Forestry Operations and the Problem of Noise

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ALONG with air and water pollution, the problem of noise is becoming increasingly important in all of the industrialised societies of the world. As a result of the developments of industry and transport, there has been an increase in the number and power of sources of noise, which have led to what may be called an acoustic pollution of many workplaces.

Until very recently little had been done to control the high levels of noise to which industrial workers are exposed throughout their working lives. Noise has tended to be accepted, both by Management and workers, simply as part of the job. Noise has an adverse effect on human health and working capacity. Prolonged exposure to lound noise has been knownn for many years to cause irreparable damage to the hearing, but now recent research has produced evidence that harmful psychological effects can result. General fatigue is a common experience, the power of concentration can be reduced and mental reactions can be slowed down. Loss of communication can impair safety standards. All these can be contributory causes of accidents and reduced productivity.

Effects on the ear

Most people realise that a noise can harm their hearing if it is sufficiently loud, but they usually think in terms of some quite exceptionally violent sound. In fact deafness can be produced in a much more insidious way. The noise we 'get used to' and endure for many years is just as likely to damage our hearing as the high level noise we instinctively avoid. Damage develops slowly, and it may take years of exposure to a noise before the effects become serious. By that time the victim may well have forgotten what it was like to hear as well he did in his youth, or if he does notice any difficulty in hearing, he may put it down to his age. He hears conversation at normal loudness, but i tsounds distorted, and he thinks that people are not speaking clearly.

The Nature of Noise

Noise measurements are relatively simple to make with a sound level meter. To rate the possible effects of noise on hearing, three

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things must be known : level of intensity, frequency range and duration of exposure.

Absolute values of sound intensity can only be expressed in long and cumbersome numbers, but the use of a logarithmic scale reduces these values to convenient limits. The unit of measurement on this scale is called the bel, and in practice, for the sake of being able to work with whole numbers, and to avoid the use of a decimal point, the value in bels is multiplied by ten, and so the sound level of intensity is expressed in decibels (dB).

The following typical values in decibels should make this term more understandable :-

20	Whisper	70	Manual typewriter
40	Quiet part of the forest	85	Power saw idling
55	Office with three persons	95	Tractor operating
65	Normal conversation	98	Discotheque-Amplified music

The sound level depends on the frequency, i.e. the number of vibrations within a given unit of time. The higher the frequency, the sharper will be the note, e.g. a train whistle, and the lower the frequency the lower down the scale the note will be, e.g. a low hum.

Frequency or pitch is expressed in cycles per second or Hertz (Hz). The ear of a healthy young person is sensitive to frequencies between about 20 Hz and 20 000 Hz. The average individual is particularly sensitive in the range 500 Hz to 4 000 Hz. This fact is very important when measuring noise, since two sounds of equal intensity, but of different frequency, may appear subjectively to be of different loudness. We can tolerate more low frequency noise than high frequency noise. When hearing is impaired the ears become less sensitive at first to the higher frequencies, such as the consonants in normal speech. This is similar to what happens at 'old age deafness'.

When measuring or analysing a noise, the frequency range is broken down or divided into slices usually octave bands, and these are conveniently designated by their approximate mid frequency. Thus the 125 Hz band covers the frequency range 90 to 180 Hz. The standard range of octave bands commonly used are 63, 125, 250, 500, 1000, 2000, 4000, 8000 and 16000. Octave band analysis provides useful information for Noise Engineers.

Weighted Sound Level

It is more important to know about the human reaction to sound than to investigate sound as a purely physical happening, and sound levels, as measured by most instruments, do not agree well

with the levels perceived by the human ear. This is why frequency weighted networks or scales have been introduced in noise meter measurements. Scales were designed to approximate to the characteristics of the ear at various levels of loudness. Those in common use are designated A, B, C and D. By reducing the influence of low sounds, a more valid measurement is obtained, and this is achieved by the A scale which discriminates severely against very low frequencies. This scale is commonly used for industrial noise measurement, and the value or noise level obtained is called dB(A). It is also most nearly the subjective response of the human ear.

Danger Levels of Noise

Some workers are more liable to noise-induced hearing loss than others, and until recently knowledge of the effects of noise exposure was limited. However it is now possible to provide a table of permissible daily noise dose limits (Table 1). It should be noted that these limits are maximum acceptable levels and not desirable levels, so some residual risk is implied.

The maximum level allowed in current Noise Regulations is 9 dB(A) for continuous exposure in an eight hour day.

TABLE 1

PERMISSABLE DAILY NOISE DOSE LIMITS

Max sound level dB(A) at ear	Exposure duration per day (Hrs)
90	8
93	4
96	2
99	1
102	$\frac{1}{2}$
105	$\frac{1}{4}$

Multiple Noise Sources

Logarithmic numbers cannot be added together in the same way as ordinary numbers. If for example two sound sources have a level of 80 dB(A) each the total value when both sources are working at the same time will not be 160 dB(A). The correct answer is 83 dB(A). When a sound level is increased by 3 dB(A)

the intensity is doubled and therefore exposure duration should be halved.

Risk of injury in Forest Industry

A joint FAO/ECE Committee in collaboration with the ILO has for many years, through its various study groups dealing with Forest machinery, been concerned with the problem of noise. The results of investigations carried out in various countries show that all types of power saw have a loudness level considerably in excess of the permissible limit, and are therefore prejudicial to the workers' hearing. The intensive mechanisation of forest produce extraction and preparation of ground operations, has led to a noise problem that has been steadily growing in recent years. A general solution has been hampered more by ignorance than by neglect, since the necessary scientific knowledge was lacking. In the UK the Department of Employment's 'Code of Practice for reducing the exposure of employed persons to Noise', published by HMSO in May 1972, gives a positive approach, and as a result, in N. Ireland certain steps were taken by The Forest Service to apply the requirements of this Code. One of these was the purchasing of a Noise Dosimeter, and some of the readings taken by this instrument are shown in Table 2.

TABLE 2

EXAMPLES OF NOISE LEVELS

		Noise level operator's ear	Permitted exposure time in any day (mins.)
Operation	Machine	operator's ear	day mins()
	Ford County Forwarder	93	240
Timber extraction	Highland County	94	200
	Highlander Half Track	93	240
Ploughing	International	98	80
	County	93	240
	Super six	97	110
Fell/sned	Husqvarna 280	104	15
	Jonsered 621	105	18
Broadcast fertiliser	Muskeg	103	20
Load stones	Excavator 22 RB	96	120
Load soil	J C B	93	240
Drain maintenance	Poclain digger	93	240
Grass mowing	Flymo Contractor	91	400
Quarrying	Manual Jack Hammer	113	1

Since the noise from these machines fluctuates over fairly wide limits, and has a continually varying pattern, a conventional sound level meter will be virtually useless in assessing the hazard. The Dosimeter is a light compact unit designed to fit a worker's top pocket with the microphone worn on the lapel. The instrument will register the noise exposure throughout either a complete working day, or a sample period of the day, and then calculate the percentage of the permitted noise dose that has been consumed. This figure set against the duration of the measurement or sample period on a conversion slide rule gives what is known as the Equivalent sound level. This can be defined as a level of steady noise that has the same energy content as the complex pattern of noise being measured.

It is important that the sample period is truly representative of the complete work period. The figures in Col. 3 of Table 2 are Equivalent sound level values. It has been found that nearly all machine operators are regularly exposed to noise levels, which if no precautions are taken are high enough to cause hearing impairment over a period of years.

Control Measures

Management is responsible for ensuring that the best practical means for noise reduction are applied. Four kinds of measures can be taken: reducing the noise at the source, preventing its propagation in the vicinity, soundproofing objects and using personal protective equipment. Not all of these measures are practicable in the Forest Industry. Power saws and tractors are purchased from various manufacturers, and must be fully utilised for economic reasons, even though the noise produced during operating is above the acceptable limit.

Power saws

The modern power saw achieves its high performance when used at the speed of maximum power and for years manufacturers have been engaged in intensive research to incorporate silencing without loss of power output and an increase in weight. A new American saw features a special "reed" silencer which "tunes out" harmful and annoying sound frequencies and recently one from Europe has a large front mounted muffler for quiet running.

Research on power saw noise in European countries shows that medium and high frequencies which have the most harmful effect on the human ear are predominant in the noise produced. The use of protective equipment is the best practical measure and this can be in the form of ear plugs, disposable ear down, plugs or

ear muffs. Valuable guidance is given in the Code of Practice. The first two are not recommended as being suitable for forestry conditions, since it is almost impossible to prevent them from becoming dirty. Hygiene is important to avoid risk of ear infection. The wearing of ear muffs is the best practical and effective means of giving hearing protection and for power saw operators they can be attached to a safety helmet. This also makes it easy for supervisors to check that protection is being worn. It is important to know the noise level for each octave centre frequency from 31.5 Hz to 8000 Hz when a saw is working at maximum power since this can help in deciding which type of muffs to use.

Only two types of power saw are used by Northern Ireland Forest Service operators and the results of recent testing of the noise level of these machines is shown in Table 3 and graphically in Fig. 1.

TABLE 3

NOISE LEVEL OF POWERS AWS

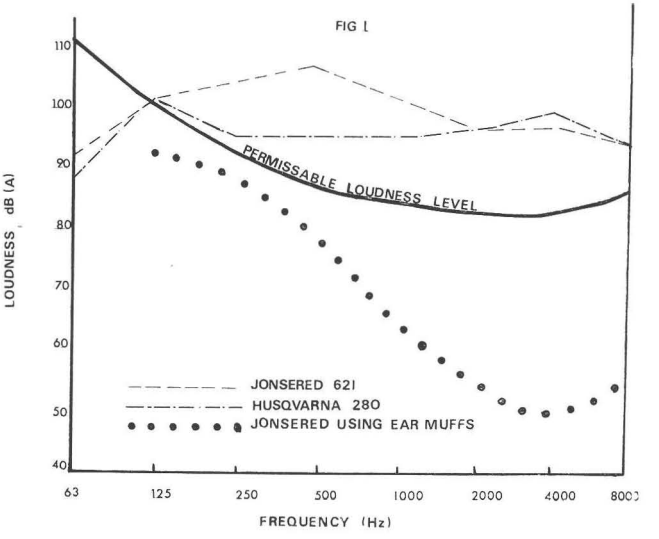
Mid Frequency Band (Hz)	Sound Pressure Level dB(A)		Ear muff attenuation*	Sound Fressure Level at operator's ear dB(A)	
	Jonsered	Husqvarna		Jonsered	Husqvarna
64	92	88	—	—	—
125	102	102	9	93	93
250	105	96	15	90	81
500	107	96	26	81	70
1,000	103	96	38	65	58
2,000	97	97	42	55	55
4,000	98	100	50	48	50
8,000	95	95	40	55	55

*A recommended type used by the Forest Service.

These confirm earlier measurements (Table 2) and indicate that not only is one saw 'noisier' than the other but the loudness level of each penetrates well beyond the permissible 90 dB(A) level contour. In fact it is on average 32 times higher than the recommended level (Table 2).

Most manufacturers of ear muffs supply full information on the sound reduction likely to be provided for the various frequency levels and these figures subtracted from measured sound levels gives the sound pressure level at the operator's ear.

The example given in Fig. 1, shows that there is adequate



attentuation for both types of saw. The aim should be to provide the wearer with enough sound attentuation to reduce the noise to an acceptable level. Comfort, ease of cleaning, durability and availability of spare parts should also be considered.

Tractors

In the UK the Agriculture (Tractor Cabs) Regulations require that from 1 September 1977, in safety cabs fitted to tractors, the noise level at the driver's ear must not exceed 90 dB(A). As in all cold climates almost all tractors were fitted with cabs to protect drivers from the weather. These were often crude, and fitted as cheaply as possible. They acted as sound boxes for the noise emitted by the engine and other components so that the noise level was higher than it would have been if there were no cab. It was therefore necessary to introduce legislation to cover cab design.

With existing machines noise level can be reduced by the fitting of simple sound proofing and information is being gathered on the best types of material and methods of fitting. One of the biggest problems is sealing areas where the various controls enter the cab. Until a new machine is purchased suitable ear protectors must be worn. As with power saws, muffs are recommended preferably with neck or head bands. The Code of Practice recommends that a warning notice should be attached to a noisy machine, e.g. the caption "Use ear protectors when operating this machine".

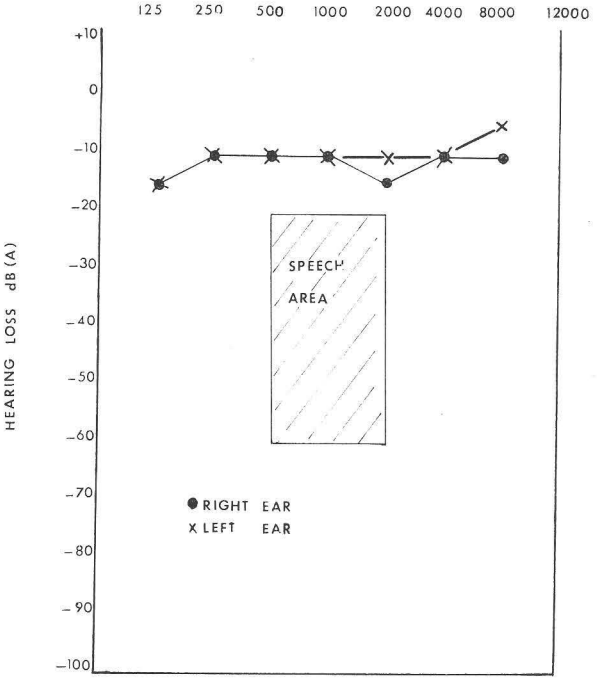


FIG 2

AUDIOGRAM SHOWING NORMAL HEARING OF A YOUNG PERSON

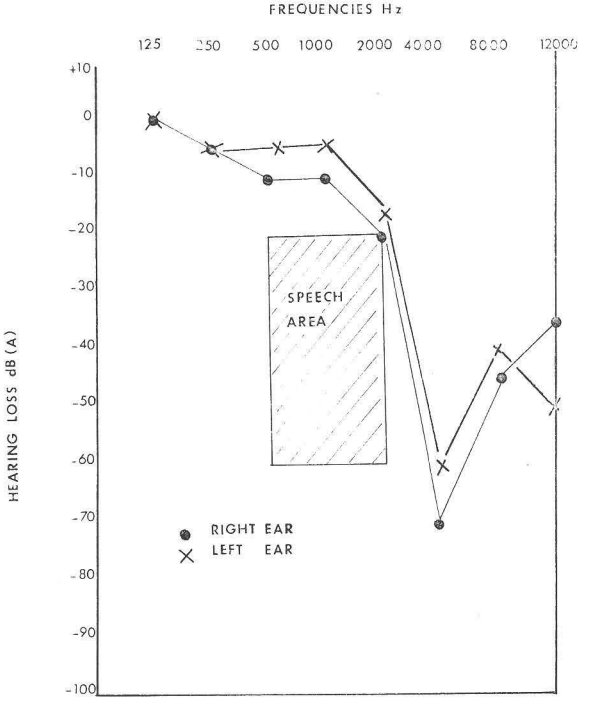


FIG 3

AGE 44 YRS EXPOSURE TO FACTORY NOISE 5YRS

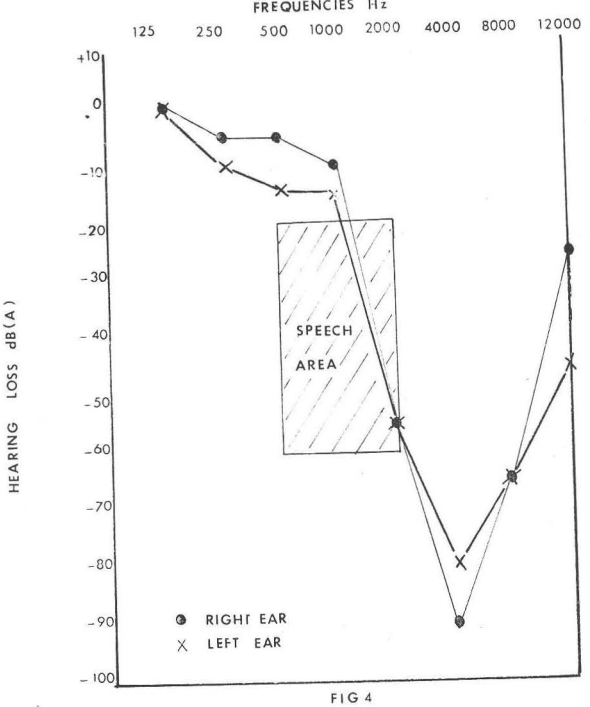


FIG 4

AGE 44YRS EXPOSURE TO FACTORY NOISE 17YRS

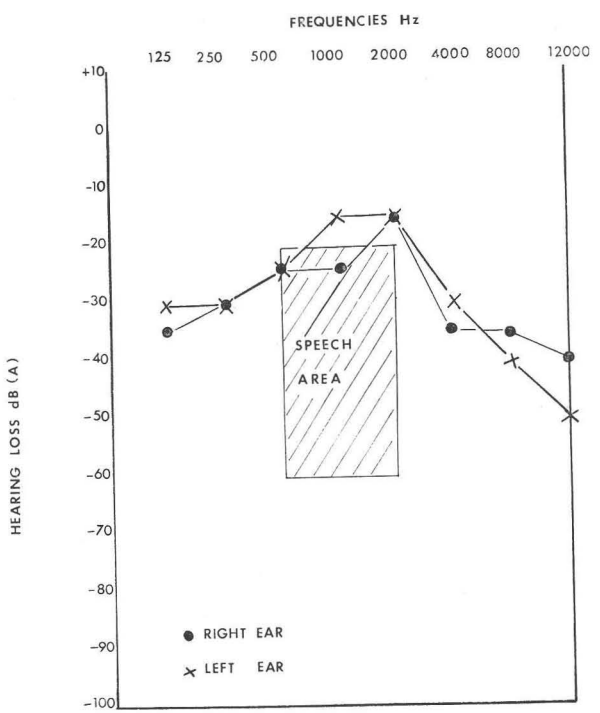


FIG 5

CHAIN SAW OPERATOR AGE 52YRS
EXPERIENCE 15YRS (NOT CONTINUOUS)

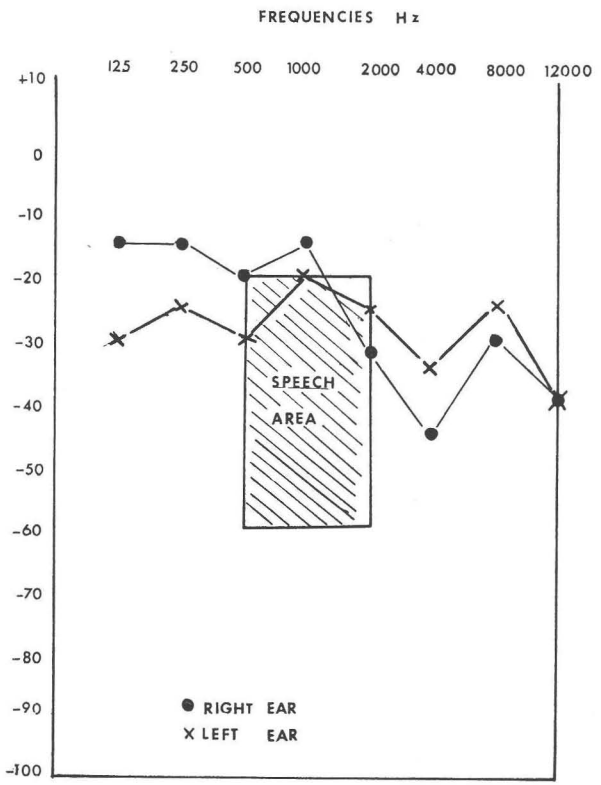


FIG 6

CHAIN SAW OPERATOR AGE 50 YRS

EXPERIENCE 8YRS (NOT CONTINUOUS)

The role of Audiometry

In a hearing conservation programme audiometric screening plays an important part both for pre-employment and periodic follow-up checks for employees, especially those who are noise sensitive. This can detect at an early stage individuals whose hearing has been impaired possibly through being exceptionally susceptible to noise or failure to use hearing protectors. It is also possible to identify those workers with ear ailments which might cause problems in the use of protective devices.

Audiometric results are plotted on suitable graph paper and are called audiograms. The aim is to find the lowest audible level at each frequency in controlled conditions. The test is performed separately for each ear at a selected number of frequencies and

the subject is asked to indicate the noise level at each frequency which he can just detect. Examples are given in Figs. 2 to 6.

The hearing loss shown in Fig. 3 would be considered not unusual. Hearing is still reasonable between 500 Hz and 2000 Hz, which is referred to as the speech area. However it is adversely affected in the mid and high frequencies. Fig 4 is an example of severe impairment, since the hearing loss extends far enough to lower the understanding of speech.

Ten Forest Service power saw operators volunteered to undergo hearing tests. Experience ranged from one year to fifteen years, and the age range was from 23 years to 52 years. We were pleased to find that there was no evidence of hearing damage which could be attributed to exposure to power saw noise. In Fig. 5 the lines are similar to those that would be expected for a man of this age, who had not been exposed to excessive noise levels. As people grow older the ears gradually become less sensitive, especially at first to the higher frequencies.

In Fig. 6 both ears showed an 'acoustic dip' at 4000 Hz frequency. It was discovered that this man was a keen sportsman, and a lifetime hobby was hunting with a shotgun, which may have been responsible for the slight hearing damage.

Temporary Hearing Loss

The first physiological effect of exposure to excessive noise is auditory fatigue. This is manifested by a slight dulling in the hearing at the end of the exposure period, and is often accompanied by a ringing in the ears. This effect is usually temporary, and the loss, from which the ear eventually recovers, is called the Temporary Threshold Shift. The extent of this shift depends on the noise intensity, and is, for chain saw operators, not as great as might be expected, since hearing can recover to some degree during periods of interruption.

Research in the Forestry Commission and in the U.S. Forest Service has shown that in an eight hour day, even with incentive working, the total noise exposure time for chain saw operators is not more than four and a half hours. Industrial Research in the U.K. indicates that recovery from a temporary threshold shift is usually complete sixteen hours after a continuous two hour exposure. In America an evaluation of damage risk was made by monitoring the morning hearing thresholds of power saw operators to determine if the hearing levels at the end of the working day had recovered by either the morning of the following day, or after a free weekend. It was found that such a recovery did take place,

but it was stressed that this conclusion could only apply to sawyers involved in thinning operations.

It could be hypothesised that these research findings explain why there was no evidence of hearing damage to the ten Forest Service operators, especially those with long experience. However in any year a considerable amount of the working time is spent both in clear felling and salvaging windblow. Therefore it is recommended that ear protectors should be worn in all sawing operations.

Occupational deafness has now been included in the list of prescribed industrial diseases which carry the entitlement of compensation Legal actions between employer and employee are increasing in number, and several successful claims have already been heard. Others have been settled out of Court, and there is a large number awaiting a hearing. Damages ranging from £7,500 to £30,000, less contributory negligence, have been awarded in Northern Ireland.

In the Forest Industry it is not always practicable to apply the control measures, suitable in Factory conditions, to combat the harmful effects of noisy machines, but a Noise Control Policy should be formulated, based on the recommendations of the Code of Practice. This will require constructive co-operation between Management, Trade Unions and employees. Operators are often reluctant to use hearing protectors. It is therefore not enough to make these available. Encouragement and persuasion are needed, and an Education programme, aimed at both Management and workers, is vital to implement Policy. The effects of noise above a certain level are real, and every precaution should be taken to minimise the risk of permanent deafness, to control inefficiency and to provide a congenial working environment.

REFERENCES

1. "Code of Practice for reducing the exposure of employed persons to Noise". HMSO 1972.
2. "The Protection Handbook of Industrial Noise Control", by Peter Sutton, B.Sc., Ml.Mech.E.