NOISE IN THE WORKING ENVIRONMENT AND L_{eq}

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INTRODUCTION

The use of L_{eq} to assess the hazardous effects of exposure to noise at places of work in the UK has its roots in a field study "Hearing and Noise in Industry", commissioned by the Government and published by HMSO in 1970 [1]. It was carried out jointly by W Burns of the British Medical Research Council and D W Robinson of the National Physical Laboratory. This work led to the "Code of Practice for reducing the exposure of employed persons to Noise" [2], the document which was used by inspectors of health and safety in their enforcement activities from 1972, when it was first published, to 1990 when the Noise at Work Regulations [3] came in to force. The Code of Practice required noise exposures to be quantified in terms of L_{eq}, because it was a reasonable predictor of hearing loss and because it would encourage the development of instruments which could be used to assess noise (steady, impulsive, intermittent, etc) in any working environment [4]. Noise exposures quantified under the Noise at Work Regulations must also use L_{eq}.

The development of field instruments capable of computing L_{eq} in real time has made the life of acoustic consultants and health & safety professionals much easier. However, if exposures are to be assessed correctly and the most appropriate control measures are to be adopted, noise measurements on their own – even in terms of dosemeter readings taken over an entire shift – are unlikely to be enough. It is also necessary to question individuals about their duties and to observe their methods of working. Incorrect interpretation of noise measurements was one of the reasons for the large number of inadequate assessments which followed the introduction of the Regulations [5]. Other causes also played a part, and these were described by Kyriakides and Galbraith in 1991 [6].

The Council of the Institute of Acoustics recognised the need for training those wishing to undertake noise assessments under the Regulations and developed a syllabus for courses which are run by accredited centres [7]. Successful completion of the course, which entails written and practical examinations, leads to the award of a "Certificate of Competence" in work-place noise assessment.

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BACKGROUND

The UK Government investigation by Burns and Robinson involved the study of hearing and noise in a variety of industries. Known noise exposure was related to the state of hearing of 1,000 volunteer subjects. The conditions for the acceptance of subjects made it possible for the state of hearing to be related only to the effects of age and of noise exposure history.

Burns and Robinson noticed that a particular value of the "age-corrected hearing level" could be associated with a high noise level for short time or a lower noise level for a longer time. The noise exposure histories of subjects in the studies were known with considerable precision. The results of the field study, and other work by Robinson and others, showed that the "age-corrected hearing level" was related to the cumulative sound energy received by the ear, over a wide range of exposures. This sound energy was termed by Robinson as the Noise Immission Level (NIL) which he expressed as:

$$E_A = L_A + \log_{10}\frac{t}{t_0}$$

where: E_A is the A-weighted NIL
L_A is the daily occupational noise exposure
t is the duration of exposure in years
t_0 is 1 year.

When the Noise Immission Level is known, the risk of hearing handicap (otologically normal people) can be estimated using the tables in BS 5330:1976 [8]. More recent tables have been published by the Health and Safety Executive [9] which enable the estimation of risk to otologically normal as well as to typical unscreened populations.

The findings of the Burns and Robinson study were used in the development of the Code of Practice, which recommended a maximum acceptable noise level of 90 dB(A) if the noise was reasonably steady and the exposure continued for 8 hours. If the exposure was for a period other than 8 hours or if the sound level was fluctuating, an equivalent continuous level was to be calculated and normalised to 8 hours on an energy basis to form $L_{eq(8\ hr)}$. This value was not to exceed 90 dB(A). This is a measure of noise dose received in one day and can be regarded as the notional sound level which would, in the course of an 8 hour period, cause the same A-weighted sound energy to be received as that due to the actual sound over the actual working day.

It is important to bear in mind that, at the time that the Code of Practice was published, integrating sound level meters were not available and there were only simple noise dose meters, whose accuracy was questionable because of the absence of Standards [2]. The Code recommended that "the instrument maker should be required to confirm" that the instrument will integrate correctly according the equations given in the Code, and to "provide full technical details of the measuring accuracy likely to be obtained when the instrument is in use."

THE NOISE AT WORK REGULATIONS 1989

These Regulations implement the requirements of the European Communities' Council Directive on the protection of workers from the risks related to exposure to noise at work [10]. To comply fully with the Directive, the UK Regulations refer to $L_{eq(8\ hr)}$ as the daily personal noise exposure which is symbolised as $L_{EP,d}$.

Three action levels are specified in the Regulations. The first action level takes effect for $L_{EP,d} \geq 85$ dB(A), and the second for $L_{EP,d} \geq 90$ dB(A). A peak action level is also defined and is set at a sound pressure of 200 pascals (140 dB re 20µPa).

The requirements of the Regulations depend on the level of noise exposure, and can be summarised as follows.

Employers are required to:

- Make and review noise assessments and keep records
- Reduce exposure to noise of their employees
- Provide personal ear protectors to their employees
- Demarcate and identify ear protection zones
- Maintain equipment provided under the Regulations
- Provide information, instruction, and training to their employees.

Employees are required to:

- Use ear protectors and any other protective equipment and report any defects to the employer.

Makers and suppliers of machines are required to:

- Provide information on the noise likely to be generated.

The "Noise assessments" required by the Regulations form the basis of effective solutions to noise problems, and their results dictate what further actions might be required under the law. Notwithstanding their importance, many of the noise assessments which followed the introduction of the Regulations were inadequate, and even now we are seeing assessments that fall short of even the most basic requirements. The essential elements of assessments have been analysed and summarised in reference [6].

Inadequate assessments can lead not only to a waste of time and substantial costs, but also to a failure to correctly identify those at risk. Some employers go to the trouble of having a second assessment to confirm the results before they proceed.

In one recent case where we were asked to repeat an assessment carried out by others we found:

(a) the exposure of one group of workers was overestimated and the group placed above the second action level instead of between the action levels;

(b) a second group of workers who were exposed to noise above the first action level were not identified as being at risk;

(c) the control measures recommended would have cost the client more than £30,000 without reducing the exposure of those who were intended to benefit.

We were able to advise the client on effective and simple controls to reduce exposures, which happened in this case to have a low cost.

MAKING ASSESSMENTS OF $L_{EP,d}$

Workplace noise is rarely steady or continuous. The major advantage of measuring noise in terms of L_{eq} at places of work is that it enables noise exposure to be quantified with relative ease, even in cases where noise is intermittent or fluctuates considerably. Prior to the availability of integrating sound level meters the assessment of noise exposure was more an estimate than an accurate quantity. Integrating sound level meters, and more recently personal dosemeters capable of logging short term L_{eq} values throughout the monitoring period, enable the value of $L_{EP,d}$ to be determined much more accurately, and a detailed history of exposure to be recorded.

For most industrial situations the $L_{EP,d}$ is determined by measuring a sample L_{eq} which is representative of the employee's noise exposure due to his particular activity. When an employee performs more than one activity, further sample L_{eq} measurements may be needed which are combined (taking account of the exposure time) to calculate $L_{EP,d}$.

Logging dosemeters set to register L_{eq} values at, say, 1-minute intervals provide the kind of information which enables significant noise sources to be identified more easily. In addition, they provide evidence on which to base questions about values which do not fit in with observed trends and are therefore suspicious. Sometimes this is the result of abuse of the instrument, but sometimes what appears to be a questionable reading has a rational explanation.

We have set out below two examples which illustrate the usefulness of short term sample L_{eq} values (obtained with logging dosemeters) in assessing the noise exposure of employees.

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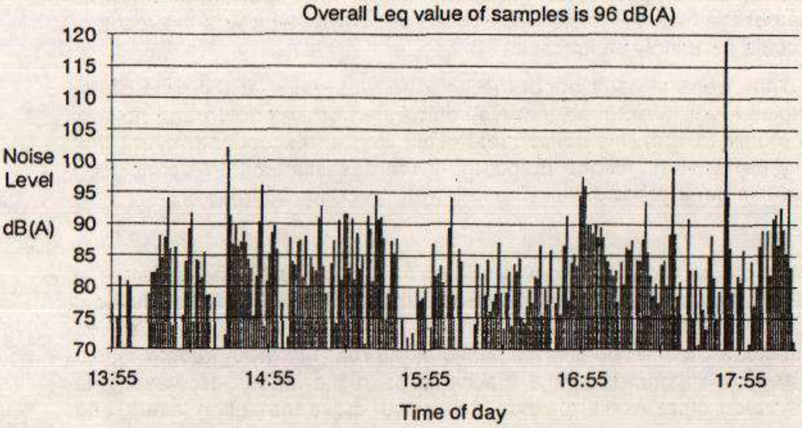
Example 1

The figure below shows the noise exposure pattern of an airport worker ("general hand") in terms of 1-minute L_{eq} levels for a period of over four hours.



The worker's job takes him to various places on the airport apron where he may be subjected to noise from auxiliary generators on aircraft and on the ground, from other equipment used in loading or transferring baggage or cargo, and from aircraft engines. During the period of our sample measurements, this worker was driving an electric vehicle towing baggage trolleys to and from aircraft.

The time exposure history shows that this particular worker was subjected to a wide range of noise levels - from less than 70 dB(A), probably when he was in the rest room, to nearly 120 dB(A). The peak level recorded by the instrument was 136 dB(A).

Bearing in mind the activities undertaken by this worker during the measurements, the results, with the exception of one of the 1-minute samples, were much as we would have expected. They were also in line with the exposures of other workers carrying out similar duties, whose exposures were generally between 84 and 89 dB(A). As these samples were representative of activities of general hands at this particular airport throughout their 8 hour shift, the figures could be taken to represent the daily personal noise exposures of this group of workers - ie above the first action level but below the second.

The overall L_{eq} of the general hand whose exposure samples are shown in the figure was 96 dB(A) - well above the others. On the face of it therefore, it would not be possible to say that the $L_{EP,d}$ of general hands was below the second action level, and the employer would have to act in accordance with the duties which are triggered by the higher level of exposure.

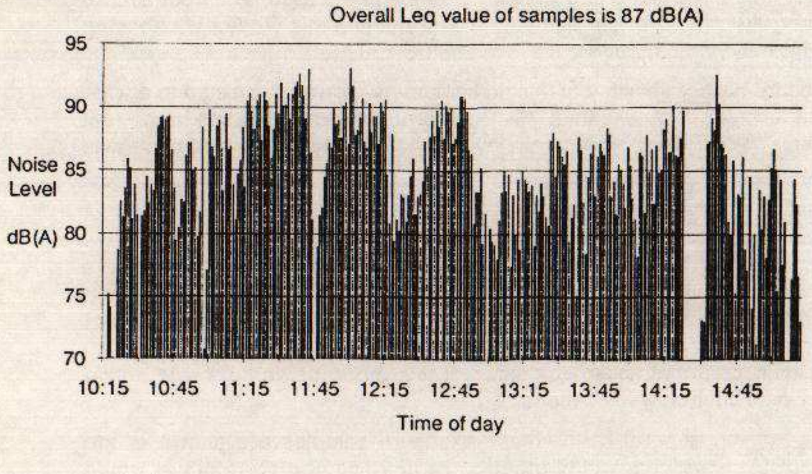
However, when the 1-minute value of nearly 120 dB(A) is excluded from the calculation, the $L_{EP,d}$ of this worker drops from 96 dB(A) to 87 dB(A) and is within the range of values obtained for other general hands. It was important therefore to determine whether the high 1-minute value was real, or whether it was the result of an event that could genuinely be ignored.

We questioned the general hand about the work he was doing at the time of the high sample noise level. We found that his vehicle had broken down and he was shouting very loudly to warn his colleagues. This was an exceptional event that could justifiably be ignored for the purposes of the assessment. We concluded that the $L_{EP,d}$ of this general hand was also below the second action level.

Example 2

The second example is taken from some work we have done on the assessment of noise exposures in bowling centres, as required by the Noise at Work Regulations. The workers of initial concern to our clients were the mechanics whose primary job is to repair and clean the pin spotting machines at the rear of bowling centres, and to clear pins and balls jammed in the machines or in the lanes. However, the assessment revealed other workers exposed to noise above the action levels, and our example concerns one of these workers.

The figure below shows the noise exposure pattern of a "customer care" employee working in a one of the bowling centres we surveyed.



Customer care staff were responsible for providing assistance to bowlers, for keeping the concourse clean, and for returning balls to racks at the rear of the concourse when no longer needed.

The exposure pattern clearly shows the time when this customer care employee left the concourse for a break at around 14:30 hours.

We were surprised to find the overall L_{eq} of the sample was 87 dB(A), because short term L_{eq} measurements taken with a sound level meter at positions occupied by bowlers showed that the noise levels at these positions were around 80 dB(A). Customer care staff worked at these same positions for some of the time, and at other positions where we knew they would have been subjected to even lower noise levels. The unexpectedly high values of sample L_{eq} were observed in the exposure patterns of other customer care workers and none could be explained by any exceptional events or other unusual or suspicious circumstances.

We undertook further investigation to identify the cause of the high exposures. One customer care worker was asked to perform her normal duties and we followed her with a sound level meter. This enabled us to obtain a good indication of the noise levels to which she was being subjected when carrying out her various duties.

The explanation became evident when we noticed the high impact noise produced by the process of balls (which were returned after use) being placed on the metallic rails of the storage racks. The peak readings were as high as 123 dB(A) and the fast response sound pressure levels reached 102 dB(A). This enabled us to propose simple noise control measures which reduced the exposure of customer care staff to below the first action level.

THE FUTURE

The likely future developments in the control of workplace noise lie in the Commission of the European Communities' draft proposals for a directive on physical agents [11]. The proposals on noise are expected to replace the existing noise directive and would require legislation to extend our current Noise at Work Regulations. The Commission's draft is not at all clear, but the main provisions appear to be:

(a) the introduction of five action levels based daily personal noise exposures (which would be renamed "$L_{EX,8h}$") ranging from 75 dB(A) to 105 dB(A);

(b) special rules which would apply to workers at "particular risk", ie

- Those with a disease or deformity of the ear or who use ototoxic substances; and
- The foetus. The draft proposal says that the exposure of pregnant women to noise above 85 dB(A) may affect the hearing of the foetus, and that for frequencies of 500 Hz and below the risk is increased.

The draft proposals have not been formally released but are being discussed with Member States with a view to publication in the Autumn of 1992. We hope to see substantial changes to these proposals before publication. It is worth noting here that the concept of L_{eq} is being retained.

In our experience occupational noise does not command a high enough priority, but since the launch of the Noise at Work Regulations there has been a noticeable increase in the efforts made to tackle noise problems [12]. It is important that the momentum gained is not lost and that future developments requiring action under the law are based on tenable scientific evidence of risk of hearing damage.

SUMMARY

The pioneer work of W Burns and D W Robinson was one of the most important contributions to scientific knowledge on the levels of noise, and the duration of exposure to them, which can cause hearing damage. It led to the Code of Practice, the Government's first "blueprint for action" in the prevention of loss of hearing due to noise at work, and to the use of L_{eq} as a means of quantifying noise exposure.

The Noise at Work Regulations were the natural development of the requirements in the Code but Regulation 4, which places a duty on employers to carry out assessments, has caused difficulties and has brought into question the competence of many of the persons carrying them out.

The importance of including information, other than noise level measurements, in a good assessment has been illustrated with examples of the kind of observations and questions that those attempting to quantify noise exposures should be asking.

The examples also demonstrate that the assessment of noise exposure should not be regarded simply as a matter of noting down the cumulative result of the samples, even if these were observed over an entire working day. Careful consideration of the findings is required in the light of other observations made during the course of the investigation.

The draft proposals for a directive on physical agents are the likely to form the next major step in the control of noise at places of work.

REFERENCES

1 W Burns and D W Robinson, Hearing and Noise in Industry, 1970, HMSO, SBN 11 760022 9.

2 Code of Practice for reducing the exposure of employed persons to Noise, 1978 (eighth impression), HMSO, ISBN 0 11 880340 9.

3 The Noise at Work Regulations 1989, (SI 1989 No 1790).

4 A R Dove, Health and Safety Executive, private communication, 1992.

5 Sound Sense, Health and Safety Executive leaflet, February 1991.

6 K Kyriakides and R N Galbraith, Essential Elements of Noise at Work Assessments, 1991, Report NAW 9102, Sandy Brown Associates, ISBN 1 8738 65 00 7.

7 Institute of Acoustics, Certificate of Competence in workplace noise assessment, Aims and objectives syllabus.

8 Method of Test for Estimating the risk of Hearing Handicap due to Noise Exposure, BS 5330 :1976.

9 D W Robinson, Tables for the estimation of hearing impairment due to otologically normal and typical unscreened populations of male and females, HSE contract research report 29/1991.

10 Council Directive on the protection of workers from the risks related to exposure to noise at work, 12 May 1986, (86/188/EEC).

11 CEC working document - Doc. 05/4578EN91L10 sw.

12 K Kyriakides, The Noise at Work Regulations - An opportunity not to be missed, 1990, Report NAW 9001, Sandy Brown Associates.