

an assessment of occupational exposure to noise in western european oil refineries

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ABSTRACT

This report summarizes personal noise exposure measurements, collected for workers in Western European oil refineries. The data are collated by different refinery process operations and offsite activities, and the 1982-84 and the 1985-88 data are separated for comparison.

It is concluded that noise exposure was lower in 1985-88 than 1982-84. However, many noise exposures still exceed specified action levels in the EC Noise Directive (86/188/EEC) at which the implementation of effective hearing conservation programmes is required.

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SUMMARY

CONCAWE has summarized and analysed results of over 800 nominal fullshift personal noise exposure measurements made available by its member companies. The data, collected in five Western European countries in the period 1982-88 relate to work in areas such as refinery plant, utilities and workshops, and were obtained using measurement procedures consistent with the CONCAWE guidelines for conducting personal noise dosimetry.

The objectives of the work were to investigate the trends in noise exposure and to compare the levels with occupational noise exposure limits set down in the EC Noise Directive. For these purposes, the 1982-84 data were separated from the 1985-88 data and both sets assessed to ascertain the percentage of measurements less than 80, 85, 90 and 95 dB(A).

It is concluded that there has been a reduction in noise exposure levels for the period 1985-1988 compared with those in the period 1982-1984. However, in spite of this improvement, many noise exposures still exceed one or both of the $L_{EP,d}$ (8h) action levels specified in the EC noise directive at which the implementation of effective hearing conservation programmes is required.

1. INTRODUCTION

It has long been known that prolonged and repeated exposure to high intensity noise can result in noise-induced hearing loss (NIHL). Consequently most Western European countries have established noise exposure limits, referred to in the CONCAWE hearing conservation guidelines (1), that represent important requirements in the practical approach to hearing conservation.

There are many noise emission sources in the oil industry, particularly at refineries, including : boilers, furnaces, flares, compressors, steam turbines, fin-fan coolers, pumps, valves and steam leaks. This has led to the development of well-established hearing conservation programmes in most member companies. Moreover, it is widely recognized that for existing activities/areas the assessment of occupational exposure to noise is the foundation of the implementation of effective conservation measures.

The EC Noise Directive (2), published in 1986, was scheduled to be implemented in all member countries by 1st January, 1990. It incorporates the following action levels:

- 85 dB(A) $L_{EP,d}$
- 90 dB(A) $L_{EP,d}$
- 200 Pascals peak (140 dB)

A summary of the key requirements where exposures are likely to exceed one or other of the $L_{EP,d}$ criteria, is given in Appendix 1 and the EC Noise Directive is reproduced in Appendix 2.

The Directive is scheduled to be re-examined before 1st January 1994, and, in order to be in a position to make an input to the scientific contribution to such a review, CONCAWE has assembled, summarized and analyzed available personal noise exposure data from member companies for work areas such as refinery plant, utilities, laboratories and workshops. This has enabled the noise exposure information and associated trends to be assessed in terms of current legislative requirements and prevailing noise exposure limits.

2. METHOD

All the exposure data were generated using personal noise dosimeters calibrated before and after each period of measurement. The dosimeter microphones were attached to the lapel or collar of workers and in most instances a microphone windshield was utilized. As far as could be ascertained, the measurement procedures were commensurate with those recommended in the CONCAWE guidelines for conducting personal noise dosimetry (3).

3. NOISE EXPOSURE

Over eight hundred nominal full shift noise exposure measurements, taken in the period 1982-1988, have been reported by CONCAWE member companies. The results were submitted by five different companies and related to oil industry exposure in five Western European countries. Some of the data were obtained using equipment that enabled time-histories to be recorded. This instrumentation provides considerable useful noise exposure information and can be particularly helpful in identifying the need for and the effectiveness of engineering control measures.

Initially the exposure data were collated and analysed as a function of the nature of the location of measurement and the length of shift. Data for two shift schedules were reported, namely 8 hour and 12 hour, although over 70% of the data related to 8 hour shift work. Subsequently a more in-depth analysis was carried out, which involved sub-dividing the 1982-84 exposure results (Table 1) from the more recent 1985-1988 data (Table 2), in order to establish whether there were any exposure trends during the 1980s.

The distribution of the exposure results for each of the seventeen areas/activities identified has also been examined and compared to current, and possible future, occupational noise exposure limits. This was achieved by determining the percentage of results <80, <85, <90 and <95 dB(A) $L_{EP,d}$ (8h), respectively. Similarly the 12 hour shift data were analyzed to establish the percentage of results in the <78, <83, <88 and <93 dB(A) $L_{EP,d}$ (12h) categories.

For the purposes of comparison some exposure trends are shown graphically in Fig. 1, which illustrates pre and post 1985 personal noise exposure data for five different types of oil industry plant/location.

4. DISCUSSION AND CONCLUSIONS

During the past decade there has been a trend to more stringent occupational noise exposure limits in Western Europe. This has occurred because it is now evident that the risk of NIHL is higher than originally believed. During the 1970s the exposure limit in most countries was 90 dB(A) Leq (8h), whereas currently in a number of companies/countries either an exposure limit of 85 dB(A) Leq (8h) applies, or alternatively there is an action level of 85 dB(A) $L_{EP,d}$ (8h).

Fig. 1 indicates that for the four selected refinery areas and vehicle drivers, noise exposures in the period 1985-88 were lower than the corresponding 1982-84 measurements. However, in spite of the improvement, it is clear that many noise exposures still exceed one or both of the $L_{EP,d}$ (8h) action levels specified in the EC Directive, thereby necessitating the implementation of effective hearing conservation programmes (1) and that associated records are kept. Indeed, the evidence suggests that the improvements to the noise environment are not being achieved at the same rate as the introduction of more stringent noise exposure criteria.

5. RECOMMENDATIONS

Attention should be focused on the content of CONCAWE Report No. 88/61 (4). This sister document to CONCAWE Report No. 7/85 (1) provides practical guidance, based on recent experiences in the oil industry, to assist in the development and implementation of effective hearing conservation programmes.

Modifications to existing plant/machinery should be made in order to control levels of noise emission, and measures for control of new plant/machinery should be incorporated at the design stage. Noise specifications should be developed in both instances and a post commissioning noise exposure/level assessment undertaken to ascertain whether on-going hearing conservation measures are required.

There is a CONCAWE programme to collect audiometric data for various refinery operations. When this has been completed, the findings should be reviewed in relation to the noise exposure data reported herein and the effectiveness of hearing conservation measures should be assessed.

Table 1 Personal noise dosimetry results (1982-84)

Refinery Plant	Total No. of Results	% Results dB(A) L _{EP,d} (8h)				% Results dB(A) L _{EP,d} (12h)			
		<80	<85	<90	<95	<78	<83	<88	<93
1. Crude Distillation	26	0	23(6)	58(15)	69(18)	-	-	-	-
	11		-	-	-	82	60	60	
2. Vacuum Distillation	19	0	32(6)	63(12)	100	-	-	-	
	5		-	-	-	100	100	100	
3. Visbreaker	-		-	-	-	-	-	-	
4. Cat. Cracker	32	3(1)	19(6)	56(18)	100	-	-	-	
5. Cat. Reformer	16	7(1)	31(5)	75(12)	100	-	-	-	
6. Hydrotreater	8	13(1)	38(3)	76(6)	100	-	-	-	
	28		-	-	-	100	100	100	
7. Alkylation	6	0	0	17	100	-	-	-	
8. Isomerization	4	0	25(1)	100	100	-	-	-	
9. Sulphur Plant	6	33(2)	50(3)	50(3)	83(5)	-	-	-	
10. Lube Oil	25	8(2)	24(6)	60(15)	96(24)	-	-	-	
11. Utilities	30	0	0	20(6)	63(19)	-	-	-	
	7		-	-	-	86	100	100	
11. B Water Treatment	8	25(2)	50(4)	100	100	-	-	-	
12. Workshop	33	6(2)	33(11)	55(18)	73(24)	-	-	-	
13. Other Maintenance	44	41(18)	66(29)	95(42)	98(43)	-	-	-	
14. Laboratory	-		-	-	-	-	-	-	
15. Offsite	28	25(7)	50(14)	86(23)	100	-	-	-	
	24		-	-	-	100	100	100	
16. Vehicle Drivers	5	20(1)	20(1)	80(4)	100	-	-	-	
17. Other	13	38(5)	62(8)	100	100	-	-	-	
	22		-	-	-	100	100	100	
	400								

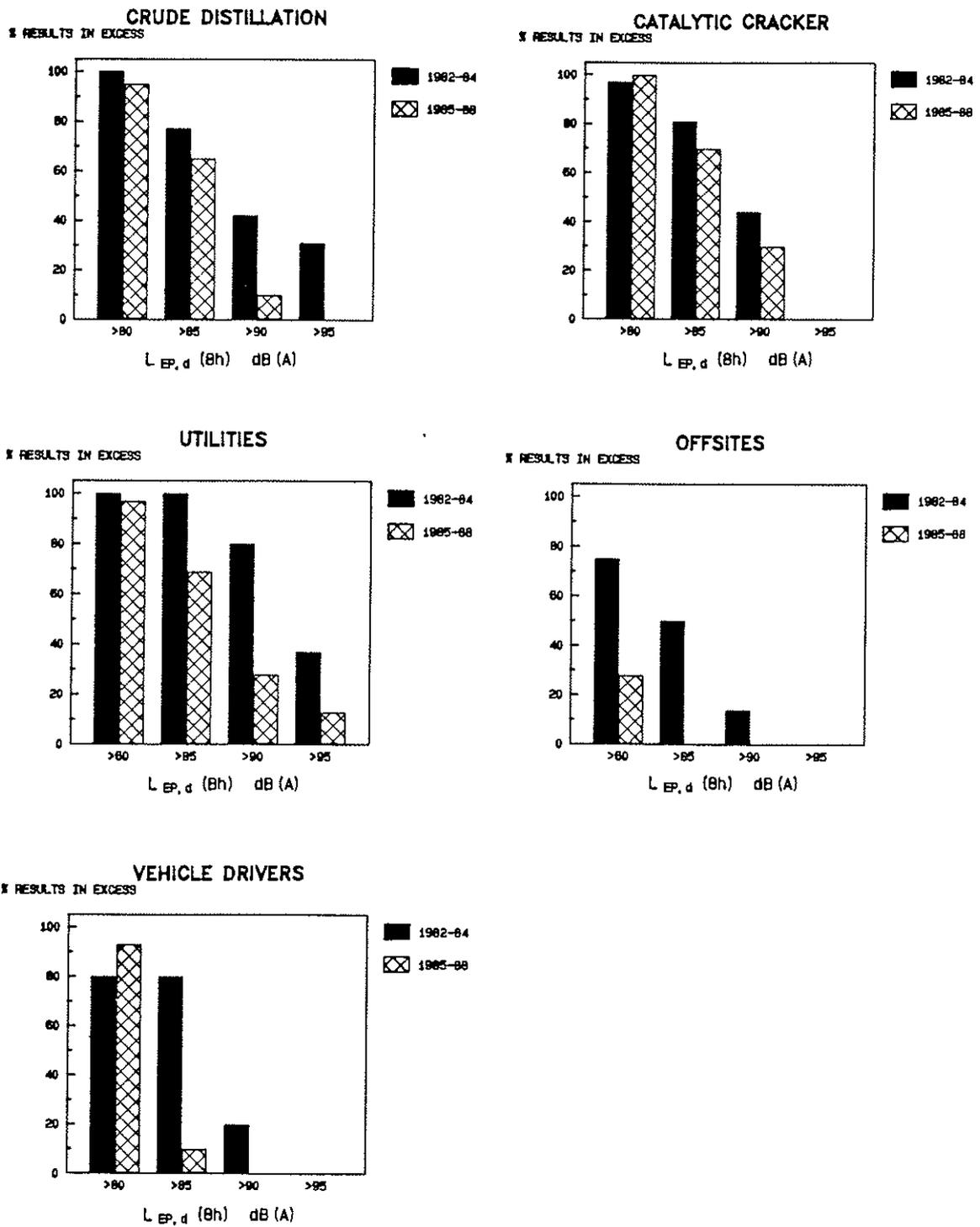
* Numbers in brackets are the actual numbers of results

Table 2 Personal noise dosimetry results (1985-88)

Refinery Plant	Total No. of Results	% of Results			% of Results			% of Results		
		<80	dB(A) $L_{EP,d}$ (8h) <85	<90	<95	dB(A) $L_{EP,d}$ (12h) <83	<88	<93		
1. Crude Distillation	20	5(1)	35(7)	90(18)	100	0	-	-		
2. Vacuum Distillation	14	0	63(5)	75(6)	100	20(2)	21(3)	71(10)		
3. Visbreaker	10	54(4)	89(24)	100	100	?	80(4)	100		
4. Cat. Cracker	5	0	30(6)	70(14)	100	0	9(1)	18(2)		
5. Cat. Reformer	20	7(2)	64(18)	36(24)	96(27)	0	38(3)	75(6)		
6. Hydrotreater	11	0	0	0	100	0	0	0		
7. Alkylation	28	0	0	0	100	17(1)	30(3)	100		
8. Isomerization	6	7(2)	64(18)	36(24)	96(27)	0	17(1)	30(3)		
9. Sulphur Plant	8	100	100	100	100	?	100	100		
10. Lube Oil	3	17(1)	17(1)	67(4)	83(5)	17(1)	30(3)	100		
11. Utilities	39	3(1)	31(12)	72((28)	87(34)	0	17(1)	30(3)		
11. B Water Treatment	56	100	100	100	100	?	100	100		
12. Workshop	4	25(1)	100	100	100	0	0	50(2)		
13. Other Maintenance	4	0	16(7)	53(23)	86(39)	0	0	100		
14. Laboratory	43	0	100	100	100	0	0	100		
15. Offsite	5	100	100	100	100	0	0	100		
16. Vehicle Drivers	18	72(13)	100	100	100	0	0	100		
17. Other	29	7(2)	90(26)	100	100	0	0	100		
	22	14(3)	55(12)	73(16)	86(19)	0	0	100		
	4	-	-	-	-	0	0	100		
	406									

* Numbers in brackets are the actual numbers of results

Fig. 1 Comparison of 1982-84 and 1985-88 personal noise exposure data for work in selected refinery areas and for road tanker motor gasoline distribution workers



7.

REFERENCES

1. CONCAWE (1985) Guidelines for hearing conservation programmes in the petroleum industry Report No. 85/88. Brussels: CONCAWE
2. EEC (1986) Council Directive on the protection of workers from the risks related to exposure to noise at work (86/188/EEC). Official Journal of the European Communities No. L 137, 28-34, 24.5.86
3. CONCAWE (1984) Workshop on personal noise dosimetry Report No. 3/84. Brussels: CONCAWE
4. CONCAWE (1988) Implementation of effective hearing conservation programmes in the European oil industry Report No. 88/61. Brussels: CONCAWE

EC NOISE DIRECTIVE - KEY REQUIREMENTS

1. Where daily noise exposure is likely to exceed 85 dB(A) $L_{EP,d}$ (8h), employer duties include the provision of:
 - Adequate hearing protective devices
 - A hearing check (in accordance with national law and practice)
 - Adequate information and training

2. Where daily noise exposure is likely to exceed 90 dB(A) $L_{EP,d}$ (8), additional employer duties include:
 - Implementation of a programme of measures for noise exposure reduction
 - Ensuring the hearing protection provided affords the highest degree of protection which is reasonably practicable, and is worn by the workers

Note: All these measures are also applicable where the peak sound pressure is likely to exceed 200 Pascals (140 dB).

II

(Acts whose publication is not obligatory)

COUNCIL

COUNCIL DIRECTIVE

of 12 May 1986

on the protection of workers from the risks related to exposure to noise at work

(86/188/EEC)

THE COUNCIL OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Economic Community, and in particular Article 100 thereof,

Having regard to the proposal from the Commission, drawn up after consulting the Advisory Committee on Safety, Hygiene and Health Protection at Work ⁽¹⁾;

Having regard to the opinion of the European Parliament ⁽²⁾,

Having regard to the opinion of the Economic and Social Committee ⁽³⁾,

Whereas the Council resolutions of 29 June 1978 and 27 February 1984 on action programmes of the European Communities on safety and health at work ⁽⁴⁾ provide for the implementation of specific harmonized procedures for the protection of workers exposed to noise; whereas the measures adopted in this field vary from State to State and it is recognized that they urgently need to be approximated and improved;

Whereas exposure to high noise levels is encountered in a large number of situations and therefore many workers are exposed to a potential safety and health hazard;

Whereas a reduction of exposure to noise reduces the risk of hearing impairment caused by noise;

Whereas, where the noise level at the workplace involves a risk for the health and safety of workers, limiting exposure to noise reduces that risk without prejudice to the applicable provisions on the limitation of noise emission;

Whereas the most effective way of reducing noise levels at work is to incorporate noise prevention measures into the design of installations and to choose materials, procedures and working methods which produce less noise; whereas the priority aim must be to achieve the said reduction at source;

Whereas the provision and use of personal ear protectors is a necessary complementary measure to the reduction of noise at source, where exposure cannot reasonably be avoided by other means;

Whereas noise is an agent to which Council Directive 80/1107/EEC of 27 November 1980 on the protection of workers from the risks related to exposure to chemical, physical and biological agents at work ⁽⁵⁾ applies; whereas Articles 3 and 4 of the said Directive provide for the possibility of laying down limit values and other special measures in respect of the agents being considered;

Whereas certain technical aspects must be defined and may be reviewed in the light of experience and progress made in the technical and scientific field;

Whereas the current situation in the Member States does not make it possible to fix a noise-exposure value below which there is no longer any risk to workers' hearing;

⁽¹⁾ OJ No C 289, 5. 11. 1982, p. 1; OJ No C 214, 14. 8. 1984, p. 11.

⁽²⁾ OJ No C 46, 20. 2. 1984, p. 130; OJ No C 117, 30. 4. 1984, p. 5.

⁽³⁾ OJ No C 23, 30. 1. 1984, p. 36.

⁽⁴⁾ OJ No C 165, 11. 7. 1978, p. 1; OJ No C 67, 8. 3. 1984, p. 2.

⁽⁵⁾ OJ No L 327, 3. 12. 1980, p. 8.

Whereas current scientific knowledge about the effects that exposure to noise may have on health, other than on hearing, does not enable precise safety levels to be set; whereas, however, reduction of noise will lower the risk of illnesses unrelated to auditory complaints; whereas this Directive contains provisions which will be reviewed in the light of experience and developments in scientific and technical knowledge in this field,

HAS ADOPTED THIS DIRECTIVE :

Article 1

1. This Directive, which is the third individual Directive within the meaning of Directive 80/1107/EEC, has as its aim the protection of workers against risks to their hearing and, in so far as this Directive expressly so provides, to their health and safety, including the prevention of such risks arising or likely to arise from exposure to noise at work.

2. This Directive shall apply to all workers, including those exposed to radiation covered by the scope of the EAEC Treaty, with the exception of workers engaged in sea transport and in air transport.

For the purpose of this Directive, the expression 'workers engaged in sea transport and in air transport' shall refer to personnel on board.

On a proposal from the Commission the Council shall examine, before 1 January 1990, the possibility of applying this Directive to workers engaged in sea transport and in air transport.

3. This Directive shall not prejudice the right of Member States to apply or introduce, subject to compliance with the Treaty, laws, regulations or administrative provisions ensuring, where possible, greater protection for workers and/or intended to reduce the level of noise experienced at work by taking action at source, particularly in order to achieve exposure values which prevent unnecessary nuisance.

Article 2

For the purposes of this Directive, the following terms shall have the meaning hereby assigned to them :

1. *Daily personal noise exposure of a worker $L_{EP, d}$*

The daily personal noise exposure of a worker is expressed in dB (A) using the formula :

$$L_{EP, d} = L_{Aeq, T_c} + 10 \log_{10} \frac{T_c}{T_0}$$

where :

$$L_{Aeq, T_c} = 10 \log_{10} \left\{ \frac{1}{T_c} \int_0^{T_c} \left[\frac{p_A(t)}{p_0} \right]^2 dt \right\}$$

T_c = daily duration of a worker's personal exposure to noise,

T_0 = 8 h = 28 800 s,

p_0 = 20 μ Pa,

p_A = 'A'-weighted instantaneous sound pressure in pascals to which is exposed, in air at atmospheric pressure, a person who might or might not move from one place to another while at work; it is determined from measurements made at the position occupied by the person's ears during work, preferably in the person's absence, using a technique which minimizes the effect on the sound field.

If the microphone has to be located very close to the person's body, appropriate adjustments should be made to determine an equivalent undisturbed field pressure.

The daily personal noise exposure does not take account of the effect of any personal ear protector used.

2. *Weekly average of the daily values $L_{EP, w}$*

The weekly average of the daily values is found using the following formula :

$$L_{EP, w} = 10 \log_{10} \left[\frac{1}{5} \sum_{k=1}^m 10^{0,1 (L_{EP, d})_k} \right]$$

where $(L_{EP, d})_k$ are the values of $L_{EP, d}$ for each of the m working days in the week being considered.

Article 3

1. Noise experienced at work shall be assessed and, when necessary, measured in order to identify the workers and workplaces referred to in this Directive and to determine the conditions under which the specific provisions of this Directive shall apply.

2. The assessment and measurement mentioned in paragraph 1 shall be competently planned and carried out at suitable intervals under the responsibility of the employers.

Any sampling must be representative of the daily personal exposure of a worker to noise.

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

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

3. Member States may lay down that personal exposure to noise shall be replaced by noise recorded at the workplace. In that event the criterion of personal exposure to noise shall be replaced, for the purposes of Articles 4 to 10, by that of noise exposure during the daily work period, such period being at least eight hours, at the places where the workers are situated.

Member States may also lay down that, when the noise is measured, special consideration shall be given to impulse noise.

4. The workers and/or their representatives in the undertaking or establishment shall be associated, according to national law and practice, with the assessment and measurement provided for in paragraph 1. These shall be revised where there is reason to believe that they are incorrect or that a material change has taken place in the work.

5. The recording and preservation of the data obtained pursuant to this Article shall be carried out in a suitable form, in accordance with national law and practice.

The doctor and/or the authority responsible and the workers and/or their representatives in the undertaking shall have access to these data, in accordance with national law and practice.

Article 4

1. Where the daily personal exposure of a worker to noise is likely to exceed 85 dB (A) or the maximum value of the unweighted instantaneous sound pressure is likely to be greater than 200 Pa⁽¹⁾, appropriate measures shall be taken to ensure that:

(a) workers and/or their representatives in the undertaking or establishment receive adequate information and, when relevant, training concerning:

- potential risks to their hearing arising from noise exposure,
- the measures taken in pursuance of this Directive,
- the obligation to comply with protective and preventive measures, in accordance with national legislation,
- the wearing of personal ear protectors and the role of checks on hearing in accordance with Article 7;

(b) workers and/or their representatives in the undertaking or establishment have access to the results of noise assessments and measurements made pursuant to Article 3 and can be given explanations of the significance of those results.

2. At workplaces where the daily personal noise exposure of a worker is likely to exceed 85 dB (A), appropriate

⁽¹⁾ 140 dB in relation to 20 µPa.

If the maximum value of the 'A'-weighted sound pressure level, measured with a sound-level meter using the time characteristic I (according to IEC 651) does not exceed 130 dB (A), the maximum value of the unweighted instantaneous sound pressure can be assumed not to exceed 200 Pa.

information must be provided to workers as to where and when Article 6 applies.

At workplaces where the daily personal noise exposure of a worker is likely to exceed 90 dB (A) or where the maximum value of the unweighted instantaneous sound pressure is likely to exceed 200 Pa, the information provided for in the first subparagraph must, where reasonably practicable, take the form of appropriate signs. The areas in question must also be delimited and access to them must be restricted, where the risk of exposure so justifies and where these measures are reasonably practicable.

Article 5

1. The risks resulting from exposure to noise must be reduced to the lowest level reasonably practicable, taking account of technical progress and the availability of measures to control the noise, in particular at source.

2. Where the daily personal noise exposure of a worker exceeds 90 dB (A), or the maximum value of the unweighted instantaneous sound pressure is greater than 200 Pa:

- (a) the reasons for the excess level shall be identified and the employer shall draw up and apply a programme of measures of a technical nature and/or of organization of work with a view to reducing as far as reasonably practicable the exposure of workers to noise;
- (b) workers and their representatives in the undertaking or establishment shall receive adequate information on the excess level and on the measures taken pursuant to subparagraph (a).

Article 6

1. Without prejudice to Article 5, where the daily personal noise exposure of a worker exceeds 90 dB (A) or the maximum value of the unweighted instantaneous sound pressure is greater than 200 Pa, personal ear protectors must be used.

2. Where the exposure referred to in paragraph 1 is likely to exceed 85 dB (A), personal ear protectors must be made available to workers.

3. Personal ear protectors must be supplied in sufficient numbers by the employer, the models being chosen in association, according to national law and practice, with the workers concerned.

The ear protectors must be adapted to the individual worker and to his working conditions, taking account of his safety and health. They are deemed, for the purposes of this Directive, suitable and adequate if, when properly worn, the risk to hearing can reasonably be expected to be kept below the risk arising from the exposure referred to in paragraph 1.

4. Where application of this Article involves a risk of accident, such risk must be reduced as far as is reasonably practicable by means of appropriate measures.

Article 7

1. Where it is not reasonably practicable to reduce the daily personal noise exposure of a worker to below 85 dB (A), the worker exposed shall be able to have his hearing checked by a doctor or on the responsibility of the doctor and, if judged necessary by the doctor, by a specialist.

The in which this check is carried out shall be established by the Member States in accordance with national law and practice.

2. The purpose of the check shall be the diagnosis of any hearing impairment by noise and the preservation of hearing.

3. The results of checks on workers' hearing shall be kept in accordance with national law and practice.

Workers shall have access to the results which apply to them in so far as national law and practice allow.

4. Member States shall take the necessary measures with a view to the doctor and/or the authority responsible giving, as part of the check, appropriate indications on any individual protective or preventive measures to be taken.

Article 8

1. Member States shall take appropriate measures to ensure that :

(a) the design, building and/or construction of new plant (new factories, plant or machinery, substantial extensions or modifications to existing factories or plant and replacement of plant or machinery) comply with Article 5 (1);

(b) where a new article (tool, machine, apparatus, etc.) which is intended for use at work is likely to cause, for a worker who uses it properly for a conventional eight-hour period, a daily personal noise exposure equal to or greater than 85 dB (A) or an unweighted instantaneous sound pressure the maximum value of which is equal to or greater than 200 Pa, adequate information is made available about the noise produced in conditions of use to be specified.

2. The Council shall establish, on a proposal from the Commission, requirements according to which, so far as is reasonably practicable, the articles referred to in paragraph 1 (b), when properly used, do not produce noise likely to constitute a risk to hearing.

Article 9

1. In the case of workplaces where the noise exposure of a worker varies markedly from one working day to the next, Member States may, for workers performing special operations, exceptionally grant derogations from Article 5 (2), Article 6 (1) and Article 7 (1), but only on condition

that the average weekly noise exposure of a worker, as shown by adequate monitoring, complies with the value laid down in these provisions.

2. (a) In exceptional situations where it is not reasonably practicable, by technical measures or organization of work, to reduce daily personal noise exposure to below 90 dB (A) or to ensure that the personal ear protectors provided for in Article 6 of this Directive are suitable and adequate within the meaning of the second subparagraph of Article 6 (3), the Member States may grant derogations from this provision for limited periods, such derogations being renewable.

In such a case, however, personal ear protectors affording the highest degree of protection which is reasonably practicable must be used.

(b) In addition, for workers performing special operations, Member States may exceptionally grant derogations from Article 6 (1) if its application involves an increase in the overall risk to the health and/or safety of the workers concerned and if it is not reasonably practicable to reduce this risk by any other means.

(c) The derogations referred to in (a) and (b) shall be subject to conditions which, in view of the individual circumstances, ensure that the risks resulting from such derogations are reduced to a minimum. The derogations shall be reviewed periodically and be revoked as soon as is reasonably practicable.

(d) Member States shall forward to the Commission every two years an adequate overall account of the derogations referred to in (a) and (b). The Commission shall inform the Member States thereof in an appropriate manner.

Article 10

The Council, acting on a proposal from the Commission, shall re-examine this Directive before 1 January 1994, taking into account in particular progress made in scientific knowledge and technology as well as experience gained in the application of this Directive, with a view to reducing the risks arising from exposure to noise.

In the context of this re-examination, the Council, acting on a proposal from the Commission, shall endeavour to lay down indications for measuring noise which are more precise than those given in Annex I.

Article 11

Member States shall see to it that workers' and employers' organizations are consulted before the provisions for the implementation of the measures referred to in this Directive are adopted, and that where workers' representatives exist in the undertaking or establishments they can check that such provisions are applied or can be involved in their application.

Article 12

1. For the measurement of noise and checking workers' hearing, any methods may be used which at least satisfy the provisions contained in Articles 3 and 7.

2. Indications for measuring noise and for checking workers' hearing are given in Annexes I and II.

Annexes I and II shall be adapted to technical progress in accordance with Directive 80/1107/EEC and under the procedure set out in Article 10 thereof.

Article 13

1. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive by 1 January 1990. They shall forthwith inform the Commission thereof.

However, in the case of the Hellenic Republic and the Portuguese Republic the relevant date shall be 1 January 1991.

2. Member States shall communicate to the Commission the provisions of national law which they adopt in the field covered by this Directive. The Commission shall inform the other Member States thereof.

Article 14

This Directive is addressed to the Member States.

Done at Brussels, 12 May 1986.

For the Council

The President

W. F. van EEKELEN

ANNEX I

INDICATIONS FOR MEASURING NOISE

A. 1. General

The quantities defined in Article 2 can be either :

- (i) measured directly by integrating sonometers, or
- (ii) calculated from measurements of sound pressure and exposure duration.

Measurements may be made at the work place(s) occupied by workers, or by using instruments attached to the person.

The location and duration of the measurements must be sufficient to ensure that exposure to noise during the working day can be recorded.

2. Instrumentation

2.1. If integrating averaging sonometers are used, they shall comply with IEC standard 804.

If sonometers are used, they shall comply with IEC standard 651. Instruments incorporating an overload indication are preferred.

If data are stored on tape as an intermediate step of the measurement procedure, potential errors caused by the process of sorting and replay shall be taken into account when analyzing the data.

2.2. An instrument used to measure directly the maximum (peak) value of the unweighted instantaneous sound pressure shall have an onset time constant not exceeding 100 μ s.

2.3. All equipment shall be calibrated in a laboratory at suitable intervals.

3. Measurement

3.1. An on-site check shall be made at the beginning and end of each day of measurement.

3.2. Measurement of workplace sound pressure should preferably be made in the undisturbed sound field in the workplace (i. e. with the person concerned being absent) and with the microphone located at the position (s) normally occupied by the ear exposed to the highest value of exposure.

If it is necessary for the person to be present, either :

(i) the microphone should be located at a distance from the person's head which will reduce, as far as possible, the effects of diffraction and distance on the measured value (a suitable distance is 0,10 m), or

(ii) if the microphone must be located very close to the person's body, appropriate adjustments should be made to determine an equivalent undisturbed pressure field.

3.3. Generally, time weightings 'S' and 'F' are valid as long as the measurement time interval is long compared with the time constant of the weighting chosen, but they are not suitable for determining L_{Aeq} , T_e when the noise level fluctuates very rapidly.

3.4. Indirect measurement of exposure

The result of the direct measurement of L_{Aeq} , T_e can be approximated with a knowledge of the exposure time and the measurement of clearly distinguishable sound-pressure-level ranges ; a sampling method and a statistical distribution may be useful.

4. Accuracy of measuring noise and determining the exposure

The type of the instrument and the standard deviation of the results influence the accuracy of measurement. For comparison with a noise limit, the measuring accuracy determines the range of readings where no decision can be made as to whether the value is exceeded ; if no decision can be taken, the measurement must be repeated with a higher accuracy.

Measurements of the highest accuracy enable a decision to be taken in all cases.

- B. Short-term measurements with ordinary sonometers are quite satisfactory for workers performing, at a fixed location, repetitive activities which generate roughly the same levels of broad-band noise throughout the day. But when the sound pressure to which a worker is exposed shows fluctuations spread over a wide range of levels and/or of irregular time characteristics, determining the daily personal noise exposure of a worker becomes increasingly complex; the most accurate method of measurement is therefore to monitor exposure throughout the entire shift, using an integrating averaging sonometer.

When an integrating averaging sonometer conforming to IEC standard 804 (which is well suited for measurement of the equivalent continuous sound pressure level of impulse noise) complies at least with the specifications of type 1 and has recently been fully calibrated in a laboratory, and the microphone is properly located (see 3.2 above), the results make it possible, with certain exceptions to determine whether a given exposure has been exceeded (see 4) even in complex situations; that method is thus generally applicable, and is well suited for reference purposes.

ANNEX II

INDICATIONS FOR CHECKING WORKERS' HEARING

In the framework of checking workers' hearing the following points are taken into consideration :

1. The check should be carried out in accordance with occupational medical practice and should comprise :
 - where appropriate, an initial examination, to be carried out before or at the beginning of exposure to noise,
 - regular examinations at intervals which are commensurate with the seriousness of the risk and are determined by the doctor.
2. Each examination should consist of at least an otoscopy combined with an audiometric test including pure-tone airconduction threshold audiometry in accordance with 6 below.
3. The initial examination should include a medical history; the initial otoscopy and the audiometric test should be repeated within a period of 12 months.
4. The regular examination should be carried out at least every five years where the worker's daily personal noise exposure remains less than 90 dB (A).
5. The examinations should be carried out by suitably qualified persons in accordance with national law and practice and may be organized in successive stages (screening, specialist examination).
6. The audiometric test should comply with the specifications of ISO standard 6189-1983, supplemented as follows :

Audiometry also covers the frequency of 8 000 Hz; the ambient sound level enables a hearing-threshold level equal to 0 dB in relation to ISO standard 389-1975 to be measured.

However, other methods may be used if they give comparable results.

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