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TNO-rapport

**CONSIDERATIONS ABOUT NOISE ASPECTS IN THE
EEC DRAFT DIRECTIVE PHYSICAL AGENTS**

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CONTENTS	page
SUMMARY	i
1. INTRODUCTION	1
2. CHARACTERIZATION OF NOISE EXPOSURE	2
3. LEVELS	4
4. CONSIDERATION OF THE THRESHOLD LEVEL	5
5. REGULATIONS	6
6. GROUPS OF WORKERS AT PARTICULAR RISK	8
7. NOISE MEASUREMENTS	9
8. PERSONAL HEARING PROTECTORS	10
9. FUNCTIONAL HEARING DAMAGE	11
10. SHORTCOMINGS OF THE DOCUMENT	12
11. PROPORTION OF WORKERS TO WHICH THE DOCUMENT APPLIES	13
LITERATURE	15

SUMMARY

This report contains an overview of and considerations about the Working Draft of a future EEC Directive Physical Agents (draft 1991). The overview in this report is limited to noise exposure. The Draft gives minimum regulations concerning the protection and prevention of workers against the risks to their health and safety from exposure to physical agents such as noise.

From research in the Netherlands industry it is estimated that 70 to 80% of the industrial workers are exposed to noise above the threshold value, given in the Draft. The implementation of the Directive will therefore have extensive implications.

It is recognized that implementation of the Directive is an important step towards safe and healthy working environments. E.g. the Draft specifies the threshold level of a daily occupational sound exposure as 75 dB(A). In the report it is shown that the risk of noise-induced hearing loss is negligible if the exposure is below the threshold level, even for live time exposures. However, the Draft gives also rise to the following critical observations.

- In the Draft it is specified that hearing protection is considered adequate if the resulting foreseeable risk is maintained at a level at or lower than the ceiling level of 90 dB(A). Since noise-induced hearing loss from noise exposure at the ceiling level is substantial, protection is adequate only if the risk is maintained at the threshold level.
- It is the author's opinion that any noise-induced hearing loss leads to functional damage in the course of the life of the worker. Therefore, the aim of the health surveillance with respect to hearing should be to diagnose and to limit any noise-induced hearing damage. This implements strict audiometric measuring conditions, which have not been specified in the Draft.
- In the Draft, workers having an ear disease are considered to be at particular risk, without any specification of the diseases. Since it is questionable

whether any ear disease is increasing the risk due to noise, the relevant ear diseases should be specified.

- The Draft is supposed to give regulations to protect workers against the risks to their health and safety. Taking into account the possible occurrence of daily sound exposures above the ceiling level or even above the highest action level of 105 dB(A), health surveillance should not be limited to a hearing check only, but also incorporate health surveillance for specified groups of workers aiming at general health effects, such as cardio-vascular diseases and stress.
- With respect to safety aspects, the Draft should specify workers with a decreased ability of directional hearing as a group of workers at particular risk.

1. INTRODUCTION

The Draft Directive Physical Agents is based on the framework Directive 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work. The Draft Directive Physical Agents lays down particular minimum regulations in the area of the protection of workers against the risks to their health and safety, including prevention of such risks, arising or likely to arise from exposure to physical agents such as noise, vibrations and electro-magnetic fields.

These considerations are limited to exposure to noise in the working environment. Concerning noise exposure, there is already effective EEC-Directive 86/188/EEC on the protection of workers from the risks related to exposure to noise at work. This Noise Directive will be repealed by the Physical Agents Directive. The Physical Agents Directive will presumably come into force by 31 December 1993.

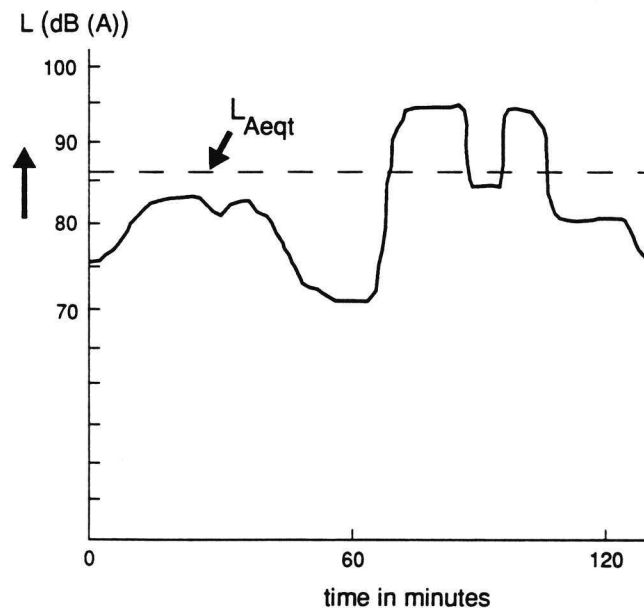
2. CHARACTERIZATION OF NOISE EXPOSURE

In the document noise exposure is expressed by two parameters:

1. daily sound exposure ($L_{EX,8h}$ in dB(A));
2. peak sound pressure (p_{peak} in dB(C)) relative to $20 \mu\text{Pa}$ or the corresponding peak sound pressure level $L_{C, peak}$

The term daily sound exposure of a worker can be elucidated as follows: the momentaneous noise level to which a worker at his workplace is exposed is usually varying in time. Figure 1 shows such a variation of noise levels over time. To express all noise levels during a period T in one value, the equivalent sound level ($L_{Aeq,T}$) can be used. This equivalent sound level is an average value of all noise levels occurring during time T, but contrary to the arithmetic average, in the determination of $L_{Aeq,T}$ the higher noise levels are rated more than the lower values. For example, when a worker is exposed for 4 hours to a constant noise level of 100 dB(A) and another 4 hours to 80 dB(A), then the equivalent sound level over 8 hours is 97dB(A) (and not 90dB(A) which is the arithmetic average).

Figure 1 Noise levels (L) at a workplace as a function of the time. L_{AeqT} is the equivalent sound level over an exposure time of 120 minutes (2h) and is indicated by L_{Aeq2h}



The equivalent sound level over a specified time incorporates, when measured correctly, all types of noises occurring during that time. Also impacts and impulses, such as noise from the falling of metal objects, nail shooting, rivetting, compressed air, ramming, hammering and chipping are incorporated in the equivalent sound level.

The daily sound exposure is equal to the equivalent sound level over a workday, normalized to a reference duration equal to a nominal eight-hour days ($L_{Aeq,8h}$ (dB(A))).

Usually the $L_{Aeq,8h}$ -value of a worker varies from day to day. To account for this variation, the $L_{Aeq,8h}$ - values are obtained for the 5 working days in a week and the equivalent average over the week is taken as representative for the daily sound exposure $L_{EX,8h}$ of the worker. This implies that, when there is noisy machinery to which a worker is exposed only one day a week, the worker's noise exposure from that machinery is spread over the week. For example, if a worker is exposed for 4 days a week to an equivalent sound level of 70 dB(A) and one day to 97 dB(A), then his daily sound exposure is equal to 90 dB(A) (the arithmetic value would be 75 dB(A)).

The document specifies that the daily sound exposure shall be representative of the personal noise exposure of a worker.

$L_{EX,8h}$ is the noise quantity which gives the best correlation with noise-induced permanent hearing loss. Noise-induced hearing loss is a deterioration of hearing which is located in the inner ear, the cochlea. Exposure to impulses, such as from shooting, fire work, nail shooting may give rise to a deterioration of hearing in the form of rupture of the ear drum, displacement of the (ossicle) chain in the middle ear and rupture of membranes in the inner ear. Such a risk of deterioration is best described by the instantaneous peak level of the impulse or impact. The C-weighting is applied, since this frequency weighting is giving more weight to the lower frequency sounds than the A-weighting and lower frequency sounds are more dangerous in this respect.

3. LEVELS

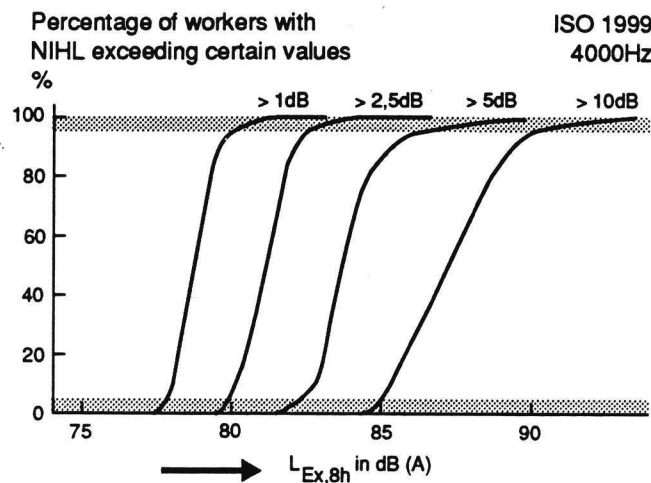
The document specifies three types of levels:

- threshold level: the value above which the risk of harmful effects is considered negligible. In the document, for noise exposure the threshold level is established at a daily sound exposure of 75 dB(A).
- ceiling level: the value above which the risk of harmful effects is considered excessive. The ceiling levels are $L_{EX,8h} = 90$ dB(A) and $L_{peak} = 140$ dB(C).
- intermediate action level: the value above which a specified measure must be undertaken. Concerning noise exposure the intermediate action levels are:
 1. $L_{EX,8h} = 80$ dB(A) $L_{peak} = 135$ dB(C)
 2. $L_{EX,8h} = 85$ dB(A) $L_{peak} = 135$ dB(C)
 3. $L_{EX,8h} = 90$ dB(A) $L_{peak} = 140$ dB(C)
 4. $L_{EX,8h} = 105$ dB(A) $L_{peak} = 150$ dB(C)

4. CONSIDERATION OF THE THRESHOLD LEVEL

To determine noise-induced hearing loss (NIHL) of workers exposed to noise at the workplace, the International Standard ISO 1999 (issued in 1990) can be used. ISO 1999 specifies a model to calculate noise-induced hearing loss as a function of daily sound exposure. Noise-induced hearing loss is specified for the frequency range of 500 to 6000 Hz. For groups of workers, the NIHL-values are maximal at the frequency 4000 Hz. NIHL-values are given for exposure times up to 40 years. Taking a life time occupational exposure of 40 years the percentage of workers with NIHL-values at 4000 Hz exceeding certain values can be calculated from ISO 1999. The model does not allow calculations for the 5% of the largest NIHL-values. In figure 2, the results are given for NIHL-values of 1, 2.5, 5 and 10 dB and for daily sound exposures varying from 75 to 90 dB(A).

Figure 2 Percentage of workers with noise-induced hearing loss at 4000 Hz exceeding certain values (1, 2.5, 5 and 10 dB) as a function of daily sound exposure for workers exposed to occupational noise for 40 years



From the figure it is obvious that at 75 dB(A) the risk of noise-induced hearing loss, even due to a life time exposure, is negligible. There is only one restriction, since the model in ISO 1999 has been based on cross-sectional research. Longitudinal research might give in general different results, but for a daily sound exposure of 75 dB(A) differences, if any, are not considered to be of any importance.

5. REGULATIONS

The following minimum regulations are specified in the document:

1. Taking account of technical progress and of the availability of measures to control noise at the source, the risks arising from noise exposure must be reduced to the lowest practicable level, with the aim of reducing exposure to below 75 dB(A).
2. The risks must be kept at a level not exceeding that resulting from exposure to 90 dB(A) or 140 dB(C) (ceiling levels).
3. Personal hearing protection must be worn when exposure exceeds the ceiling levels.
4. Intermediate action levels and actions to be undertaken, are
 1. $L_{EX,8h} = 80$ dB(A) and $L_{peak} = 135$ dB(C)
 - . informing workers likely to be exposed
 - . informing workers of the places and times at which the provisions apply
 - . supplying personal hearing protectors to workers on request
 - . the right of a hearing check to diagnose any hearing impairment by noise. Unfortunately it is not specified under which conditions such a hearing check has to be performed. In the former noise Directive (86/188/EEC) a higher level of 85 dB(A) has been specified concerning health surveillance.
 2. $L_{EX,8h} = 85$ dB(A) and $L_{peak} = 135$ dB(C)
 - . training of the workers in the implementation of measures taken.
 - . making personal hearing protectors available
 - . providing information on the noise produced by machinery
 - . programming of noise reducing measures.

3. $L_{EX,8h} = 90 \text{ dB(A)}$ and $L_{peak} = 140 \text{ dB(C)}$

- . delimiting of areas
- . restricting access to areas
- . information in the form of signs.

$L_{EX,8h} = 105 \text{ dB(A)}$ and $L_{peak} = 150 \text{ dB(C)}$

- . declaration of activities giving rise to a significant hazard to the authority responsible

6. GROUPS OF WORKERS AT PARTICULAR RISK

Measures specified in the document have to be adapted to meet the requirements of particularly sensitive risk groups. Concerning noise exposure, the following groups risk are specified:

- Workers having a disease or deformity of the ear and workers using ototoxic drugs. It is questionable whether an (unspecified) ear disease is increasing the risk due to noise. For instance, a middle ear disease may even protect the worker to some extent from noise-induced hearing loss. On the other hand, workers with an ear disease having already a substantial hearing loss should be protected more carefully than others to preserve the rest of their hearing .
- Pregnant women. Exposure of pregnant women to $L_{EX,8h}$ of 85 dB(A) or more may affect the hearing of the unborn child. This seems to be correct, especially for the last three months of pregnancy. It is also correct that the risk is increased for low frequency noise as stated in the document.

7 NOISE MEASUREMENTS

Since the document specifies that the measuring result must be representative of the personal exposure a worker, it is stated that measurements are to be made at the position occupied by the worker's ears during work. Member States may as a derogation allow the daily noise exposure of a worker to be replaced by noise exposure determined at the workplace. Although the relevant paragraph is phrased such that the meaning is difficult to understand, the text may imply that noise measurements may be organised such that the results are representative for areas occupied by groups of workers and not for only one individual worker.

8. PERSONAL HEARING PROTECTORS

In the Directive it is specified that hearing protection is considered adequate if the resulting foreseeable risk is maintained at a level at or lower than the ceiling level. Figure 2 shows that noise-induced hearing loss is substantial if the daily sound exposure is at the ceiling level of 90 dB(A). To give adequate protection, the risk should be maintained at the threshold level.

Concerning the protection of personal hearing protectors, it is still the question which attenuation values are representative for the real-world attenuation of such protectors for the average worker. Results of research into the attenuation of hearing protectors as worn by the worker in the workplace have shown that this protection is on average much less than the attenuation, measured in the laboratory under excellent conditions, and specified by the manufacturer of the devices. Taking into account the large inter-individual variation in the attenuation values of hearing protectors as used in the real world, an estimate of the protection which the individual worker will obtain from his personal hearing protection is only possible when this protection is actually measured on a personal basis and under field conditions.

9. FUNCTIONAL HEARING DAMAGE

The aim of the health surveillance is to diagnose and to limit any functional damage of hearing. Research has shown that a decrease of speech intelligibility in normal living conditions already starts at small hearing losses. Since there is also a deterioration of the hearing of workers with increasing age, it is obvious that any noise-induced hearing loss leads to functional damage in the course of the life of the worker and should therefore be limited.

10. SHORTCOMINGS OF THE DOCUMENT

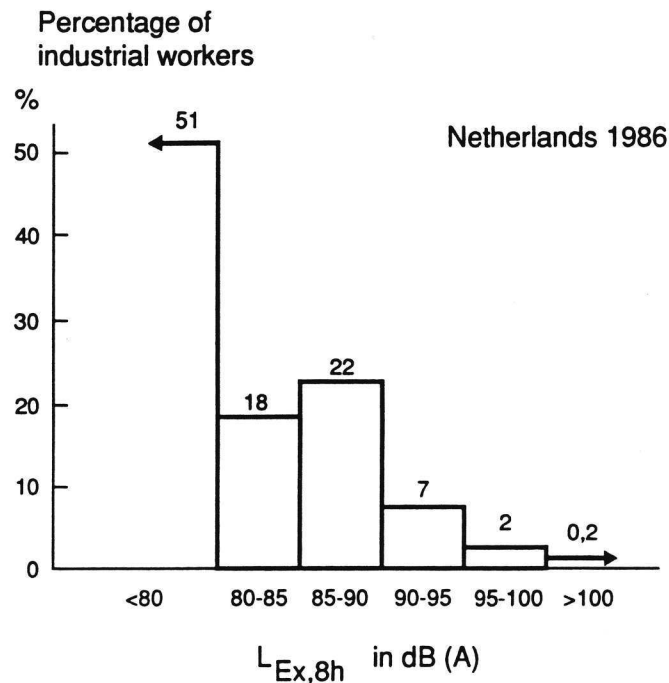
The document is supposed to give regulations to protect workers against the risks to their health and safety arising from exposure to noise. Unfortunately, possible health effects such as cardio-vascular diseases, stress and annoyance are not covered in the document. However, daily sound exposures above the ceiling level or even above the highest action level ($L_{EX,8h} = 105 \text{ dB(A)}$) may have adverse effects on health, apart from noise-induced hearing damage. Health surveillance, aiming at diagnosing such effects, would therefore be appropriate for exposures above the ceiling level.

Also, safety aspects are hardly mentioned in the document. Nevertheless, noise at the workplace is able to mask warning signals, voices from and shouting by other persons and noises coming from moving vehicles. Another safety aspect concerns a decreased ability of directional hearing of workers with a substantial (noise-induced) hearing impairment. Since their directional hearing is even worse when they wear hearing protectors, especially ear muffs, these workers might as well be considered a group of workers at particular risk.

11. PROPORTION OF WORKERS TO WHICH THE DOCUMENT APPLIES

In figure 3 an estimate is given of the daily sound exposures existing in the Netherlands industry. Half of the industrial workers in the Netherlands are exposed to daily sound exposures of less than 80 dB(A). Since this lowest class of daily sound exposures has not been divided into several sub-classes, it is estimated that about 70 to 80% of the workers in the Netherlands industry are exposed above the threshold level. Nine percent of the industrial workers are exposed at and above the ceiling level.

Figure 3 Percentage of industrial workers in The Netherlands as a function of the daily sound exposure. Estimate from 1986



Since also other activities, such as the building industry, agriculture and mining contain many noisy situations, occupational noise exposure is to be considered as a major risk to the health and safety of workers.

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