.1.1. Vibration measurements should adequately represent the levels of vibration to which workers are exposed.

5.1.2. Vibration should be measured under standard conditions ¹ so that the figures obtained may be comparable with the limits laid down.

5.1.3. (1) Vibration should be measured as close as possible to the point or area through which it is transmitted to the body.

(2) If such transmission has to pass through a cushion or depends on other factors, these factors should be taken into account.

5.2. Measuring instruments

5.2.1. The manufacturers of measuring and analysing instruments should provide full information about such instruments and in particular about their use, calibration, maintenance, margins of error and sensitivity, the interpretation of results and accessories.

5.2.2. Measuring and analysing instruments should be used in accordance with the manufacturer's instructions.

5.2.3. The measuring and analysing instruments used should meet the relevant international and national standards.

¹ Standard methods are proposed at the international level; see Appendix 1. In particular vibration should be measured in all three axes of an orthogonal co-ordinated system.

5.3. Instrument accuracy and calibration

5.3.1. Measuring and analysing instruments should be suitably calibrated, in accordance with the relevant standards and with the recommendations made about such calibration.

5.3.2. Measuring and analysing instruments should be tested at suitable intervals, and the qualified person should draw up a certificate of calibration to be kept with the instrument.

5.3.3. The person responsible for maintenance and testing of measuring and analysing instruments should be specially trained, and should be responsible for ensuring that the equipment is kept in good condition.

5.4. Recording of data

5.4.1. When vibration is measured at places of work, adequate data should be collected, especially regarding —

- (a) the characteristics of the source of vibration studied and the type of work being performed;
- (b) the characteristics of the path or manner in which vibration is transmitted to the human body (whether there are shock-absorbers, cushions, etc.);
- (c) the point at which (including the description of any intermediary elements such as seat sheets) and the pick-up device with which measurements were made, and the values obtained;
- (d) the instrument used, its accessories and their characteristics (including sensitivity, dynamic properties and fineness of resolution);
- (e) the number of workers exposed to vibration;
- (f) the duration of workers' exposure; and
- (g) the date and time, and the name of the observer.

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5.4.2. The data collected should be suitably recorded. It would be advisable to have a special form for this purpose.

6. Vibration limits

6.1. General

6.1.1. (1) Vibration limits should be laid down with due consideration to the aim to be achieved and to the degree of protection required ¹ especially for —

- (a) vibration affecting the hands * ² and arms (vibrating tools); and
- (b) whole-body vibration * transmitted through the supporting surface.

(2) Vibration limits should also be laid down depending on the work to be done and to avoid fatigue.

6.1.2. The limits should be reviewed from time to time in the light of new scientific knowledge, technical progress and possibilities of prevention.

6.2. Vibration transmitted to hands and arms

6.2.1. For a continuous exposure, maximum permissible levels of vibration, depending on the daily exposure duration, should be laid down, account being taken of current knowledge.

6.2.2. When daily exposure to vibration is made up of two or more periods of exposure at different levels of vibration, or when there are adequate regular breaks, different limits may be laid down.

¹ See Appendix 2, and Appendix 1, section 5.

² See "Vibration, hand-transmitted" among the preliminary definitions.

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6.3. Whole-body vibration ³

6.3.1. In places of work, the limits for whole-body vibration transmitted by the supporting surface should be laid down with consideration to the boundary of reduced well-being and proficiency caused by fatigue.

6.3.2. For a continuous exposure, maximum permissible levels of vibration depending on the daily exposure should be laid down, with due account to the current technical information available.

6.3.3. When daily exposure is made up of two or more periods of exposure at different levels of vibration, or when adequate regular breaks are allowed, different limits may be laid down.

6.4. Comfort

6.4.1. It would be advisable to lay down standards ensuring a degree of comfort and to consider these standards as objectives to be aimed at.

³ See in particular International Standard ISO 2631-1978. That standard provides guide-lines for the prevention of adverse effects on health, performance and comfort caused by whole-body vibration. It recommends boundaries for occupational daily exposure of workers in terms of acceleration and as a function of vibration frequency and daily exposure time. The boundaries are different for vibration in the direction of man's longitudinal body axis (head-to-foot) and in the transverse directions (chest-to-back or side-to-side). For each of these conditions three boundaries are specified: (a) an exposure limit (health or safety); (b) a fatigue-decreased proficiency boundary, above which vibration exposure leads to increased fatigue and potential interference with specific tasks; (c) a reduced comfort boundary that should not be exceeded for most persons if discomfort is to be avoided.

7. Identification of risk areas

7.1. Risk assessment

7.1.1. Noise or vibration, or both, should be measured in all places of work where —

- (a) the work done or the working environment possibly will involve a risk due to noise or vibration;
- (b) occupational safety and health supervision or inspection discloses that such risks may exist; and
- (c) the workers maintain that they are subject to an uncomfortable or disturbing level of noise, vibration, or both noise and vibration.

7.1.2. Noise should be measured whenever speech intelligibility is impaired (in a normal voice) at a distance of 50 cm.

7.2. Ambient noise *

7.2.1. A noise survey should be made to ascertain levels of ambient noise in the various shops within the enterprise.

7.2.2. (1) For the purpose of establishing the noise survey, each shop and other place of work should be taken separately.

(2) If necessary, the workplace may be considered as divided up into areas so that the noise characteristics of the working environment could be better determined.

7.2.3. Noise measurements should be made at a distance of about 1.50 m above the floor or work platform and at least 1 metre from walls, and a mean should be taken of the sound levels measured in various directions.

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7.2.4. Consideration should be given to the measurement of ambient vibration.

7.3. Sources of noise and vibration

7.3.1. The sources of noise and vibration should be identified by appropriate measurements.

7.3.2. (1) If the figures obtained for noise measurements exceed 85 dB(A),¹ a noise map should be made in places of work.

(2) This map should draw the contours of areas in which noise is equal to or more than 80 dB(A), 85 dB(A), 90 dB(A), 100 dB(A) and 115 dB(A).

(3) These measurements should be repeated on various occasions until exact and proper contours² can be established.

7.3.3. If noise or vibration measurements vary widely because of changes in working conditions (as when machine-tool runs unload and then start working), account should be taken of the least favourable conditions, and it may be as well to undertake two or more separate series of measurements.

7.4. Assessment of exposure

7.4.1. Measurements should be made at locations normally occupied by the workers in the area under observation.

7.4.2. (1) Measurements of noise should be made in one of the following ways:

¹ Measurements made in accordance with section 3.2.

² See Appendix 4.

- (a) either by a measurement made at the level of the worker's head in his ordinary working posture; or
- (b) with the microphone at 1 m away from the worker's head in this position, and on both sides; should the figures obtained vary from one place to another, the highest value should be used.

(2) A supplementary assessment may also be made with an integrating dosimeter of an approved type, checked from time to time; its use should be taught and supervised by a qualified person.

7.4.3. Measurements should be made of the vibration transmitted to the whole body and of the vibration transmitted to a particular part of the body.

7.5. Other noise measurements

7.5.1. Measurements of noise levels undertaken in each working environment should also aim at the assessment of noise attributable to the propagation or transmission of noise emitted in adjacent areas.

7.5.2. Measurements of ambient noise and assessment of noise sources should be supplemented by measurement of reverberation time in certain places, where this measurement is of interest.

7.6. Marking of areas and equipment

7.6.1. The contours of areas of equal exposure level should be marked.³

7.6.2. Equipment producing noise in excess of the noise limit levels should be clearly marked with an indication of the

³ See Appendix 5.

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nature of the risk, and the need to wear personal protective equipment.

7.6.3. Equipment, fixed or portable, which may cause vibration in excess of the maximum limits laid down should be clearly marked with an indication of the risk, of the maximum period of use and of the personal protective equipment needed.

7.6.4. (1) Noisy areas within which exposure time should be reduced and workers should wear personal protective equipment should be marked, due account being taken of the measurements made and the contours drawn.

(2) Only workers wearing adequate personal protective equipment should be allowed access to those areas.

(3) A suitable sign, prominently displayed, should forbid entry to all persons not wearing appropriate means of protection.

8. Noise and vibration control: new equipment

8.1. Specifications for new equipment

8.1.1. Manufacturers should so design the equipment they produce (embodying therein suitable devices) that the noise and vibration emitted is at the lowest feasible level.

8.1.2. (1) Manufacturers should provide information concerning the availability of accessories that are not provided with the equipment itself, but that may be useful or essential to control noise and vibration.

(2) They should also provide information concerning the installation of such accessories so as to obtain maximum efficiency.

8.1.3. Manufacturers should provide full information about levels of noise and vibration emitted, as well as on means of controlling them.

8.1.4. When ordering equipment the purchaser should specify maximum limits for the noise and vibration emitted.

8.1.5. The competent authority should establish maximum levels for noise and vibration emitted by all equipment, or by specific types of equipment.

8.2. Testing

8.2.1. Tests to assess noise and vibration should be performed in accordance with internationally or nationally recognised standard procedures.¹

¹ See Appendix 1, section 6.

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8.2.2. An analysis by frequency band * ² of the noise and vibration produced should be made with a view to discovering means of attenuating that noise or vibration, combating the emission of pure sounds and providing users with the fullest possible guidance.

8.3. Replacement of hazardous equipment or processes

8.3.1. Whenever possible, processes and equipment producing less noise and vibration should be given preference.

8.3.2. It should be considered preferable to purchase equipment that is quieter or produces less vibration than to be compelled to take steps against excessive noise and vibration later on.

8.4. Design and installation

8.4.1. Noise and vibration control should begin with the design and planning of new buildings, installations and processes; it should be based on the relevant technical knowledge, and in particular —

- (a) a knowledge of the noise and vibration characteristics of the equipment and processes to be used;
- (b) the choice of suitable construction;
- (c) the isolation of operations or plant giving rise to high noise or vibration that is difficult to control.

8.4.2. As far as possible, preference should be given to materials and structures having a high isolating factor or attenuation factor, or both.

² See "frequency band analysis" among the preliminary definitions.

Noise and vibration control: new equipment

8.4.3. Once suitable equipment has been chosen, its installation should be studied with due regard to —

- (a) the kind of noise and vibration likely to be emitted;
- (b) the number and type of machines and other equipment;
- (c) the number of workers employed on the particular work premises;
- (d) the acoustical characteristics of the work premises; and
- (e) the noise already present in the working environment.

8.4.4. Measurements should be made as soon as machines and equipment have been installed, in order to establish the resulting noise and vibration levels.

9. Noise and vibration control in the working environment

9.1. General

9.1.1. Appropriate technical action should be taken to keep noise and vibration in the working environment below the maximum permissible limits.

9.1.2. Should it be impossible to keep below those limits the following action should be taken, in order of preference:

- (a) a reduction in exposure time;
- (b) the use of personal protective equipment; or
- (c) a combination of time reduction and personal protective measures.

9.2. Control methods

9.2.1. (1) The methods used should aim at —

- (a) reducing noise and vibration produced and emitted by the sources;
- (b) preventing the propagation, amplification and reverberation of noise and vibration; and
- (c) isolating the workers.

(2) Noise and vibration should also be attenuated, as appropriate in particular cases, by distance or by isolating the workers liable to exposure, either by collective measures (such as soundproof booths) or by personal protective equipment.

9.2.2. The various control methods may be combined in order to achieve a suitable reduction in noise and vibration levels.

9.3. Control at source

9.3.1. A distinction should be drawn between the following three main kinds of noise and vibration according to their source:

- (a) sound or vibration attributable to the vibration of a solid or liquid (mechanical forces);
- (b) sound or vibration attributable to turbulence occurring in a gaseous medium (aerodynamic forces); and
- (c) sound or vibration attributable to electrodynamic or magnetodynamic forces, or to electrical arc or corona discharge (electrical forces).

9.3.2. Methods of controlling sources of noise and vibration which should be specifically considered include the following:

- (a) reducing the intensity of vibration by dynamic balancing, reducing the driving force acting on the vibrating part, reducing revolutions per minute, and increasing the length of the working cycles;
- (b) reducing the emission efficiency of the vibrating parts by increasing their damping capacity and improving the way in which they are attached;
- (c) reducing turbulence and the rate of flow of fluids at inlets, in ducts or pipes, and at outlets;
- (d) changing from impact action to progressive pressure action;
- (e) changing from reciprocating movements to rotating movements;
- (f) changing from sudden stopping to progressive braking;
- (g) changing from cylindrical toothed gears to helical gears, and from metal gears to gears of other materials if practicable;

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- (h) design of the shape and speed of tools with due regard to the characteristics of the material worked;
- (i) design of adequate systems for fixing the materials or objects to be worked;
- (j) prevention of the striking of objects or materials being transported mechanically, and prevention of their free fall from conveying equipment;
- (k) design of burners, torches and combustion and explosion chambers with appropriate characteristics;
- (l) adequate design of electrical machinery in regard to electrodynamic, magnetodynamic and aerodynamic forces;
- (m) insertion of adequate damping joints at connecting points of machinery and equipment;
- (n) adequate design of fan blades; and
- (o) adequate design of air tubing and ducting systems (compressed air, ventilation air), and gas or liquid tubing systems to prevent the propagation of noise and vibration and resonance build-up.

9.3.3. Maintenance of equipment should receive special attention so as to prevent any abnormal increase in noise and vibration emitted by the source.

9.3.4. The maintenance personnel should be adequately trained in oiling, adjusting, replacement of worn-out parts and the regular and correct maintenance of anti-noise and vibration devices.

9.3.5. When there is more than one type of source of noise in a particular area, the noisiest one should be attended to first if noise is to be effectively reduced.

9.4. Control of propagation, amplification and reverberation

9.4.1. (1) Since noise and vibration may take different paths from a single source, their transmission should be studied so that it may be controlled with efficiency.

(2) Steps should also be taken to reduce amplification and reverberation.

9.4.2. Measures to control the propagation of noise and vibration through solids should include especially —

- (a) the mounting of machinery on damping foundations isolated from the floor and walls;
- (b) the interposition of anti-vibration materials for mounting and floor-joints;
- (c) the siting of noisy and vibrating machinery so that it does not come into contact with other parts of the installation and the workroom.

9.4.3. Measures to control the propagation and reflection of noise through air should include especially —

- (a) partially or totally enclosing the source;
- (b) using screens and soundproof partitions and linings;
- (c) the proper design of premises from the acoustical point of view; and
- (d) soundproofing of premises (lining the walls, partitions, floors and ceilings with isolating and absorbent materials).

9.4.4. Measures to control the propagation of noise should include the use of silencers if necessary.

9.4.5. (1) The acoustical characteristics of the isolating and absorbent materials and the anti-vibration qualities of the material used for the construction of premises, equipment and enclosures should be carefully considered.

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(2) The manufacturers should supply detailed information about the noise-transmission and noise-reduction factors of their isolating and absorbent materials.

(3) Users should take this information into consideration in order to choose the most appropriate materials.

9.5. Remote control and isolation

9.5.1. When equipment emits high levels of noise or vibration, or both, about which little can be done by other means —

- (a) the work should be done at a distance by remote control under suitable methods of supervision; or
- (b) arrangements should be made whenever possible to install the equipment in remote locations where the least possible number of workers will be exposed to the nuisance.

9.5.2. When places of work are especially noisy and technical action is not practicable or has proved unsatisfactory, acoustically isolated areas should be provided whenever possible from which all, or the greater part of, the operations required can be undertaken.

9.6. New risks

9.6.1. Action taken to control noise and vibration should not be such as to create new hazards (for instance, the accumulation of flammable gas within a protective enclosure, where an abnormal increase of temperature may also cause a fire).

9.6.2. The means whereby noise and vibration are controlled should be so chosen as not to increase the potential

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risks involved (for instance, the use of materials likely to absorb dust or oils which may increase the risk of fire).

9.6.3. (1) Heating systems, air conditioning and ventilation systems to control air pollution or to ensure hygienic working conditions should be so designed that they do not increase noise or vibration in the working environment.

(2) Special attention should be given to low frequency vibration and infrasound control.

10. Protective equipment and reduction of exposure time

10.1. General

10.1.1. When noise and vibration levels cannot be brought below the danger limit either by suitable design of equipment or by suitable installation —

- (a) the workers should be provided with and have easy access to soundproof booths either totally enclosed (and air-conditioned if necessary), or partially enclosed;
- (b) the workers should be provided with anti-vibration working platforms or stands;
- (c) the workers should be provided with adequate hearing protection and anti-vibration devices; or
- (d) the length of exposure should be limited.

10.1.2. Personal protective equipment and limitation of exposure time should bring workers' exposure within permissible limits.

10.1.3. (1) Personal hearing protection and anti-vibration equipment should on no account be regarded as adequate substitutes for technical prevention.

(2) They are to be used temporarily to keep risks within the limits, until such time as noise and vibration control can be made more effective through technical improvements.

10.1.4. Every effort should be made to ensure that workers actually use the personal protective equipment that is provided.

10.2. Choice of personal protective equipment

10.2.1. Personal protective equipment should afford effective and reliable protection against the risk.

Protective equipment and reduction of exposure time

10.2.2. Manufacturers should provide full information about the attenuation and protection afforded by the personal protective equipment marketed by them.

10.2.3. Since the attenuation offered by hearing protectors varies considerably with the frequency, the noise to be reduced should be analysed by band and the attenuation brought about by the devices should be subtracted for each band, and the noise then converted into dB(A).

10.2.4. Provided equivalent protection can be assured, the workers should be free to choose between different kinds and types of personal protective equipment.

10.2.5. The following personal hearing protective equipment should be considered —

- (a) earplugs that can be used more than once;
- (b) disposable earplugs;
- (c) ear muffs; and
- (d) helmets and other specialised ear protectors.

10.2.6. (1) Disposable earplugs should be of a type that can be efficiently used.

(2) Earplugs should in any case be worn only on medical advice.

(3) Earplugs made of ordinary cotton wool should be prohibited.

10.2.7. (1) Personal protective equipment should not be uncomfortable or be a source of accidents.

(2) If there is additional risk when surrounding noise cannot be heard, or when communications are difficult, appropriate measures should be taken.

10.3. Testing of protective equipment

10.3.1. Personal protective equipment should be tested for efficiency.

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10.3.2. Tests should be carried out according to a method which has been standardised or approved, or both, by the competent authority.

10.3.3. Only such personal protective equipment as has been duly tested or approved, or both, by the competent authorities should be allowed in places of work.

10.4. Issuing and training in use of equipment

10.4.1. Personal protective equipment should be individually provided to the workers, and identified accordingly.

10.4.2. Steps should be taken to ensure that such devices will produce no undesirable effects and will not be especially uncomfortable to use for the worker concerned; this provision applies especially to the use of earplugs.

10.4.3. Workers who normally wear glasses and those who, for safety reasons, have to wear goggles and safety helmets during work, in addition to ear muffs, should receive appropriate equipment.

10.4.4. (1) When individual protective devices are distributed, the need for them, their use and maintenance should be explained.

(2) The requisite instructions should continue to be given from time to time.

10.5. Inspection and maintenance

10.5.1. Personal and other protective equipment against noise and vibration should be inspected periodically to ensure that it has suffered no damage and is in good condition.

Protective equipment and reduction of exposure time

10.5.2. Tests should be carried out at suitable intervals to ensure that personal protective equipment remains effective.

10.5.3. A suitable maintenance programme should be instituted, including proper storage of the personal protective equipment when not in use.

10.6. Reduction in exposure time

10.6.1. When noise or vibration levels cannot be brought within permissible limits, there should be a reduction in exposure time.

10.6.2. The following possibilities should be considered with a view to reducing the time of exposure —

- (a) rotation of jobs;
- (b) reorganisation, so that part of the work can be done without exposure to the risks;
- (c) provision of breaks during which exposed workers can relax in a quiet environment.

10.7. Co-operation with workers

10.7.1. Whenever a prevention programme including the use of personal protective equipment or a reduction in exposure time, or both, is implemented, a special effort should be made to secure the co-operation of the workers.

11. Health supervision

11.1. General

11.1.1. The provisions of this chapter set out the objectives to be reached. Their attainment may be achieved progressively at the national level as a function of the local conditions and possibilities.

11.1.2. All workers continuously or occasionally working in areas or in workplaces where noise or vibration exceeds a certain level,¹ especially workers whose protection is ensured by the use of personal protective equipment or by a reduction of exposure time, or both, should, in so far as possible, be subject to appropriate health supervision.

11.1.3. (1) Health supervision may be prescribed for workers exposed to levels of noise or vibration, or both, that are determined by the competent authority and are lower than the maximum permissible limits.

(2) In addition, the occupational health physician should have the possibility of supervising the health of certain groups of workers as required for preventive purposes.

11.2. Organisation and aims ²

11.2.1. Workers' health supervision should include —

- (a) a pre-employment medical examination;
- (b) periodical medical examinations; and
- (c) medical examinations after sickness or on specific occasions.

¹ Which for noise should be the danger limit specified in Chapter 4.

² See Appendix 6.

11.2.2. The aim of the pre-employment medical examination should be —

- (a) to determine any contra-indication to exposure to noise or vibration, or both;
- (b) to detect any abnormal sensitivity to noise or vibration;
- (c) to establish a baseline record useful for later medical supervision; and
- (d) to advise the workers about the risks they will encounter in their jobs and about the preventive measures to be taken.

11.2.3. The purpose of the periodical medical examinations should be —

- (a) to detect the first signs of occupational disease;
- (b) to detect the appearance of any abnormal sensitivity to noise or vibration;
- (c) to detect signs of stress due to the work or to the conditions of work so that corrective ergonomic action can be taken; and
- (d) to continue the task of informing and advising, and ensure that suitable personal protective equipment is being used.

11.2.4. Medical examinations should be carried out after sickness or on specific occasions.

11.2.5. The medical examination performed on cessation of employment should be such as will provide a general picture of the eventual effects of exposure to noise or vibration.

11.2.6. Health supervision should not put the workers to any expense, and medical examinations should as far as possible be undertaken during working hours.

11.2.7. (1) Workers should be informed of the outcome of the medical examinations they have undergone, and should

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be informed if, in the occupational health physician's opinion, they are suffering from a professional hypo-acousia or from a disorder attributable to noise or to vibration.

(2) In addition, at the workers' request a copy of their medical records should possibly be forwarded to their own doctors.

11.3. Frequency of health examinations

11.3.1. (1) A medical examination should take place on recruitment or before the worker is allotted to a place of work involving exposure to noise or vibration, or both.

(2) Thereafter, periodical examinations should be carried out at intervals to be laid down as a function of the magnitude of the exposure hazard.

11.3.2. Medical examinations should be repeated more often if risks are especially great or if the occupational health physician feels it necessary for the protection of the health of certain workers or groups of workers.

11.4. Structure of the medical examinations

11.4.1. Pre-employment medical examination³ for noise exposure should comprise –

- (a) a case history;
- (b) a general clinical examination;
- (c) a clinical examination of the ears; and
- (d) a screening (or simplified) audiometric test.⁴

³ One view expressed at the meeting of experts was that in coming years a simplified examination could be carried out by specially trained health personnel; only abnormal cases would then be referred to the physician.

⁴ A screening (or simplified) audiometric test is a pure-tone audiometric test (transmission through air) carried out separately for each ear at a number

11.4.2. Periodical health examinations for noise exposure, which may be carried out by specially trained health personnel, should comprise —

- (a) a short case history;
- (b) a simplified clinical examination of the ears; and
- (c) a screening (or simplified) audiometric test.⁵

11.4.3. For noise exposure, medical examinations after sickness or on special occasions, as well as medical examinations carried out when hearing impairment is discovered, should include at least —

- (a) a case history;
- (b) a general clinical examination;
- (c) a thorough clinical examination of the ears, nose and throat; and
- (d) a complete (or baseline) audiometric test.⁵

11.4.4. For exposure to local vibration transmitted to fingers and hands or to hands and arms the medical examination should comprise —

- (a) a case history, with special reference to the specific occupational risk;
- (b) a clinical examination; and
- (c) special tests which, according to the kind of exposure involved, should explore in particular the vascular system, the skin sensitivity of the hands, and the state of the bones, the joints and the ligaments.

of selected frequencies; temporary threshold shift should be avoided. See "Audiometer, pure-tone screening" among the preliminary definitions.

⁵ A complete (or baseline) audiometric test is a pure-tone audiometric test conducted in a soundproof chamber, carried out separately for each ear, at the full range of frequencies after a period of at least 12 hours and preferably 16 hours without exposure to noise. See "Audiometer, pure-tone, for general diagnostic purposes" among the preliminary definitions.

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11.4.5. For exposure to whole-body vibration, the medical examination should comprise—

- (a) a case history; and
- (b) a general clinical examination.

11.4.6. For exposure to noise and exposure to local and whole-body vibration, all supplementary and special medical examinations should be carried out by the medical specialists concerned when an abnormality is found in the course of the above-mentioned examinations and it requires further investigation.

11.5. Results and interpretation

11.5.1. The results of medical examinations and supplementary examinations and tests of each individual should be recorded in a medical file.

11.5.2. (1) Fitness for any particular job should be certified by a suitable certificate containing no data of a medical nature.

(2) The decision on whether or not a worker is fit for a particular job should be a decision based on all relevant considerations, including the outcome of the medical examinations performed, with due consideration to the working conditions and to the risks encountered in the working environment, as well as to any possible contra-indications.

11.5.3. A decision to the effect that a worker is fit for the job should in certain circumstances be conditional and prescribe certain specific measures.

11.5.4. Pregnant women should not be exposed to vibration.

11.5.5. Special attention should be devoted to young workers exposed to noise and vibration, and to women workers exposed to vibration.

11.6. Audiometric testing

11.6.1. (1) In the case of a maximum permissible audiometric loss, the necessary preventive action and medical treatment should be initiated to limit further loss of hearing on the part of the worker concerned.

(2) In addition, the cause of the hypo-acousia that has been found should be determined through an inquiry carried out at the workplace.

11.7. Audiometric methods and equipment

11.7.1. (1) The audiometer used should meet the relevant international and national standards.⁶

(2) It should have a certificate of calibration and there should be a clear indication of the calibration standards used (zero dB reference).

11.7.2. The audiometer should be maintained and calibrated in accordance with standards approved by the competent authority or in accordance with the guide-lines concerning the calibration of such instruments to be provided by the manufacturer.

11.7.3. (1) The room or booth in which audiograms are made should be silent (the noise level within it being lower than 30 dB(A)).

(2) Such a room or booth should be properly ventilated and maintained at a suitable temperature.

11.7.4. Screening audiograms may be carried out with ear muffs.

⁶ See Appendix 1, section 3.

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11.8. Staff training

11.8.1. Audiometric tests should be undertaken by a specially trained staff.

11.8.2. The auxiliary health personnel should be given special training in how to instruct workers in the proper use of their personal protective equipment.

12. Monitoring

12.1. General

12.1.1. A long-term programme should be drawn up with the workers' participation to keep noise and vibration risks under control. It should include environmental and health monitoring.

12.1.2. The aims of this programme should be —

- (a) to ensure that the preventive action which has been taken is still effective;
- (b) to ensure that the levels, as measured previously, remain unchanged or fall;
- (c) to ensure that any changes made in manufacturing processes will not lead to the emergence of new risks;
- (d) to promote the study and implementation of more efficient preventive measures; and
- (e) to ensure that the health of the workers is efficiently protected.

12.2. Environmental monitoring

12.2.1. Measurements made in places of work should be repeated at suitable intervals, and a record of the readings obtained should be kept in an appropriate manner.

12.2.2. Measurements made at places of work should be repeated whenever there is a change in premises, equipment or production which might affect noise and vibration. Likewise, they should be repeated with a view to assessing the effectiveness of the preventive action being taken.

12.2.3. (1) An inspection programme should be drawn up by the enterprise to ascertain whether the technical preventive measures taken remain effective.

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(2) This inspection programme should comprise regular periodical inspections, and special checks whenever necessary.

(3) Special attention should be given to the use of an inspection checklist, to the maintenance of equipment, to the technical preventive devices (such as silencers, casings and soundproof barriers) to reduce noise or vibration, or both, as well as to personal protective equipment and its use.

(4) Such inspections should be carried out by competent persons.

12.3. Health monitoring

12.3.1. Statistics should be derived from the data obtained by medical examinations, so as to ascertain whether the preventive action taken has proved satisfactory.

12.3.2. The medical records should also be used for research purposes, and for epidemiological studies intended to help in defining more precisely maximum permissible levels as well as to collect data on individual sensitivity.

12.4. Comparisons of findings

12.4.1. (1) The data provided by noise and vibration measurements in places of work should be correlated with the outcome of medical examinations to ascertain how effective preventive action has been and what groups of workers are most at risk.

(2) Within the programme of an occupational health service, technical and medical dose response records, when properly maintained, should form an important part of an epidemiological long-term follow-up of the working conditions.

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12.4.2. The data available within the undertakings should as far as possible be made available for research purposes for the assessment of the noise and vibration hazards and their prevention.

12.4.3. Scientific research institutes in individual countries should undertake, in close co-operation with each other, more intensive research on the biological effects of noise and vibration, and epidemiological studies should be carried out.

Appendix 1

Existing international standards and other international provisions

1. WORKING ENVIRONMENT

A number of international labour Conventions and Recommendations deal with the problem of noise and vibration in the working environment. Mention should be made of the following:

- (1) Recommendation No. 97 (1953), concerning the protection of the health of workers in places of employment, provides that in such places "all appropriate measures should be taken by the employer to ensure that the general conditions prevailing in places of employment are such as to provide adequate protection of the health of the workers concerned, and in particular that . . . measures are taken to eliminate or to reduce as far as possible noise and vibrations which constitute a danger to the health of workers".
- (2) Convention No. 120 (1964), concerning hygiene in commerce and offices, lays down (in Article 18) that "noise and vibrations likely to have harmful effects on workers should be reduced as far as possible by appropriate and practicable measures".
- (3) Recommendation No. 120 (1964), concerning hygiene in commerce and offices, lays down (in Paragraph 57 (2)) that "particular attention should be paid –
 - (a) to the substantial reduction of noise and vibrations caused by machinery and sound-producing equipment and devices;
 - (b) to the enclosure or isolation of sources of noise or vibrations which cannot be reduced;
 - (c) to the reduction of intensity and duration of sound emissions, including musical emissions; and

- (d) to the provision of sound-insulating equipment, where appropriate, to keep the noise of workshops, lifts, conveyors or the street away from offices”.

This Recommendation adds (in Paragraph 58) that “if the measures referred to in subparagraph (2) of Paragraph 57 prove to be insufficient to eliminate harmful effects adequately —

- (a) workers should be supplied with suitable ear protectors when they are exposed to sound emissions and vibrations likely to produce harmful effects;
 - (b) workers exposed to sound emissions and vibrations likely to produce harmful effects should be granted regular breaks included in the working hours in premises free of such sound emissions and vibrations;
 - (c) systems of work distribution or rotation of jobs should be applied where necessary”.
- (4) Recommendation No. 141 (1970) concerning control of harmful noise in crew accommodation and working spaces on board ship also contains relevant provisions.
 - (5) Convention No. 148 (1977) concerning the protection of workers against occupational hazards in the working environment due to air pollution, noise and vibration covers the subject in a comprehensive way. The most important provisions are as follows: “For the purpose of this Convention, [. . .] the term ‘noise’ covers all sound which can result in hearing impairment or be harmful to health or otherwise dangerous”, and “the term ‘vibration’ covers any vibration which is transmitted to the human body through solid structures and is harmful to health or otherwise dangerous” (Article 3). “National laws and regulations shall prescribe that measures be taken for the prevention and control of, and protection against, occupational hazards in the working environment due to [. . .] noise and vibration” (Article 4). Co-operation between the competent authority and representatives of employers and workers, and their duties, respectively, are dealt with in Articles 5 to 7. “The competent authority shall establish criteria for determining the hazards of exposure to [. . .] noise and vibration [. . .] and shall specify exposure limits [. . .]” (Article 8).

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"As far as possible, the working environment shall be kept free from any hazard due to [...] noise and vibration (Article 9):

(a) by technical measures applied to new plant or processes in design or installation, or added to existing plant or processes; or, where this is not possible,

(b) by supplementary organisational measures."

"Where the measures taken in pursuance of Article 9 do not bring [...] noise and vibration within the limits specified in pursuance of Article 8, the employer shall provide and maintain suitable personal protective equipment" (Article 10). Article 11 provides that there shall be supervision of the working conditions and health of workers exposed or liable to be exposed to noise and vibration.

- (6) Recommendation No. 156 (1977) concerning the protection of workers against occupational hazards in the working environment due to air pollution, noise and vibration elaborates in further detail the preventive and protective measures, supervision of health of workers, and training, information and research.
- (7) Convention No. 155 (1981) concerning occupational safety and health and the working environment formulates principles of national policy on occupational safety, occupational health and the working environment (Part II), action at the national level (Part III) and at the level of the undertaking (Part IV). Although noise and vibration are not mentioned explicitly, this is done by the Recommendation given below.
- (8) Recommendation No. 164 (1981) concerning occupational safety and health and the working environment. Paragraph 3 provides that measures should be taken in pursuance of the policy of the Convention, including "(j) prevention and control of, and protection against, occupational hazards due to noise and vibration."

The *Model code of safety regulations for industrial establishments for the guidance of governments and industry* and the various codes of practice published by the ILO contain provisions dealing with the control of noise and vibrations, particularly the following:

- (1) Regulation 229 of the *Model code of safety regulations for*

industrial establishments for the guidance of governments and industry (under revision) deals with ear protection.

- (2) The code of practice *Safety and health in building and civil engineering work* lays down (in paragraph 2.7.2) that "noise should be reduced to the appropriate values, which should be fixed by competent authorities" and (in paragraph 2.7.3) that "if noise cannot be rendered harmless, workers should be provided with suitable ear protectors".
- (3) The code of practice *Safety and hygiene in shipbuilding and ship repairing* specifies (in paragraph 2.8.1) that "the noise of equipment and operations should be kept as low as possible and not exceed 90 dB(A) at any time during work"; and (in paragraphs 2.8.2 to 2.8.4) that "in acquiring and installing new machinery, special attention should be given to noise prevention. If noise cannot be reduced to a safe level, workers should be provided with ear protectors. Workers continuously exposed to noise should undergo periodical medical examinations".
- (4) The code of practice *Safe construction and operation of tractors* contains the following provisions in Section 10 ("Noise"):

"10.0.1. (1) All practicable steps should be taken to reduce the noise associated with the running of the tractor to a level not exceeding the level established by the competent authority. When levels have not been established, the level of 90 dB(A) at the driver's ear is suggested. In all cases the exhaust system should include a silencer.

(2) The noise level indicated in subparagraph (1) should not be exceeded regardless of the mode of operation, the implements used or the presence of a safety cab or frame.

(3) Where it is not feasible to reduce the noise level to

Duration per day (hours)	Sound level dB(A) Slow response	Duration per day (hours)	Sound level dB(A) Slow response
8	90	1½	102
6	92	1	105
4	95	½	110
2	100	¼ or less	115

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90 dB(A), operators should use ear defenders to reduce the sound levels to within the limits of the table.

(4) The level of the noise generated by the tractor should be determined by using approved national or international testing methods."

As far as tractor seats are concerned, paragraph 4.2.1 of the code provides that "Operators' seats should be adequately sprung or suspended to absorb vibrations", and that "particular attention should be paid to vibrations in the 4 Hz to 9 Hz range, which are particularly troublesome".

- (5) The code of practice *Safe design and use of chain saws* contains a great number of provisions concerning protection of workers against noise and vibration. An extract is given as follows:

"3.7. Noise

3.7.1. (1) Whenever technically feasible, chain saws should be so designed and constructed that the operator is not exposed to harmful noise [. . .]

3.7.2. (1) When operators are exposed to noise levels in excess of established levels, or their eight-hour equivalent, either the duration of their exposure to the harmful noise should be reduced or they should be provided with personal hearing protection.

(2) This reduction in exposure time or the use of the hearing protection should reduce the exposure of the operator to a level equal to or lower than the equivalent eight-hour continuous sound level of the established safe noise exposure level.

3.7.4. (1) Chain saws should be marked in a visible place with a clear and durable text along the following lines, or its equivalent in the language(s) required by government regulations: 'Use hearing protectors at all times when operating this machine.'

(2) An approved warning sign may replace or accompany the above text.

3.9. Handle vibration isolation

3.9.1. (1) Chain saws should be so designed and construc-

ted that the operator is not exposed to harmful vibration under normal working conditions.

(2) The vibration level in the handles of the saw should not exceed the established national vibration threshold limit value for a daily exposure of eight hours [. . .]”

The appendices D and E give methods for measurement of noise and vibration respectively, as well as recommendations on safe sound or noise tolerance levels related to exposure time.

“D. Noise

D.I.1.1. This appendix is based on the equal energy concept for hearing conservation which accumulates each exposure to noise into a daily dosage; it also indicates a possible allowance for the intermittent nature of the exposure of chain saw operators to noise. It indicates how much daily exposure to noise can be tolerated with a minimum risk of permanent hearing loss, and recommends the use of ear protectors where this exposure will be exceeded.

D.I.3.3. Table 4 gives the time exposure and sound level in dB(A) which are equivalent to a continuous sound level for eight hours of 85 dB(A) and 90 dB(A), using equal energy criteria and the intermittent noise variation on equal energy.

D.I.4.2. Since the noise level of most, if not all, chain saws used by regular operators exceeds 100 dB(A), it is strongly recommended that all regular chain saw operators wear ear protectors at all times when the chain saw is in use. For example, using equal energy criteria, the use of ear protectors should lead to a reduction in the noise level of the chain saw at the operator's ear to below 87 dB(A) (85 dB(A) equivalent for five hours per day).

D.III.4.2. If the sound level at the operator's ear exceeds 90 dB(A) with the best ear protectors, it is recommended that the chain saw should not be used for regular operations.”

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Table 4. Exposure times

dB(A)	Equal energy in in 3 dB(A) steps				Intermittent energy in 5 dB(A) steps			
	85 dB(A)		90 dB(A)		85 dB(A)		90 dB(A)	
	Hours	Minutes	Hours	Minutes	Hours	Minutes	Hours	Minutes
85	8				8			
86	6	30			7			
87	5				6	10		
88	4				5	20		
89	3				4	40		
90	2	30	8		4		8	
91	2		6	30	3	30	7	
92	1	30	5		3		6	10
93	1	15	4		2	40	5	20
94	1		3		2	20	4	40
95			2	30	2		4	
96			2		1	45	3	30
97			1	30	1	30	3	
98			1	15	1	20	2	40
99			1		1	10	2	20
100					1		2	
101							1	45
102							1	30
103							1	20
104							1	10
105							1	

"E. Vibration

E.I.4. Vibration exposure criteria to prevent vibration diseases

E.I.4.1. The fundamental principle for the prevention of vibration diseases is that of the elimination of vibration at

source. To achieve this, appropriate measures must be taken when chain saws are being designed.

E.I.4.2. As a first step, manufacturers should be required to provide, with each chain saw, a data sheet giving all the necessary information about the level of vibration emitted. For this purpose, an operator-held measurement method has been designed, pending the development of an internationally acceptable vibration testing machine for chain saws.

E.I.4.3. Subsequently, maximum vibration levels should be established in accordance with local and national regulations and standards.

E.I.4.4. Only when the above principle cannot be applied should regulations concerning the reduction of exposure time be adopted.

E.I.4.5. When such regulations are applied, the actual exposure time per eight-hour day should be monitored.

E.I.5. Personal precautions for the prevention of vibration diseases

E.I.5.1. It is thought that good blood circulation to the hands will help to protect them from vibration diseases. The first essential is therefore to maintain the central body temperature at the right level. The correct clothing for the climatic conditions at the work site, and dry gloves in colder weather, are clearly important. In a cold climate it is also wise to achieve a good level of body warmth before starting to use the saw.

E.I.5.2. Smoking reduces the circulation of blood to the extremities. It is therefore recommended that smoking before and during working hours be kept to a minimum. [. . .]"

- (6) The code of practice *Safety and health in the construction of fixed offshore installations in the petroleum industry* contains a chapter (Chapter 10) on noise and vibration.

"10.1.1. The installation manager should be responsible for action to reduce by all appropriate means the exposure of workers to harmful noise and vibration.

10.2.3. (1) Such measures should be taken as will reduce noise levels to those permissible in national laws or regulations.

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(2) For continuous eight hours' exposure to a reasonably steady noise in one day, the limit should not exceed 90 dB(A).

(3) For ease of reference the table below gives, to the nearest decibel, values equivalent to this level for continuous exposure for longer periods to a reasonably steady noise.

Period of continuous exposure to a reasonably steady noise (hours)	Limit dB(A)
8	90
12	88
16	86

10.2.4. If the noise level is fluctuating, an equivalent continuous noise level (L_{eq}) may be calculated and its value should not exceed 90 dB(A).

10.2.5. Where it is difficult to measure and control exposure to non-continuous noise (for example, where persons move from one area to another), any exposure at a general level of 90 dB(A) or more should be regarded as exceeding the accepted limit and requiring the use of hearing protection.

10.2.6. No matter for how short a time, a person should not, without appropriate ear protection, enter an area in which the noise level is 115 dB(A) or more.

10.2.7. If there are single isolated bursts of noise which can go above 130 dB(A) "Impulse" or 120 dB(A) "Fast", personal protective equipment should be worn.

10.2.8. No person should enter an area where the noise level exceeds 140 dB(A).

10.2.9. The monitoring of the working environment should be systematic and repeated as often as needed to ensure that noise and vibration risks are kept under control.

10.2.10. When it is not possible to control noise and vibration to below permissible levels, other measures should be taken to provide protection, including:

- (a) the reorganisation of the work; or
- (b) the provision of appropriate hearing protection.

10.2.11. (1) The guidance in paragraphs 10.2.3 to 10.2.5 on noise levels relates to levels of noise likely to cause hearing damage and not to lower noise levels that may be required for other purposes such as sleeping and recreation.

(2) Particular attention should be given to the control of noise, or protection from noise produced by continuous operations such as piling, that may affect persons in off-duty hours.

10.2.12. (1) Persons on the installation or vessels and accommodation alongside should abide by instructions given and recommendations made to them concerning the prevention of noise and vibration.

(2) In particular, they should:

- (a) make use of noise and vibration control devices and techniques;
- (b) indicate whenever such devices are faulty or are in need of maintenance;
- (c) be willing to undergo the prescribed medical surveillance; and
- (d) use the personal protective equipment provided."

- (7) The code of practice *Occupational safety and health in the iron and steel industry* deals with the protection of workers against noise and vibration in Chapter 6.11 under the following headings: objectives of prevention, preventive measures, implementation of preventive measures, noise measurement and assessment, noise limit levels, vibration measurement, vibration limits, noise and vibration control: new equipment, noise and vibration control in the working environment, protective equipment and reduction of exposure time, health supervision. Some of the provisions concerning exposure limits are quoted below.

"6.11.21. Depending on the degree of protection against hearing impairment that is required, the following limit values should be determined:

- (a) a warning limit value that sets the noise level under which there is very little risk of hearing impairment to an unprotected ear for an equivalent eight-hour daily exposure; and
- (b) a danger limit value that sets the noise level above which hearing impairment and deafness may result from an

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equivalent eight-hour daily exposure of an unprotected ear.

6.11.22. In the light of present knowledge on hearing impairment, the following values may be recommended:

- (a) a warning limit value of 85 dB(A); and
- (b) a danger limit value of 90 dB(A).

These values are equivalent continuous sound levels.

6.11.23. During emergencies, or because of unforeseen technical imperatives, a worker may be temporarily authorised to exceed the daily dose, provided that the next day he recovers so that the maximum weekly dose (as determined on the basis of paragraph 6.11.22) is respected.

6.11.24. No matter for how short a time, a worker should not, without appropriate ear protection, enter an area in which the noise level is 115 dB(A) or more.

6.11.25. If there are single isolated bursts of noise which can go above 130 dB(A) "Impulse" or 120 dB(A) "Fast", personal protective equipment should be worn.

6.11.26. No worker should enter an area where the noise level exceeds 140 dB(A).

6.11.30. (1) Vibration limits should be laid down with due consideration to the aim to be achieved and to the degree of protection required, especially for:

- (a) vibration affecting the hands and arms (vibrating tools); and
- (b) whole-body vibration transmitted through the supporting surface.

(2) Vibration limits should also be laid down depending on the work to be done and to avoid fatigue.

6.11.31. The limits should be reviewed from time to time in the light of new scientific knowledge, technical progress and possibilities of prevention.

6.11.32. For a continuous exposure to vibration transmitted to hands and arms, maximum permissible levels of vibration, depending on the daily exposure duration, should be laid down, account being taken of current knowledge.

6.11.33. When daily exposure to vibration transmitted to hands and arms is made up of two or more periods of exposure at different levels of vibration, or when there are adequate regular breaks, different limits may be laid down.

6.11.44. When noise and vibration levels cannot be brought below the danger limit either by suitable design of equipment or by suitable installation:

- (a) the workers should be provided with, and have easy access to, soundproof booths either totally enclosed (and air-conditioned if necessary), or partially enclosed;
- (b) the workers should be provided with anti-vibration working platforms or stands;
- (c) the workers should be provided with adequate hearing protection and anti-vibration devices; or
- (d) the length of exposure should be limited.

6.11.45. Personal protective equipment and limitation of exposure time should bring the exposure of workers within permissible limits.

6.11.46. (1) Personal hearing protection and anti-vibration equipment should on no account be regarded as adequate substitutes for technical prevention.

(2) Personal hearing protection and anti-vibration equipment are to be used temporarily to keep risks within the limits, until such time as noise and vibration control can be made more effective through technical improvements.

6.11.53. All workers continuously or occasionally working in areas or in workplaces where noise or vibration exceeds a predetermined action level, especially workers whose protection is ensured by the use of personal protective equipment or by a reduction of exposure time, or both, should, in so far as possible, be subject to appropriate health supervision."

2. INSTRUMENTS FOR MEASURING NOISE AND VIBRATION

Limit levels cannot be set unless measurement methods are defined. Measurements carried out at the workplace can be validly referred to the established limits only if the measurement has been carried out with standardised equipment and techniques.

Due account should be taken of existing international standards in this field, in particular that of the International Organisation for Standardisation and those recommended in publications of the International Electrotechnical Commission:

- (a) International Standard ISO 266-1975: *Acoustics — Preferred frequencies for measurements*;
- (b) IEC Publication 123: *Recommendations for sound level meters* (1961). Superseded by IEC Publication 651: *Sound level meters* (1979);
- (c) IEC Publication 179: *Precision sound level meters* (second edition, 1973). Superseded by IEC Publication 651: *Sound level meters* (1979);
- (d) IEC Publication 179A: First supplement to Publication 179 (1973): *Precision sound level meters: Additional characteristics for the measurement of impulsive sounds*. Superseded by IEC Publication 651: *Sound level meters* (1979);
- (e) IEC Publication 225: *Octave, half-octave and third-octave band filters intended for the analysis of sounds and vibrations* (1966, second impression 1982);
- (f) IEC Publication 184: *Methods for specifying the characteristics of electro-mechanical transducers for shock and vibration measurements* (1965);
- (g) IEC Publication 222: *Methods for specifying the characteristics of auxiliary equipment for shock and vibration measurement* (1966).

3. AUDIOMETERS

The establishment of a maximum allowable level is based in particular on the results of epidemiological research, comparing sound levels (measured with sound level meters) and the correspond-

ing hearing loss encountered in exposed persons (assessed by means of audiometers). Standardisation of audiometers, their accessories and the reference zero is essential in this connection. It is also necessary if the audiometric examinations carried out are to be reliable and if their results are to be comparable.

Reference should be made to the following international standards concerning audiometers and their accessories:

- (a) International Standard ISO 389-1975: *Acoustics — Standard reference zero for the calibration of pure-tone audiometers*;
- (b) ISO Recommendation ISO/R 226-1961: *Normal equal-loudness contours for pure tones and normal threshold of hearing under free field listening conditions*;
- (c) IEC Publication 178: *Pure tone screening audiometers* (1965). Superseded by IEC Publication 645: *Audiometers* (1979);
- (d) IEC Publication 177: *Pure tone audiometers for general diagnostic purposes* (1965). Superseded by IEC Publication 645: *Audiometers* (1979);
- (e) IEC Publication 303: *IEC provisional reference coupler for the calibration of earphones used in audiometry* (1970);
- (f) IEC Publication 318: *An IEC artificial ear, of the wideband type, for the calibration of earphones used in audiometry* (1970).

4. CRITERIA FOR NOISE (HEARING AND HEALTH)

Noise exposure standards should take available criteria into consideration. In this connection, reference may be made to the document *Noise*, Environmental Health Criteria No. 12, published by the World Health Organisation, 1980.

International Standard ISO 2204-1979 (*Acoustics — Guide to International Standards on the measurement of airborne acoustical noise and evaluation of its effects on human beings*) classifies the different kinds of noise (steady noise, non-steady noise, fluctuating noise, intermittent noise, impulsive noise, quasi-steady impulsive noise and an isolated burst of sound energy), studies the question of the physical measurements of noise and deals with the evaluation of effects of noise on human beings. This standard considers, in particular, the question of allowable exposure for hearing conversation (with reference to International Standard ISO 1999-1975) and

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the problem of noise nuisance (with reference to International Standard ISO 1996/1-1982: *Acoustics — Description and measurement of environmental noise. Part 1: Basic quantities and procedures*). Standard ISO 2204-1979 mentions that the question of noise interference with speech communication is being studied with the aim of developing a simple method giving results of practical value.¹

International Standard ISO 1999-1975: *Acoustics — Assessment of occupational noise exposure for hearing conservation purposes* provides a basis for interested bodies to set limits for tolerable noise exposure during work. Entry 7, note 1, in this standard states that in many cases the competent authorities have demanded the institution of hearing conservation programmes if an equivalent continuous sound level of 85-90 dB(A) is exceeded.

The hearing impairment criterion defined by International Standard ISO 1999-1975 (entry 3.4) is "impairment of hearing for conversational speech", by which "the hearing of a subject is considered to be impaired if the arithmetic average of the permanent threshold hearing levels of the subject for 500, 1,000 and 2,000 Hz is shifted by 25 dB or more compared with the corresponding average given in International Standard ISO 389-1975: *Acoustics — Standard reference zero for the calibration of pure-tone audiometers*."

Entry 4 of International Standard ISO 1999-1975 specifies that the sound level at the approximate position occupied by the listener's ear should be determined over an appropriate time and expressed in dB(A). The occurring noise levels should be grouped in classes with a width of 5 dB(A) each. In the case of steady noise where the sound level averaged over a short time is almost unchanged within a week or varies in a regular manner among a few clearly distinguishable levels, the measurement may be made with a sound level meter with A-weighting set at slow response. Where there is an impulsive noise component, correction is necessary; according to entry 6, International Standard ISO 1999-1975 is not applicable to impulsive noise consisting of single bursts of noise but can be applied to quasi-stable impulsive noise by using a correction of 10 dB(A) which should be added to the measured sound level.

Entry 3.3 of International Standard ISO 1999-1975 defines the concept of "equivalent continuous sound level" as the "sound level

¹ Technical Report ISO/TR 3352-1974 drawn up by Technical Committee ISO/TC 43 — Acoustics.

in dB(A) which, if present for 40 hours in one week, produces the same composite noise exposure index as the various measured sound levels over one week". While, for noise with an impulsive component and for quasi-steady impulsive noise, measurements can be made in dB(A) slow response with a suitable correction, or by using another method giving equivalent results, the use of an impulse sound level meter as defined in IEC Publications 179 and 179A has been recommended by the experts. The noise limit levels (warning and danger levels: Chapter 4) are the continuous equivalent noise levels of 85 dB(A) impulse response and 90 dB(A) impulse response;² for an exposure of eight hours per day and 40 hours per week to a virtually constant noise level, these values would be respectively 85 dB(AI) and 90 dB(AI).³

5. CRITERIA FOR VIBRATION (HEALTH)

As is the case with noise, it is important to measure vibration with standardised equipment and techniques, and workplace exposure standards should be established on the basis of available criteria.⁴

As far as vibrations are concerned, wide-ranging research is still required, especially for simplifying the measurement and assessment methods, before the hazards can be accurately delineated and precise exposure limits established.⁵

In this context reference should be made to the following international documents:

² In practice, many industrial noises have an impulse sound component and, consequently, the measurement in dB(A) impulse response is often higher (by around 5 dB) than that made in dB(A) slow response. The sound level limits of 85 and 90 dB(A) impulse response recommended would then, in practice, often correspond to the levels currently categorised as being respectively 80 and 85 dB(A), since one generally uses the A-weighting curve and the slow response without always including the necessary corrections.

³ If the exposure is for four hours per day and 20 hours per week, the noise limit levels would be, respectively, 88 dB(AI) and 93 dB(AI). Whenever the duration of exposure is reduced by one-half, the noise level limits are increased by 3 dB(AI).

⁴ ILO: *Noise and vibration in the working environment*, op. cit., pp. 4-5, paras. 9, 14.

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- (a) International Standard ISO 2631-1978: *Guide for the evaluation of human exposure to whole-body vibration*;
- (b) a draft International Standard ISO/DIS 5349 for a guide for the evaluation of human exposure to hand-transmitted vibration.

6. NOISE AND VIBRATION CONTROL

Noise and vibration control is subject to a number of basic principles: collective protection should be given preference over personal protection;⁶ prevention is more effective if measures are taken at the design stage of machinery and equipment; assessment of noise and vibration emitted by machinery and equipment should be standardised at the international level;⁷ finally, noise and vibration emission levels for machinery and equipment should be established.⁸

As far as the assessment of machinery noise is concerned, mention may be made of the following international recommendations:

- (a) ISO Recommendation ISO/R 495-1966: *General requirements for the preparation of test codes for measuring the noise emitted by machines*;

⁵ ILO: *Noise and vibration in the working environment*, op. cit., p. 17, para. 97.

⁶ "Collective protection methods" are those intended to protect several persons. They are not only applicable to buildings, equipment and work methods, but may also be of a kind used directly by workers, such as specially insulated booths or premises. "Individual means of protection" means all protective measures which, by their nature, are applicable to one single person at a time. *ibid.*, p. 7, footnote.

⁷ The noise and vibration emission levels indicated by the manufacturers or specified by the purchasers or by the competent authority should be expressed in such a manner that the worker's exposure can be readily deduced from these data. The emission levels which may be expected when the equipment is used under different installation or environmental conditions should be indicated wherever possible.

⁸ ILO: *Noise and vibration in the working environment*, op. cit., pp. 6-8, paras. 16, 20, 24, 25.

- (b) International Standard ISO 1680-1970: *Test code for the measurement of the airborne noise emitted by rotating electrical machinery.*

In the field of noise and vibration control, mention should be made of the following recommendation and standards:

- (a) ISO Recommendation ISO/R 354-1963: *Measurement of absorption coefficients in a reverberation room;*
- (b) International Standard ISO 1940-1973: *Balance quality of rotating rigid bodies;*
- (c) International Standard ISO 2371-1974: *Field balancing equipment — Description and evaluation;*
- (d) International Standard ISO 2017-1982: *Vibration and shock — Isolators — Procedure for specifying characteristics.*

The application of preventive methods should follow an order of priority: (1) measures taken at the design stage; (2) collective methods; (3) reduction of exposure duration; (4) personal protection.

Reduction of exposure duration is based on the calculation of an equivalent continuous sound level; in this context note should be taken of International Standard ISO 1999-1975 as regards noise exposure and International Standard ISO 2631-1978 as regards exposure to whole-body vibration. To assess the exposure of persons using personal protective equipment, the equivalent continuous sound level is calculated whilst making allowance for the attenuation provided by the personal protective equipment; the data contained in Annex A to International Standard ISO 1999-1975 should be given due consideration here; it is essential to use octave filters that meet the requirements of IEC Publication 225.

Appendix 2

The health hazards of noise, ultrasound, infrasound and vibration

1. NOISE

Noise may be the cause of various types of injury, disorders, annoyance and disturbance. The effects of noise may be physiological, mental and pathological; a distinction is made between the effects on hearing, the effects on other organs of perception and the general effects.

Effects on the auditory system

(a) Masking

Noise of greater intensity may, in certain conditions, mask less intense noises and make them less readily audible, i.e. reduce the subjective intensity. The former are called masking noises and the latter masked noises.

The masking effect may have certain advantages but it may also have severe consequences when it renders less audible or completely inaudible sounds or noise which, in other circumstances would give warning of an imminent danger against which the subject should seek protection.

(b) Interference with spatial localisation of sound

The presence of intense sound or noise may reduce the capability of localising a sound source in space. In particular, it may become difficult to perceive the movement of the sound source. This may have serious consequences since the closeness of danger may no longer be correctly perceived.

(c) Pain

High levels of sound and noise become difficult to bear and subsequently intolerable; at even higher levels (about 130 dB), auditory sensation is replaced by pain.

(d) Auditory sensation

Auditory sensation does not occur immediately even if the establishment of the sound or noise that produces it is virtually instantaneous; it develops progressively. Some 100 to 200 ms may be required before the maximum level is attained; in the same way when the noise or sound disappears, the auditory sensation terminates only after a short period of time.

If one measures the time between the onset of sound emission and a predetermined voluntary motor response, one encounters what is called the "reaction time". This is relatively long and varies in length depending on the circumstances and a variety of factors such as the sound intensity and the subject and his or her physical and mental status. Even with perfectly healthy and well-trained individuals, the reaction time may be between 100 and 400 ms. An increase in the length of the reaction time increases the accident hazard.

(e) Auditory fatigue

Auditory fatigue results in a reduction of auditory sensitivity — a progressive rise in the perception threshold as the duration of noise exposure is increased. The greater the auditory fatigue, the more intense must the noise be to be perceived. Recovery from this fatigue is always complete.

The appearance of auditory fatigue depends not only on the duration but also the intensity of the noise exposure. Noise which is very intense but of a relatively short duration may, for example, cause auditory fatigue equal to that produced by a significantly less intense noise but for which the exposure time is longer.

Auditory fatigue occurs only if the sound or noise level is sufficiently intense (at least 60 or 70 dB); below this level, exposure may be very prolonged without ever causing auditory fatigue.

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(f) Pathological effect on hearing

The deleterious effect of noise on hearing is essentially one of permanent hearing loss, also called auditory trauma. This is the result of lesions to the ear caused by very intense noise.

Acoustic trauma is characterised by irreversible hearing loss in a frequency band of varying width. In the majority of cases and, in particular, in hearing damage due to industrial noise, the frequency band affected is centred around 4,000 Hz.

Noise-induced hearing loss does not progress after exposure to the noisy environment is terminated. Consequently, it is only necessary to remove from a noisy environment anybody in whom the onset of permanent hearing damage has been detected, in order to prevent any further aggravation.

Effects on other organs of perception

Exposure to very high noise levels may often disturb the sense of balance and give the impression of "walking in space". Sufficiently high noise levels may also cause vertigo and nausea.

Psychological effects

The psychological effects of noise consist basically of various feelings of discomfort caused by noise. They may occur as malaise and a feeling of discomfort which may extend even to well characterised mental or neurological disorders. Noise may also be the cause of discomfort due to the impairment of speech communication and speech intelligibility and may also reduce intellectual or psychomotor performance.

(a) General psychological disorders

General psychological disorders are widely encountered but, unfortunately, they are usually ill defined and vary from person to person. The cause-and-effect relationship between noise and the observed disorders is not always easy to establish.

They vary widely in type and degree, ranging from malaise to neurological or psychiatric disorders. The malaise may be a feeling of distress, discomfort, annoyance or surprise.

(b) Interference with speech intelligibility

Very intense noise may interfere with speech intelligibility, make it impossible to hold a conversation, follow a lesson, understand a lecture, talk over the telephone, hear recommendations. It may also prevent a warning of imminent danger from being heard.

(c) Interference with intellectual and psychomotor performance

The effects that noise may have on intellectual and psychomotor performance are seen in particular by the greater difficulty subjects experience in a noisy environment when carrying out intellectual operations or tasks which require concentration or special psychomotor ability.

General somatic effects

A distinction is made between two types of physiological reaction to noise: the first is a startle reflex (alarm or stress reaction) as soon as the noise appears; the second is that which develops when exposure to the sound is prolonged.

Prolonged exposure to intense noise leads to fatigue, lassitude sometimes accompanied by general debility. This may be followed by the development of various disorders such as giddiness, fainting, headaches, migraine, loss of appetite, loss of weight and anaemia, depending on the case.

2. INFRASOUND

Infrasound is acoustic oscillation whose frequency is too low to affect the sense of hearing in man. Infrasound has a frequency range from 0 to 20 Hz.

Infrasound has the following effects:

- (a) cochleo-vestibular effects:* pain which occurs at an intensity of 165 dB at a frequency of 3 Hz, and 140 dB at 15 Hz;
- (b) general effects:* the appearance of manifestations such as changes in rate of respiration, skin tension, vision disorders in the vicinity of 10 Hz, fatigue and somnolence.

3. ULTRASOUND

Ultrasound is acoustic oscillation whose frequency is too high to affect the sense of hearing in man. It has a frequency range above 20,000 Hz.

The majority of biological effects observed in exposure to ultrasound are the result of acoustic energy being converted to heat. Ultrasound is rapidly absorbed in air, and protection against it is very easy. When exposed to high intensity ultrasound, warning is given by a feeling of skin burning.

It should incidentally be noticed that in practice the audible high frequencies which often accompany ultrasound are sufficient to cause the effects attributed to ultrasound. It should also be noted that often "borderline ultrasonic" noise, i.e. noise in the range of 10,000 to 20,000 Hz, may be a problem for some individuals, particularly for younger persons, even though the noise may not be audible to the persons who have the authority and responsibility for its control.

4. VIBRATION

The physiological and pathological effects of vibration transmitted to the human body may be grouped in the following four categories:

- (1) *Very low-frequency vibration (lower than 1 Hz)*. Responsible for the motion sickness which has as its symptoms nausea and vomiting; this sickness is due to the action of changes in acceleration on the labyrinth of the internal ear.
- (2) *Low-frequency whole-body vibration (between 1 and 20 Hz)*. Gives rise to a wide range of pathological phenomena including lumbago, sciatica in the lumbar region, neck ache, hernia and twinges in the intervertebral discs; these manifestations may occur after a period of exposure in persons who were initially in good health.
- (3) *Low-frequency vibration (between 10 and 20 Hz) transmitted to the hands and arms*. Leads to high biomechanical and muscular strain as a consequence of resonance.

- (4) *Higher frequency vibration (above 20 Hz)*. May produce the following pathological effects:
- (a) vibration in the 20-30 Hz range applied to upper limbs is the cause of osseous or articular lesions in the hands, wrists, forearms and upper arms;
 - (b) vibration in the 40-300 Hz range produces vascular manifestations; these may be attributed to local disturbance of the nervous system controlling vasomotor action;
 - (c) vibration in the 500-1,000 Hz range may cause sensory and trophic manifestations giving a burning or numb sensation.

Appendix 3

Maximum allowable levels of ultrasound ¹

The maximum allowable sound pressure levels at workplaces in the neighbourhood of ultrasound sources should be established in accordance with the data in table 1.

Table 1. Maximum allowable sound pressure levels at the workplace in the vicinity of ultrasound sources

Geometric frequency means by third octave bands (Hz)	12 500	16 000	20 000 +
Sound pressure level (dB)	75	85	110

The levels shown in table 1 may be increased in accordance with the data in table 2 when the total duration of ultrasound does not exceed four hours per day.

The duration of ultrasound exposure must be calculated or based on technical documentation.

Table 2. Corrections for sound pressure levels at workplaces in the vicinity of ultrasound sources

Total ultrasound exposure duration (hours)	Correction (dB)	Total ultrasound exposure duration (minutes)	Correction (dB)
1-4	+6	5-15	+18
1/4-1	+12	1-5	+24

¹ USSR Health Standards — SN 245-71, 313.8, p. 94, "Ultrasound".

Appendix 4

Noise hazard contours

As stated in section 7.3 of the code, noise sources should be sought out and identified; and if the level measured is higher than 85 dB(A),¹ a noise contour study should be carried out.

Sound level measurements should be carried out in the vicinity of a source, i.e. as close as a worker's ear can be brought to it. If in these extreme conditions the sound levels measured are lower than 85 dB(A), it is clearly impossible for a worker to be exposed to an equivalent continuous noise level at the 85 dB(A) warning level (see section 4.2 of the code). If, on the other hand, the sound level measured is higher than 85 dB(A) under the extreme conditions mentioned above, this means that it is possible to have an exposure higher than the warning level and that the hazard should be controlled. Sound level measurements should be carried out at increasing distances from the source, in all directions, in order to delineate the contours of the zones in which the sound levels are equal to or greater than 80, 85, 90, 100 and 115 dB(A).¹ These measurements should be repeated until contours of sufficient accuracy have been delineated.

The 90 dB(A) contour should be clearly marked since, beyond this line, exposure above the danger level (equivalent continuous noise level of 90 dB(A)) is possible. Workers employed permanently or occasionally in this zone should be duly informed of the hazard and subject to medical supervision (see paragraph 11.1.2 of the code). Technical safety measures should be taken to eliminate this potential hazard zone. If these are not sufficiently effective, steps should be taken to reduce the exposure time so that workers are not exposed to an equivalent sound level of more than 90 dB(A). If this latter measure does not achieve the desired effect, use should be made of personal hearing protective equipment which will reduce the perceived sound level to below the limit laid down by the competent authorities. The personal protective equipment should be such as to eliminate all hearing hazard. It would in fact be unacceptable for a

¹ These measurements should be carried out in accordance with the requirements of section 3.2 of the code of practice.

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worker who had worn ear protection for several years to suffer from occupational deafness on account of inadequate personal protection. In addition, comfort is an important aspect of personal hearing protective equipment.

The 85 dB(A) contour line should be indicated. Provision may be made for workers permanently or occasionally employed in this zone to be subject to medical supervision — see paragraph 11.1.3. The noise levels should be monitored periodically and suitable records kept.

The “danger level” (equivalent continuous noise level = 90 dB(A)) is either a limit level or a maximum permissible level, but if greater protection is required, the “warning level” (equivalent continuous noise level = 85 dB(A)) may be regarded as the limit level or the maximum permissible level.

Appendix 5

Symbols indicating noise zones

The programme of ISO Technical Committee TC 145 (Graphical symbols) includes the study of standard graphical symbols.

As an example, the following symbols might be envisaged to indicate noise zones (see figures 1 to 3):

- (1) For the 85 dB(A) zone (warning level): a yellow triangular sign with a black border, located at the external limit of the zone;¹
- (2) for the 90 dB(A) zone (danger level): a blue circular sign containing the silhouette of a head wearing ear protectors outlined in white, the sign being put up at the exterior limit of the zone to indicate that hearing protection measures must be taken;² and
- (3) for the 140 dB(A) zone: a white circular sign with a red border depicting an open hand in black, prohibiting access (paragraph 4.3.4 of the code).

¹ The contours of the zones would have been determined in accordance with the data given in Appendix 4, and the measurements carried out in accordance with the provisions of section 3.2 of the code of practice.

² This symbol has been approved by the International Standard ISO 3864-1984: *Safety colours and safety signs*, without reference to any noise level.

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Fig. 1
85 dB+
Warning sign

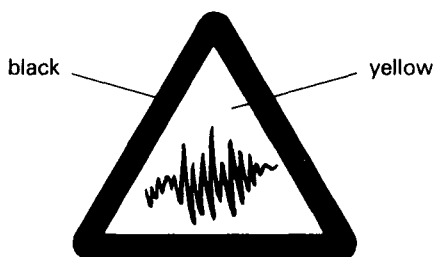
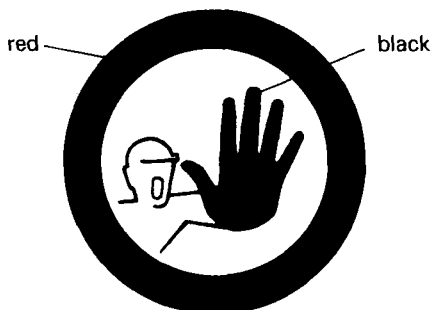


Fig. 2
90 dB+
Hearing protection
must be worn



Fig. 3
140 dB+
Proceeding beyond this
sign prohibited



Appendix 6

Medical aspects: contra-indications

The objectives of the pre-employment medical examination and periodic medical examinations are specified in paragraphs 11.2.2 and 11.2.3 of the code. The result will be an assessment of fitness or unfitness which should be certified in a suitable manner (see paragraph 11.5.2 (1)); the decision arrived at should be an overall one taking into account the results of the medical examinations carried out, the working conditions, the hazards involved in the work and any contra-indications (see paragraph 11.5.2 (2)).

1. NOISE

Long-term or permanent contra-indications

There are certain long-term or permanent contra-indications to work in a noisy environment. In particular, unfitness for such work may result from —

- (a) a disorder of the hearing or vestibular system, or both; certain chronic diseases of the middle or inner ear; impaired hearing that should not be aggravated, especially if there is increased sensitivity indicating special auditory fragility;
- (b) certain clinical diseases, including certain forms of epilepsy and recurrent cephalalgia;
- (c) certain mental disorders, namely psychoses and neuroses; contra-indications here should be determined on an individual basis, due account being taken of the whole of the existing health problem and the working conditions.

Temporary contra-indications

In some cases temporary unfitness may be certified for such reasons as —

- (a) potentially increased hearing sensitivity to noise due, for example, to streptomycin treatment;

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- (b) potential increased sensitivity to noise due to a clinical disease, such as rhinopharyngitis or acute middle ear infection;
- (c) psychological problems such as depression;
- (d) the subject's youth (under 18 years of age).

Over-exposure to noise

Certain symptoms of over-exposure to noise — a sensation of muffled hearing, ringing in the ears, and persistence of auditory deficit after the working day — demand suitable action.

Audiometry may demonstrate the occurrence of a permanent hearing loss, the progression of which should be halted by suitable preventive measures; the competent authority, in collaboration with suitable specialists, should specify —

- (a) audiogram changes which should be regarded as significant in relation to age; and
- (b) the various steps to be taken in relation to the measured deficit — increased medical supervision, better personal hearing protective equipment, certification of temporary unfitness or permanent unfitness.

Contra-indications for certain jobs

For certain types of work, good hearing is particularly important and deafness or significant auditory deficit would make the worker unfit for the job. Mention should be made of the following —

- (a) jobs in which hearing is an essential safety factor (e.g. professional motor vehicle drivers, crane drivers);
- (b) jobs in which hearing is directly related to the work (e.g. telephonist, watch and clock maker, radio technician, automobile or locomotive mechanic), people in contact with the public (e.g. hairdressers, sales staff, beauticians, nurses);
- (c) certain jobs with an increased hearing hazard, such as compressed-air workers.

2. VIBRATION

Long-term or permanent contra-indications

There are certain long-term or permanent contra-indications for work entailing exposure to vibration, or more specifically to whole-body vibration, hand-transmitted vibration or both types of vibration. In particular, unfitness for this type of exposure may be attributable to —

- (a) disorders of the peripheral nervous system (especially for hand-transmitted vibration): neuritis, polyneuritis;
- (b) a disorder of the central nervous system: e.g. sequelae of cranial injury, epilepsy, post-concussion syndrome; or a mental disease: psychosis, neurosis;
- (c) cardiovascular diseases: including Raynaud's phenomenon, neurovascular dystonia and angiospasm (in particular for hand-transmitted vibration), stenocardia, hypertension;
- (d) gynaecological disorders;
- (e) disorders of the urinary system: gallstones, kidney stones;
- (f) certain eye disorders, including detachment of the retina and marked myopia;
- (g) manifest endocrinological disorders;
- (h) organic locomotor system changes, *arthritis deformans* of the hands, and shoulder disorders (in particular for hand-transmitted and arm-transmitted vibration), cervical and spinal arthrosis in general;
- (i) miscellaneous diseases such as active pulmonary tuberculosis, stomach and duodenal ulcer, chronic liver disease, ptosis, hernia;
- (j) old age (over 50 years).

Temporary contra-indications

The most obvious and most categorical temporary contra-indication is pregnancy, and pregnant women should not be exposed

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to vibration. Unfitness may also be declared for certain reasons such as —

- (a) a recent surgical operation;
- (b) certain clinical diseases: chilblains, painful menses, certain gynaecological disorders;
- (c) the subject's youth (under 18 years of age).

Over-exposure to vibration

(a) Local vibration

A series of symptoms may indicate the onset and constitute the first stage of a vibration-induced disease — development of paraesthesia, periodic pain in the hands, pronounced whiteness of one or two terminal phalanges of the fingers after exposure to cold water, hyper-aesthesia or hypo-aesthesia — at this stage the disease is still reversible and the symptoms may disappear spontaneously if exposure is terminated.

(b) Whole-body vibration

Disorders indicating over-exposure are more vague and the symptomatology may be related primarily to changes in the central nervous system and the neurovegetative system: there is emotional disturbance, psychasthenia, neurovascular lability, cephalalgia, vertigo; these signs may regress if exposure is terminated.¹

¹ ILO: *Noise and vibration in the working environment*, Occupational Safety and Health Series, No. 33 (Geneva, 1976), p. 84.

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