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SAFETY, HEALTH AND WELFARE

Noise and the Worker

FIRST EDITION 1963

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MINISTRY OF LABOUR

NOISE and THE WORKER

Introduction

1. Many workers in industry to-day are exposed to excessive noise. This leaflet briefly discusses the problem and the ways in which it can be overcome.

The Effects of Noise

2. There is still much to be learnt about the effects of different kinds of noise, and scientific research is at present being undertaken with this object. It is, however, already well-known that excessive industrial noise interferes with communication, and can adversely affect working efficiency and also safety, because it may mask warning signals. It is also known that persistent loud noise may affect the delicate mechanism of the human ear and result in damage to hearing which is permanent and incurable.

Is there Excessive Noise in your Factory?

3. You should consider the following points:—

(a) Do workers find it difficult to hear each other speak ?

(b) Have workers complained of head noises or ringing in the ears after working in noise for several hours ?

(c) Have workers experienced temporary deafness, severe enough for them to seek medical advice ?

(d) Have workers complained that they have suffered a loss of hearing which has had the effect of muffling speech and other sounds, or that their families say that they are going deaf ?

(e) Has there been an exceptionally high labour turnover in a particularly noisy section of the factory compared with other less noisy sections ?

If the answer to a number of these questions is " yes " you should consider whether you have a noise problem, and if so, take action on the lines suggested in this leaflet. It is advisable to make any noise reduction programme the special responsibility of one person, and to explain the objectives of the programme to supervisors and workers.

Analysing the Noise

4. Before you can deal with your noise problem you need to know:—

(a) The extent to which workers are exposed to the noise during a typical working day or working life;

(b) The overall level of the noise; and

(c) The composition of the noise.

To arrive at (b) and (c), measurements must be taken with special equipment, by people who have had training and experience in the use of it. Your engineer may be qualified to do this or you may wish to seek specialist help. Advice about organisations which can give such help may be obtained from H.M. District Inspector of Factories.

Control of Noise

5. When you know the extent of your problem, you should consider what can be done to reduce the level of noise or the amount of exposure to it. Possible lines of approach are:—

(a) The reduction of the noise at source, e.g. the modification of the machinery or the process.

(b) A reduction in the amount of noise transmitted through the air or through buildings, e.g. by increasing the distance between the noise source and the working area, or by enclosing or placing a barrier before the noise source.

(c) An alteration in working arrangements, e.g. arranging for staff to work in rotation on particularly noisy processes.

Personal Protection

6. If the methods described in paragraph 5 fail to reduce the noise exposure sufficiently, workers should be issued with ear protectors, either ear plugs or ear muffs. If these are worn, it is possible to work in relatively high levels of noise without damage to hearing, and workers may also find it easier to hear each other speak, because the sound levels are reduced to levels at which the ear can discriminate more comfortably.

Monitoring the Hearing of Workers

7. It is advisable to arrange for tests of hearing before workers are placed on noisy processes, and for follow-up tests after they have been engaged upon them for some time. Advice on organisations able to arrange such tests, which need special equipment, can be obtained from H.M. District Inspector of Factories. The tests show the state of a person's hearing before he is exposed to a noisy environment and so enable any subsequent changes in hearing sensitivity to be noted. They may make it possible to identify individuals who are particularly susceptible to noise, and to judge the effectiveness of protective measures.

Booklet giving further information

8. A booklet " Noise and the Worker " issued by this Ministry is obtainable from H.M. Stationery Office (price 1*s.* 3*d.*); this discusses the subject of noise measurement, and explains some of the methods used to protect workers from excessive noise.

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(*H.M. Factory Inspectorate*)

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CONTENTS

INTRODUCTION

The problem of noise has attracted increasing attention in recent years, and the Report of the Committee under the Chairmanship of Sir Alan Wilson, of March 1963, reflected the considerable public interest in this question. Noise is not a new problem in industry but for a long time it has tended to be accepted, both by management and workers, simply as part of the job. This is still the attitude in many factories, either because the harmful effects of noise are not appreciated, or because it is thought that nothing can be done about them. There is still much to be learnt about the precise effects of noise, and scientific research is being undertaken with this object. Enough is already known about the problem, however, to suggest some measures which can be taken to control it. The purposes of this booklet are to set out the basic facts, to suggest ways in which the working environment can be made less noisy and the harmful effects of noise on workers prevented or mitigated, and to indicate where further information and advice can be obtained. It should help managements in factories where there is a lot of noise but where no special action has been taken, to look again at the problem and take some positive steps about it.

HOW IS NOISE HARMFUL?

Besides being an annoyance, noise may interfere with working efficiency, by inducing stress and disturbing concentration, especially where the work is difficult or highly skilled, and by hindering communication between

workers; it may be a cause of accidents, by masking warning signals; and most importantly, it may damage workers' hearing. A temporary hearing loss, lasting from a few seconds to a few days, may result from exposure to intense noise for a short time. Much more serious, regular exposure to some kinds of noise over a long period may result in the destruction of certain inner ear structures and a loss of hearing which is permanent and incurable.

HAVE YOU A NOISE PROBLEM?

A convenient test of hearing impairment is whether workers can hear and understand everyday speech under everyday (quiet) conditions. If they begin to find this difficult it may well be that they are being exposed to excessive noise. This effect may not, however, show itself for some considerable time.

The following points should also be considered:

1 Do workers find it difficult to hear each other speak while they are at work in a noisy environment?

2 Have workers complained of head noises or ringing in the ears after working in noise for several hours?

3 Have workers who have been exposed to very high noise levels for short periods experienced temporary deafness, severe enough for them to seek medical advice?

4 Have workers exposed for longer periods complained of a loss of hearing that has had the effect of muffling speech and certain other sounds? Have they been told by their families that they are becoming deaf?

5 Has there been a higher labour turnover in workshops or sections where there is a lot of noise?

6 Has management formed the opinion that noise is affecting production?

If the answer to several of these questions is 'yes', there

may well be a problem of excessive noise. If so, efforts should be made to reduce it, or, if it cannot be sufficiently reduced—for example, where impact is essential to the process—to reduce the exposure of workers to the noise, or to provide them with ear protection, or both if necessary.

THE CONDUCT OF A NOISE REDUCTION AND HEARING CONSERVATION PROGRAMME

The first steps in the programme are to carry out a noise survey and to obtain specialist advice. H.M. Factory Inspectorate will always be ready to advise managements about organisations able to give such advice. Even where it is obvious that the noise is excessive a survey may be useful in establishing its precise origin. Where this can be done it may sometimes be possible, without further detailed enquiry, to reduce the noise, perhaps by one of the methods described later in this booklet, to such an extent that it no longer constitutes a problem.

If a considerable noise reduction programme is necessary, it will be essential to co-ordinate the work of all concerned, including not only the Medical Officer, whose part is vital, but also the people who will have to deal with any engineering or structural changes necessary to reduce the noise. If this is to be done effectively, it is advisable that the responsibility for dealing with noise problems should be placed primarily upon one person in the factory.

THE MEASUREMENT OF NOISE

Noise has been defined as 'sound which is undesired by the recipient'. Sound in industry is a by-product of the

conversion of energy. No process using power is completely efficient; some energy is inevitably wasted. Most of this is converted into heat; but some also into sound, when surfaces vibrate or turbulence is set up in the air. If these vibrations are regular, we get a sound having a definite 'pitch' or 'frequency' (i.e. number of vibrations per second). In most industrial noises the vibrations are very irregular, and the sound has components distributed over a wide range of frequencies.

The important characteristics of sound, from the point of view of noise in industry, are (a) 'loudness' or 'intensity' (the meanings of the terms are not quite the same but the difference may be disregarded for the purposes of this booklet) and (b) the way in which the energy in the sound is distributed over the different frequencies present. The normal human ear is sensitive to sound frequencies between 20 and 20,000 cycles per second, being particularly sensitive in the range of 1,000–4,000 cycles per second. The frequencies important for speech intelligibility lie between 500 and 4,000 cycles per second.

In order to judge the noise level of a workshop, a preliminary measurement will usually be made with a sound level meter, calibrated in 'decibels' (dB). The reading of this is broadly related to the loudness of the sound as judged by the observer. For a closer analysis, it is necessary to measure the distribution of the energy in the noise area in the different frequency ranges. An octave band frequency analyser is used for this purpose: it incorporates filter circuits to analyse the noise, usually in the standard eight frequency bands of cycles per second viz: 37·5–75; 75–150; 150–300; 300–600; 600–1,200; 1,200–2,400; 2,400–4,800; 4,800–9,000.

The process of measurement should always be undertaken by people with training and experience of the necessary technique. The engineer at the factory may be suitable and qualified to do this, or the management may prefer to call in a specialist agency. H.M. Factory

Inspectorate can advise about where this help may be obtained. It may sometimes be possible to have the noise from a particular source recorded on a tape and later analysed in a laboratory.

The instruments mentioned are most suitable for the measurement of steady noises. If there is a high proportion of impact noise (such as is caused by hammering or riveting) among the general noise in the workshop it is sometimes very difficult to interpret their readings, and special equipment may be necessary.

THE DANGER LEVELS OF NOISE

The effects of noise on hearing cannot be estimated without taking into account, besides the intensity of the noise, the duration and distribution of exposure to it. Obviously exposure to steady loud noise for a period of years is more dangerous than exposure for a period of days, and exposure for eight hours per day more dangerous than exposure for two hours. Moreover, the effects of continuous exposure differ from the effects of exposure interrupted by a period of reduced noise level. Before the effects of loud noise can be judged, therefore, it is necessary not only to measure the noise but to assess the amount of exposure to it during a normal working day or working life.

Our knowledge of the relation of noise to hearing loss is as yet too limited for it to be possible to say with certainty what amount of exposure is safe—partly because people vary greatly in their susceptibility to noise. It is generally agreed, however, that if workers are exposed for eight hours a day, five days a week, to a continuous steady noise of 85 dB or more in any octave band, in the speech range of frequency (500 to 4,000 cycles per second), it is desirable to introduce a programme of noise reduction or hearing conservation. (This is a level of noise in which normal speech cannot easily be heard; at a distance of a few feet communication can be achieved only by shouting.) Fre-

quency as well as intensity must be taken into account; high frequencies are more dangerous than low, at the same pressure level. As the following table shows, a sound pressure level of 80 dB, for example, is not considered harmful at frequencies below 1,200 cycles per second, but should be avoided at frequencies above that level.

Sound pressure levels at which noise reduction and/or hearing protection and conservation programmes should be introduced

Frequency band (cycles per second)	Sound pressure value (decibels)
37·5 – 150	100
150 – 300	90
300 – 600	85
600 – 1,200	85
1,200 – 2,400	80
2,400 – 4,800	80 ≡ 89.18 A

This table applies only to steady noise. Impulsive noise (such as comes from hammering or riveting) may be dangerous at levels about 10 dB lower than those given in the second column of the table; and so may noise containing intense pure tones or energy in narrow bands, such as the whine produced by a rotating machine running at high speed.

NOISE REDUCTION

ENVIRONMENTAL CONTROL OF NOISE

When a new factory is being built and equipped, or an established factory is being re-equipped, the question of noise should be considered from the beginning. To a very great extent, the process used determines whether there will be a noise problem. Where there are two equally acceptable methods, the quieter method should be selected. In choosing machine tools and other equipment, different makes should be compared for noise as well as other qualities. Excessive noise, besides being undesirable in itself, may well indicate that a tool is badly designed. It may be considered desirable, when ordering machinery, to stipulate that noise should be suppressed as far as possible.

If it is necessary to install very noisy processes or equipment, consideration should be given to isolating them when the buildings are planned. The noisiest part of the factory should be placed well away from the rest, and consideration should be given to the use of sound absorbing materials and the siting of structures to act as screens.

Other methods of reducing exposure to noise are equally applicable in established and in new factories. They can be summarised under three heads—the reduction of noise at source, the reduction of noise transmitted through air and buildings, and alterations in working arrangements.

Reduction of noise at source

This is the most effective method of securing a diminution in noise levels. The following are examples of successful action which has been taken in some factories:

1 When machines are being designed or redesigned the level of noise emission should be considered as well as other desirable features such as high performance. Apparatus is available for testing machine noise and identifying the loudest components to which attention can then be paid. Even large machines can be taken into anechoic chambers and the effects of modification in design noted. For example, electric motors can be run at various speeds and flux densities and the effects of skewed or semi-closed slots and graded air gaps investigated. Comparison can be made between spur and helical gears with different combinations of materials and geometry of teeth and viscosity of oil. The noise of ball and roller bearings can be studied while varying the roundness of balls, hardness of races,

material of cages, finish of the rolling surfaces and amount of lubrication.

2 Machines already in use may be modified in order to reduce noise. For example, punches in die sets may be redesigned so as to convert one major impact into a series of lesser impacts. Electric motors are sometimes overcooled on full load and, if so, it may be permissible to reduce the amount of cooling air and so reduce the 'fan note'. Where possible, as in some textile drives, the substitution of a fibre pinion for a steel one can effect a marked reduction in noise.

3 The proper upkeep and repair of equipment will do much to reduce noise. Often a rattle can be eliminated merely by securing a loose panel. Squeaking brushes can be quietened by applying a wax candle to the commutator surface. Gears may deteriorate in use and so increase in noise, especially if the gear teeth are initially incorrectly formed and of poor surface finish; it is sometimes possible to effect improvements by examining the teeth and filing or scraping high spots and by checking the depth of engagement. Vibration from machinery with rotating parts can be reduced by attention to proper balancing. Frictional noise from the cutting action of tools and saws is reduced if the tools are kept sharp. Other noises caused by friction in machines, conveyor rollers and trolleys can be reduced by proper lubrication.

4 Noise from air and steam exhausts can often be reduced by a specially designed silencer. Similarly the noise from fans used in ventilating systems can be reduced by silencers, and also by the use of resilient mountings (see (5)) and flexible couplings.

5 Vibration noise may be reduced by using pads or mountings made of felt, cork, glass wool or rubber. In particular cases it may be worthwhile to have a low-frequency spring mounting for the whole machine.

6 The noise radiated by supporting structures for vibrating and other equipment will often be less if they are frames than if they are cabinets or sheeted enclosures. The noise from machinery guards can be minimised by making them of perforated sheet or wire mesh.

7 The noise radiated from metal plates and other metal parts is generally made more intense by resonance in the plate. This can be reduced by stiffening the plate (e.g. by adding ribs) or by increasing the damping—for example, by coating the surface of resonating equipment with compounds of the kind used for under-sealing cars.

8 Noise caused by the handling or dropping of materials on hard surfaces can be reduced by covering surfaces with resilient materials and by using such materials for containers. For example, a rubber lining in the interior of a tumbler cylinder will reduce noise.

9 Noise may often be reduced by substitution of plant or equipment. For instance, electric trucks may be substituted for internal combustion trucks; rivets on an assembly line may be fixed by hot squeezing with hydraulic pressure in place of pneumatic riveting; rubber buckets may be used in place of galvanised buckets; pneumatic tyres may be used on workshop trucks instead of solid wheels; rubber chutes may be used instead of metal; plastic gears and fibre bearings may be substituted for others.

Reduction of noise transmitted through air or building structures

A reduction in the transmission of noise will have little effect on the amount of noise in the immediate vicinity of the source, but it can lower the overall level substantially. Such reductions can be accomplished in various ways:

1 The distance between the work area and the source may be increased. In open-air conditions the noise

intensity from a source is reduced by about 6 dB by doubling the distance. This method of noise control is obviously liable to be expensive, especially when applied to an existing factory, but its possibilities should not be overlooked. For example, automatic machinery not requiring constant attention may sometimes be placed in a storage area where no one is working continuously, or in an out-building. This has been done with gas-burner ladle drying equipment.

2 An enclosure may be provided for the noise source—whether this is a set of machines, a single machine, or even a part of a machine. For example, the complete enclosure in a solid box (with doors of equally heavy construction) of tumblers used to separate scrap from parts has been known to reduce the noise at a distance of 5′ from 111 dB to 88 dB. Similarly, a motor generator or core knock-out operation may be completely enclosed.

3 Where the machine cannot easily be enclosed, the operator may be isolated, e.g. in a mechanised foundry where one man may operate the controls for many noisy machines. The operator of a scrap baling machine in one such foundry was completely enclosed in a box with its own air supply system: this reduced the noise reaching him by 26 dB overall, and was particularly effective in reducing high frequency noise.

4 Barriers may be placed between the work area and the source of noise. The heavier the barrier the greater the reduction in noise transmission. Brick walls are more effective than partitions made of lighter materials; and a 9″ brick wall, suitably plastered, can reduce the noise by 50 dB. Heavy partitions are better insulators than light ones, provided that they are not porous and all cracks and holes are sealed. Double walls or partitions are more effective than single. Glass windows or doors in a partition may much reduce the sound insulation, but less so if they are double glazed. Where fixed walls are not possible, mobile screens will effect some sound reduction; they should preferably extend up to the roof, or, in constructions of more than one storey, to the structural floor above.

5 The use of sound-absorbing materials such as glass wool, mineral wool, and acoustic tiles, will reduce noise due to reverberation. This is more effective in a factory where the machines are not too close together. For maximum effect, machines should be spaced at intervals of more than 30′. However, even with densely packed machines, the use of sound absorbing material is worthwhile; the reduction in total noise level in such circumstances may be small, but because there is less reflected noise from distant machines, direct noise from those near at hand stands out and is less confusing to workers, who should find it easier to work and to hear each other speak. Absorbent material may be used on any flat surface, not only on roof or ceilings. It is particularly desirable to use it inside an enclosure designed to reduce noise, if anyone is required to work within it.

6 Baffles may be used—e.g. for dust extraction equipment and fans.

7 The mounting of machinery on insulating material (already mentioned on page 10) will reduce transmission of noise.

8 Ancillary operations like loading and moving materials may be placed under cover, with shields or baffles. Openings should be shielded if doors are impracticable.

Alterations in working arrangements

Where processes are not all equally noisy, the risk to workers can be reduced by the introduction of shift or rotation systems, under which they take turns on the noisiest work.

HEARING CONSERVATION

EAR DEFENDERS

Where it is not possible, by environmental control, to reduce noise to sufficiently safe levels, workers should be protected by ear defenders. Even in a workshop where the general level of noise is not too high, some operators of especially noisy machines may need such protection.

There are two forms of ear protectors available commercially: both need to be carefully fitted. It is advisable to examine the worker's ears and test his hearing when the fitting is done.

1 EAR PLUGS are designed to occlude the ear canal and must be correctly fitted; various sizes may be obtained. They are small, inexpensive and inconspicuous, and workers soon become accustomed to them, though some may find them uncomfortable at first. They may be made of rubber, neoprene, plastic, or cotton impregnated with wax—not dry cotton wool, which affords little or no protection.

2 EAR MUFFS completely cover the external ears. They are bulkier, heavier and more expensive than ear plugs, but if properly designed and fitted, they give more protection, and they may be more comfortable. Moreover, it is easier for a supervisor to check that they are being worn.

For extreme noise-exposure, a combination of ear plugs and ear muffs may be necessary.

It has been shown that when background noises are above 85 dB the intelligibility of speech both for communication and warning may actually increase if ear protectors are worn. This is because the sound levels are reduced to those at which the ear can discriminate more comfortably.

Investigations have shown that when efficient types of ear plugs or muffs are worn continuously the following

levels of noise are permissible as compared with those suggested in the table on page 8.

Levels at which a hearing conservation programme should be introduced, where ear protection is used

Frequency band (cycles per second)	With ear plugs (decibels)	With ear muffs (fluid seal type) (decibels)
37·5 – 150	110	120
150 – 300	110	115
300 – 600	110	118
600 – 1,200	110	125
1,200 – 2,400	110	122
2,400 – 4,800	110	125

It will be seen that the use of efficient ear protection may have the same value as a noise reduction of 20–30 dB.

It may be difficult to convince workers that they should wear ear-protectors; and a planned programme of education about the dangers of excessive noise to unprotected ears may be needed. The importance of correct fitting of ear protectors should be emphasised in this programme.

Examples of ear plugs and ear muffs may be seen at the Industrial Health and Safety Centre, 97 Horseferry Road, London, SW1 (see page 20).

MONITORING WORKERS' HEARING

If workers are exposed to levels of noise at or approaching those set out on page 8 (without ear protectors) or those on page 15 (with properly fitted ear protectors) or to higher levels, it is advisable where possible to make arrangements for periodic tests of their hearing.

Such tests should be undertaken before workers are placed on noisy processes, and thereafter at regular intervals. This procedure will establish the state of hearing of each worker before he is exposed to the noisy environment and will enable a record to be kept of any

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change in hearing acuity. Thus it will be possible to assess the effect of noise reduction or ear protection measures. It will also be possible to identify, and move to other work, individuals who are especially susceptible to noise and who may therefore be endangered by levels harmless to the majority.

The detailed testing of hearing is called 'audiometry'. Tests are arranged in a soundproof room with the subject wearing a pair of headphones. Sound of a single frequency (e.g. 1,000 cycles per second) is produced in one ear in decreasing volume, and the subject signifies when he can no longer hear it. This gives what is termed the 'threshold of hearing' for this frequency. The test is repeated with both higher and lower frequencies, usually in the range 500–8,000 cycles per second. The other ear is then tested. The test thus determines the hearing ability of each ear at varying frequencies.

If such testing cannot be undertaken by the works' Medical Officer it may be possible to make arrangements for it with a specialist agency, though facilities are at present rather limited. H.M. Factory Inspectorate can advise about such agencies. Examples of audiometric equipment may be seen at the Industrial Health and Safety Centre, 97 Horseferry Road, London, SW1 (see page 20).

APPENDIX 1

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APPENDIX 2

FILMS FOR HIRE

Two 16mm films can be hired from the Government-run Central Film Library, Bromyard Avenue, Acton, London, W3.

'Dangerous Noise (No. V518)'. Black and White. 16 minutes. Emphasises the value of noise control and timely medical checks by studying the case history of two foundry workers. Dutch film with English sound track.

'Ear Protection in Noise (No. V511)'. Colour. 12 minutes. Covers the same ground as V518 above but devotes more time to audiometric procedures. Made in USA.