Noise levels in a clinical chemistry laboratory

P. D. GRIFFITHS, R. L. KELL, AND W. TAYLOR

From the Departments of Clinical Chemistry and Social and Occupational Medicine, University of Dundee

SYNOPSIS An investigation into the noise levels in a clinical chemistry laboratory has been carried out. It was shown that although the levels were insufficient to cause damage to hearing, they exceeded the criteria of acceptability for offices and workshops.

Most pathology laboratories are housed in old buildings which have been converted with varying degrees of success for purposes for which they were never originally intended. As the building programme for new hospitals slowly gathers momentum, more attention is being paid to the design of laboratories. Advances in technology and diagnostic procedures must profoundly influence the type and content of buildings in which the changing activities of the laboratories can most suitably be housed. Most of the problems arising were aired at a meeting in January 1969 at the Scottish Hospital Centre, Edinburgh, on 'Laboratory design: trends in user requirements', but apart from a comment 'there could be a significant loss of efficiency if workers were distracted by noise' during the course of discussion, scant attention appears to have been paid to this aspect of the laboratory environment.

The continually rising demand and the constant clash between the needs of accuracy on the one hand and the need to produce a mass of results as quickly as possible are stresses familiar to all pathologists, and clinical chemists in particular. The strain and fatigue of the technical staff, however, seemed to us to be greater than the degree of stress due to these causes.

It has also been apparent that the steadily increasing mechanization of clinical chemistry laboratories has been accompanied by a rising degree of noise. As there was a lack of objective data on the subject, following a preliminary investigation, it was decided to carry out a more detailed study on the noise levels in the section

of the clinical chemistry laboratory of the University of Dundee which was housed in the Royal Infirmary.

Procedure

The clinical chemistry laboratory is a relatively new structure divided into two areas and built on the roof of the pathology building. Most of the structure is timber framed and clad outside either with aluminium sheet or wood, and on the inside by various types of insulating board. The two areas, the older 'main' laboratory and 'newer' extension laboratory, are separated by a short open corridor. In a small room off the main laboratory, a small computer is housed. Ten members of the staff work in the main laboratory, seven in the extension, and one in the computer room.

MEASUREMENT OF NOISE LEVELS

This was approached by two methods: (1) by monitoring the overall laboratory noise level for the complete working day, and a paper chart record of the sound level, dB(A), with the time was obtained; (2) by making a tape recording of distinct noise sources for subsequent analysis in order to determine the octave band analysis (frequency content) of the noise.

For method (1) a Bruel and Kjaer (B. and K.) microphone, type 4131, was mounted near the head position of a laboratory worker, and the

Fig. 1 Octave band analyses of noise in main laboratory and computer room.

Fig. 2 Octave band analyses of noise in extension laboratory.

output fed into a B. and K. audio-frequency, type 2112, from which the amplified signal, filtered to give a sound level dB(A), was charted on a B. and K. pen recorder, type 2305.

The tape recording was undertaken with a Nagra IIIb recorder, the output signal being fed from a Bruel and Kjaer type 2203 sound level meter. This method enabled a level calibration signal from a B. and K. pistonphone sound source to be recorded on tape and thereafter all gain adjustments were made on the sound level meter. The tape recordings were subsequently analysed into octave bands with the B. and K. spectrometer and chart records were obtained by means of the pen recorder. The calibration tapes were used to set the gain of the complete analysis system.

The measurements were made in early December 1968.

INTERPRETATION OF NOISE LEVELS

Sound pressure levels are given in decibels (dB), which are a logarithmic unit of the ratio of measured sound pressure to a reference sound pressure of 0.0002 dynes/cm². Overall sound levels are given in dB(A). The 'A' indicates that the response of the sound level meter is modified to some extent to simulate the response of the human ear. The unit dB(A) is given as a single number to represent a noise level and avoids involved calculation.

The octave band analysis results have been converted to noise ratings (NR) numbers. The octave band levels in dB are shown graphically in Figures 1 and 2. The lowest curve, which is not crossed by connecting the plotted levels, gives its number to the noise as the noise rating number. Appropriate criteria for buildings have been proposed by Kosten and Van Os (1962), and the code of the International Standards Organisation has been based upon these noise rating numbers. For most industrial noises the NR value and dB(A) level are comparable; for a given noise the dB(A) level is usually 3 to 6 dB higher than the noise rating values.

Results

MAIN LABORATORY

The major sources of noise in this room are as follows:

Flame photometer (Technicon AutoAnalyzer, mark II)

The noise from this instrument dominates the room and the noise level depends upon the distance from the machine, but is 75 dB(A) (NR 72) 3 feet from the machine, and 71 dB(A) (NR 70) 6 feet from the machine.

Fume cupboard

The noise emitted is at a lower level than from the flame photometer, and is at 70 dB(A) (NR 66) at a distance of 4 feet.

Other noises

Other noises are more general in nature, consisting of voices, peak levels up to 75 dB(A), centrifuges (Griffin Christ UJ3, M.S.E. Minor, Hawksley microhaematocrit), stirrer motors, and other minor noises due to general laboratory work.

The time chart of noise level showed that between 9 am and 5 pm the noise level did not depart from the range 70-75 dB(A) (NR 67-72), with the exception of occasional peaks up to 80 dB(A), and that the major contribution to these noise levels was made by the flame photometer.

COMPUTER ROOM

An Elliott 903C computer with two Westrex teletype machines is situated in this room. The fans in the equipment give a noise level of 64 dB(A), and, when the punch tape reader is also running, the overall noise level rises to 74-76 dB(A) (NR 74-76).

EXTENSION LABORATORY

The noise environment in this laboratory is much more complicated than in either of the above rooms because there are a number of sources of noise, of approximately similar power, and which are used intermittently. These are the fume cupboard 71 dB(A), NR 69; centrifuges (M.S.E. Multex—floor mounted, and Pico Griffin Christ—bench mounted) together 69 dB(A), NR 67; laboratory washer (Heinicke, USA), 68-70 dB(A), NR 68; heating system, detectable subjectively, but not objectively when the laboratory washer is working; lift (the motor of the lift in the pathology block being housed on the original roof was incorporated into the structure of the additional buildings in which clinical chemistry is situated), not measurable objectively when other laboratory equipment is working; punch, a stamping punch used on request forms by a laboratory assistant was the loudest source of noise in the room, peak levels exceeding 75 dB(A).

The time charts of the noise level showed a basic ambient level in the laboratory of 50 to 55 dB(A) which existed for one-third of the time between 9 am and 7 pm. Superimposed upon this were the noises listed above, the loudest source controlling the peak level, ie, punch operation up to 75 to 80 dB(A), steam input to washer up to 85 dB(A), voice and footstep peaks, or glassware impacts up to 85 dB(A). Thus, for most of the time the level was in the range 60 to 70 dB(A) with isolated peaks (repeated in the case of the punch) of 75 to 80 dB(A).

Discussion

When considering the design of laboratories and laboratory equipment, potential noise levels are rarely taken into account. Possible reasons for this are difficulties in measurement and even greater difficulty in interpretation of results. An important step would be to define what levels of noise are acceptable in a laboratory. Criteria which may be used are of two types, namely objective criteria based upon physiological human performance data, and subjective criteria which are based upon 'acceptability' judgments.

OBJECTIVE CRITERIA

Hearing protection

The long-term exposure to high levels of noise eventually produces a permanent loss of hearing. The threshold level of noise which can give rise to this physiological damage to hearing is in the region of 85 to 90 dB(A) for a continuous exposure of eight hours/day, five days/week. Noise rating 85 is taken as an equivalent exposure and this level has been indicated in Figures 1 and 2. The 'damage risk criterion' (DRC) of Burns (1965), also shown, is more onerous, but it is not exceeded by any of the noise levels measured in either laboratory. It can thus be stated categorically that no damage to hearing can result from long-term exposure to any of the existing noise levels measured in the clinical chemistry laboratory at Dundee Royal Infirmary.

Speech/telephone criteria

The only other objective criteria, which can be used for areas such as laboratories, are those based upon intelligibility of speech and telephone usage. Three criteria are background noise, intelligibility of speech, and noise-rating curves for intelligibility on the telephone.

Background noise

The Wilson Committee Report on the Problem of Noise gives 55 dB(A) as the upper limit of background noise tolerable for a building in which communication by speech is of great importance, eg, offices, committee rooms, lecture rooms, educational institutions, and hospitals.

Speech intelligibility

Two sets of data for speech intelligibility are given in Tables I and II. Table I shows the distance at which normally loud speech is still intelligible in the presence of noise. The method of noise assessment is that of noise rating number and is due to Furrer (1964). When voices are raised, the distances should be doubled.

The method of Webster (1965) uses the concept of speech interference level (SIL) which is in this case the average sound pressure level, in decibels, of noise in octave bands centred at 500,

Noise Rating Curve Number	Distance at which Normally Loud Speech is Still Intelligible (ft)
40	27
45	16
50	8.5
55	4.7
60	2.8
65	1.6
70	0.8
75	0.5
80	0.3

Table I Use of noise-rating curves for speech intelligibility

Distance from Listener (ft)	Speech Interference Level (dB)			
	Normal Voice	Raised Voice	Very Loud Voice	Shouting
0.5	76	82	88	94
1	70	76	82	88
2	64	70	76	82
3	60	66	72	78
4	58	64	70	76
5	56	62	68	74
6	54	60	66	72
12	48	54	60	66

Table II Speech interference levels of noise just permitting conversation with marginal reliability at the distances and voice levels indicated

Site	Noise Rating ¹	Distance (ft) for Intelligibility			
		Normal Voice		Raised Voice	
		Webster	Furrer	Webster	Furrer
Main Laboratory	NR 67-72 SIL 66-69	1.25	0.7	2.5	1.4
Extension Laboratory	NR 58-68 SIL 57-66	1.5-4.5	1.3	3.9	2.6

Table III Comparison of measured noise levels and speech criteria

¹NR = noise rating number; SIL = speech interference level.

Noise Rating Curve Number	Quality of Telephone Conversation
50	Satisfactory
60	Slightly difficult
75	Difficult
>75	Unsatisfactory

Table IV Use of noise-rating curves for telephone conversation

1,000, and 2,000 Hz. Table II shows the levels of noise which just permit conversation with marginal reliability and is based upon the correct understanding of 75% of isolated phonetically balanced words.

Results from these two sets of criteria are presented in Table III for each laboratory area. There is some discrepancy in the conclusion given by each method, probably due to difference in meaning of 'still intelligible' and 'marginal

reliability', but it is quite clear that normal speech levels in the main laboratory will not permit the accurate transmission of words or data at the normal working distance between technicians.

Noise-rating curves for telephone conversation

These are shown in Table IV (Furrer, 1964). Telephones are present in both the main and extension laboratories. Their main use is for the transmission of urgently required results and dealing with enquiries on the conduct or interpretation of tests. Apart from the quieter periods in the extension laboratory, it is clear that communication is difficult and even hazardous. The noise interference is such that instructions or results may be incorrectly heard.

SUBJECTIVE CRITERIA

So-called 'acceptability' criteria for environmental noise have been proposed. These are based upon subjective judgments by a large number of people that the character and level of a noise is 'acceptable or unacceptable', 'annoying or not', etc, in a particular area. Judgments of this nature obviously depend upon many factors, some of which are difficult to evaluate, eg, whether or not the subject is engaged on a noisy operation, comparison with other areas, job, and economic status, etc. Laboratories have as yet not been included in any of the published acceptability criteria to date.

In a Building Research Station survey of office noise, quoted in the Wilson Committee Report on Noise, it was found that environmental noise levels of 80 dB(A) were regarded as noisy by machine operators, 75 dB(A) regarded as noisy by punch operators, and 70 dB(A) regarded as noisy by clerical workers. Kosten and Van Os (1962), working upon the evaluation of the International Standards Organization Noise Rating System for Acceptability, give the following criteria:

Private offices	NR 40
Office (typewriters)	NR 55 (range 50-60)
Workshops	NR 65 (range 60-70)

It is apparent from the above data that tolerance plays a part in an individual's reaction to noise. On this basis, it might be considered that the laboratory worker will have grown accustomed to levels of noise that others would find unacceptable, so that the laboratory might be equated with the workshop. If this standard is adopted, then in these laboratories the acceptability criteria are exceeded and the staff could be expected to find the background noise level annoying. Thus, another stress is added, and this must be considered as a factor contributing to the fatigue mentioned earlier.

In the light of these findings, it would seem justified to take steps to combat the noise problem. The first and most important must lie in the

design and layout of the laboratory areas. Where noisy equipment must be used, it should where practicable be housed in rooms which can be shut off from the main working areas. Consideration should be given also to incorporating noise-absorbing materials in the construction of walls and ceilings. Improvement in the design of noisy equipment must also be considered, and since this is most advantageously carried out by the manufacturer, representations should be made in that quarter. It is perhaps worth noting that attention has been drawn to closer liaison between hospital scientists and manufacturers in the Zuckerman Report on Hospital Scientific and Technical Services (1968).

With regard to noise reduction measures for existing equipment, an asbestos baffle, placed round the flame photometer (it would have to be easy to remove), could be designed. Fortunately, the manufacturer has noted objections to the noise produced by this instrument, and the later designs are said to be quieter. The fume cupboard noise is almost certainly a matter of bad design, and by adjusting vent sizes and flow rates, it is possible that noise emission could be reduced. Theoretically, centrifuges could be placed within noise-insulating boxes without interfering with accessibility to the chamber and the controls. Computer noise is now beginning to be considered seriously by manufacturers, but at the present time it is difficult to see what can be done to improve existing installations. The glass-ware washer appears to present an intractable problem.

Conclusions

This investigation has demonstrated that in one clinical chemistry department noise levels are becoming an increasing problem. Fortunately, they are insufficient to cause damage to hearing, but the levels exceed those acceptable in offices and workshops. At present no noise acceptability criteria have been laid down for laboratories, and this is a matter requiring attention. It is suggested that there is urgent need for consideration of the noise problem by both laboratory architects and laboratory equipment designers.

References

- Burns, W. (1965). Noise as an environmental factor in industry. *Trans. Ass. Industr. med. offrs*, 15, 2-11.
- Furrer, W. (1964). *Room and Building Acoustics and Noise Abatement*, p. 43. Butterworths, London.
- Kosten, C. W., and Van Os, G. J. (1962). In *The control of noise*. (National Physical Laboratory Symposia, No. 12.) H.M.S.O., London.
- Scottish Hospital Centre Report (1969). *Laboratory Design: Trends in User Requirements*. January, 1969.
- Webster, J. C. (1965). Speech communications as limited by ambient noise. *J. Acoust. Soc. Amer.*, 37, 692-699.
- Wilson, A. (1963). *Final Report, Committee on the Problem of Noise*. (Cmd. 2056.) H.M.S.O., London.
- Zuckerman, S. (1968). *Hospital Scientific and Technical Services. Report of the Committee, 1967-1968*. H.M.S.O., London.