Proceedings of The Institute of Acoustics

IMPLICATIONS OF AN AUDIBILITY CRITERION FOR ASSESSING NOISE BETWEEN DWELLINGS

W A Utley(1), Jeannette Brooks and K Attenborough(2)

(1) Building Research Establishment, England, UK
(2) Open University

INTRODUCTION

The numbers of complaints about noise from domestic premises has increased considerably in recent years. Research undertaken by the Building Research Establishment has provided information about the relative importance of various sources and details about the sources themselves(1). However, information about the criteria used by Environmental Health Officers to assess nuisance is not generally available. The evidence from the BRE study indicates that measured noise levels generally play no part in their assessment of domestic noise.

Audibility has been proposed as a criterion for assessing disturbance caused by amplified music(2). The criterion has been used by Edinburgh District Council to control noise from licensed premises such as clubs and discos. This paper examines the implications of using such a criterion for assessing whether the noise transmitted from one dwelling to another is a significant disturbance.

To do this it is necessary to establish what levels of noise might occur inside a dwelling under 'normal' usage and then to determine the levels transmitted to an adjoining dwelling. The next stage is to establish what noise level could be considered audible, taking into account factors such as internal ambient noise. Finally the transmitted levels can then be assessed to give an indication of audibility. This type of procedure might also be used to derive standards for sound insulation but has been used only rarely(3). Standards for party wall and floor insulation have usually been established by using surveys of residents' attitudes to different levels of insulation.

Measurements of television listening levels and internal ambient noise levels in dwellings have been obtained by Open University students undertaking Course T234 'Environmental Control and Public Health'(4). These student data have been supplemented by measured levels for a variety of sources including domestic appliances and by analyses of noise spectra. Details of sound insulation performance have been obtained from the BRE data bank of measurements in dwellings.

SOURCE LEVELS AND SPECTRA

Listening levels for 297 Open University students when watching television news broadcasts are shown in Figure 1. The levels are values of L_{Aeq} obtained over ten minute periods but excluding commercial breaks. The mean level is 56 dB(A) and the standard deviation is 7 dB(A). An analysis of the spectrum for this source showed that there was little acoustic energy below 200 Hz and a fall off after 1.6 kHz. The A-weighted spectrum was quite level between these frequencies. A limited investigation of the relationship between sound levels from news broadcasts and from other television programmes was carried out. This indicated that for the same setting of the volume control values of L_{Aeq} could be 3-5 dB higher for other outputs.

Although there are relatively few complaints about noise from domestic appliances, some of these appliances can produce quite high noise levels and their audibility in adjoining dwellings needs to be considered. The measured noise from a vacuum cleaner, a hair dryer, a food mixer and a liquidiser have been analysed to determine levels and one-third octave band spectra. The A-weighted noise levels were rather similar varying from 72 dB for the vacuum cleaner to 77 dB for the two kitchen appliances. The spectra, however, showed some marked differences. The two kitchen appliances emitted most acoustic energy at high frequencies and there was some evidence of tonal components in the 160 Hz, 400 Hz and 1.6 Hz bands for one and in the 250 Hz, 500 Hz and 2 kHz bands for the other. The vacuum cleaner had a very broad band spectrum covering the whole range of frequencies which were considered (100-3150 Hz) but with little energy below 100 Hz. The hair dryer was predominantly a high frequency source with the highest levels between 1.25 kHz and 5 kHz.

The voices of people and children give rise to much fewer complaints than amplified music but there is evidence that vocal sounds may bother just as many people. The level of vocal sounds varies quite considerably and certain assumptions have to be made in deciding what constitutes a 'normal' level. A quiet conversation might only produce a level of 55 dB L_{Aeq} while a heated argument could result in a level of 75 dB L_{Aeq} . Children produce even wider variations and are well capable of producing levels of 90 dB L_{Aeq} and more over short periods. Speech spectra vary depending on the vocal effort involved. When A-weighted spectra are considered the highest one-third octave band levels occur from 200-1.25 kHz for normal voice and 400-2.5 kHz for loud voice.

There are no published data about amplified music, either in regard to typical listening levels or on spectra in living rooms. Some limited data have been obtained but these reflect the personal preference of one of the authors and it is not claimed that the levels quoted are in any way typical of levels found in British homes. It may be worth noting that the mean listening levels LAeq for users of personal cassette players (PCP) is 85 dB(5). Clearly if PCP users wish to emulate this level when listening to hi-fi equipment at home then the levels of amplified music quoted here will seriously under-estimate the audibility of this source in those situations. For classical music (Elgar - Symphony No. 1) the maximum of the A-weighted spectrum was between 250 Hz and 2 kHz. The pop record which was analysed had its acoustic energy spread over a wide range, from 125 Hz to 2.5 kHz.

NOISE REDUCTION

In order to determine the noise level in an adjoining dwelling it is necessary to assume a particular value of sound insulation for the party wall. Two sound insulation curves have been used in this paper to calculate received levels. The first is the insulation curve proposed in the Building Regulations, ie $D_{n,T}$ = 52 dB as specified in British Standard

BS5821. The second is an insulation curve for a cavity masonry wall with a poor performance and is derived from the measured performance of plastered walls of lightweight aggregate blockwork(6). The actual one-third octave band levels used correspond to the mean - 1.64 standard deviations at each frequency. Taken over all frequencies the performance corresponds approximately to the 95% level for party walls measured by BRE in the early 1970s(7), ie only about 5% of walls had a lower performance. An example of the performance curve for a poor party floor construction has not been used since the BRE field survey showed that the performance of walls and floors overall were somewhat similar.

After the two insulation curves have been used to derive one-third octave band levels for an adjoining dwelling the A-weighted levels have been calculated. Temporal variations have been taken into account by giving in all cases the value of L_{Aeq} and for those sources which vary considerably with time the level exceeded for 5% of the time L_{A05}. The results of the calculations are shown in Table 1.

AUDIBILITY

A number of factors need to be taken into account in making a judgment whether a particular noise would be audible in an adjoining dwelling under normal conditions. These are the source levels which could be considered normal, the level of ambient noise and the minimum level which is audible (threshold). The first factor has to be considered in the context of noise nuisance since for some sources it will always be possible to increase the level such that the audibility criterion is exceeded. The question then is whether such a source level can be considered normal or excessive. This question can best be answered by obtaining data similar to that given in Figure 1 for TV News Broadcasts.

TABLE 1: Levels of noise produced by sources in an adjoining dwelling

		Received noise level			
		Good insulation		Poor insulation	
Source	Source Level L_{Aeq}	L_{Aeq}	L_{A05}	L_{Aeq}	L_{A05}
TV News (mean)	56	3	8	14	19
TV News (95%)	68	15	19	26	30
Food mixer	77	24	-	31	-
Liquidiser	77	21	-	25	-
Vacuum cleaner	72	27	-	35	-
Hair dryer	75	17	-	20	-
Voice (normal)	57	6	11	15	20
Voice (loud)	74	21	-	28	-
Music (pop)	53	7	11	15	19
Music (classical)	56	6	11	14	19

The Open University students have also measured levels of ambient noise inside their homes and the distribution is shown in Figure 2. The measurements were made when the room was free of any sound sources. The level determined was L_{Aeq} but in most cases the temporal variation would be very small. The meter used could only measure noise levels down to 30 dB(A) and 24% of students had ambient noise at or below this level.

The threshold at which a sound becomes inaudible varies for different people. It is likely that in the domestic situation for those with normal hearing the noise will become inaudible because of masking by ambient noise before the individual's threshold of audibility is reached. Caution is required in the use of A-weighted levels for assessing audibility. When the spectrum of the received sound is similar to that of the ambient noise the sound will probably be inaudible at a level just below the ambient level. However, when the received sound has a spectrum which is markedly different from ambient the sound may be audible even 10 dB(A) or more below ambient. This is particularly so for sounds which are concentrated over a narrow frequency range such as the individual notes of a musical instrument.

After taking into account the factors considered above, it has been assumed that the dividing line between audibility and inaudibility should be 25 dB(A). Only in a very few cases would noise below that level be likely to be audible.

The levels given in Table 1 show that an audibility criterion if applied at all to noise between dwellings could only be applied to certain sources. It is clear that certain domestic appliances will be audible in some situations and yet this must be considered acceptable particularly in view of the low level of disturbance caused. The situation is clearly complicated by the fact that some dwellings have rather poor insulation. Thus for some sources the fact that noise is audible next door may be due to poor sound insulation rather than excessively high source noise levels. If an audibility criterion were to be used it would have to be applied to the average noise level. The application of the criterion to noise peaks would result in the criterion being exceeded in too many situations where the source level did not exceed what would be considered a normal and acceptable level in dwellings.

CONCLUSIONS

This analysis has shown that a single criterion of audibility is not likely to prove satisfactory for assessing the problem of inter-dwelling noise nuisance. This is because some 'normal' noise such as that from certain types of domestic appliance can be expected to be audible in an adjoining dwelling. Other noises such as television sound and voices would generally not be audible at 'normal' levels but the occasional peak of television sound or raised voices might be audible particularly where the party wall insulation is poor. It is not clear that such occasional audibility could be considered to constitute a nuisance. In view of the large number of complaints about amplified music it would be useful if an audibility criterion could be used for such a noise source. Unfortunately, the lack of data about 'normal' source levels means that the situation is currently less clear than for other sources. There is a distinct possibility that whether or not music is generally audible at 'normal' levels may depend critically on the insulation provided by the party wall.

REFERENCES

(1) W A Utley and I B Buller, 1988. A study of complaints about noise from domestic premises. Journal of Sound and Vibration 127(2), pp 319-330.

(2) J R Stirling and R J M Craik, 1986. Amplified music as a noise nuisance. Proceedings of the Institue of Acoustics, 8, pp 13-18.

(3) J van Den Eijk, 1966. The new Dutch Code on Noise control and sound insulation in dwellings and its background. Journal of Sound and Vibration, 3 (1), pp 7-19.

(4) Jeanette Brooks, K A Attenborough and W A Utley, 1988. Student-based surveys of noise levels around and inside dwellings in the UK. To be published.

(5) C G Rice, M Breslin and R G Roper, 1987. Sound levels from personal cassette players. British Journal of Audiology, 21, pp 273-278.

(6) E C Sewell, R S Alphey, J E Savage and S J Flynn, 1980. Field measurements of the sound insulation of plastered cavity masonry walls. Building Research Establishment Current Paper 4/80.

(7) E C Sewell and W E Scholes, 1978. Sound insulation performance between dwellings built in the early 1970s. Building Research Establishment Current Paper 20/78.

AUDIBILITY CRITERION FOR ASSESSING NOISE BETWEEN DWELLINGS

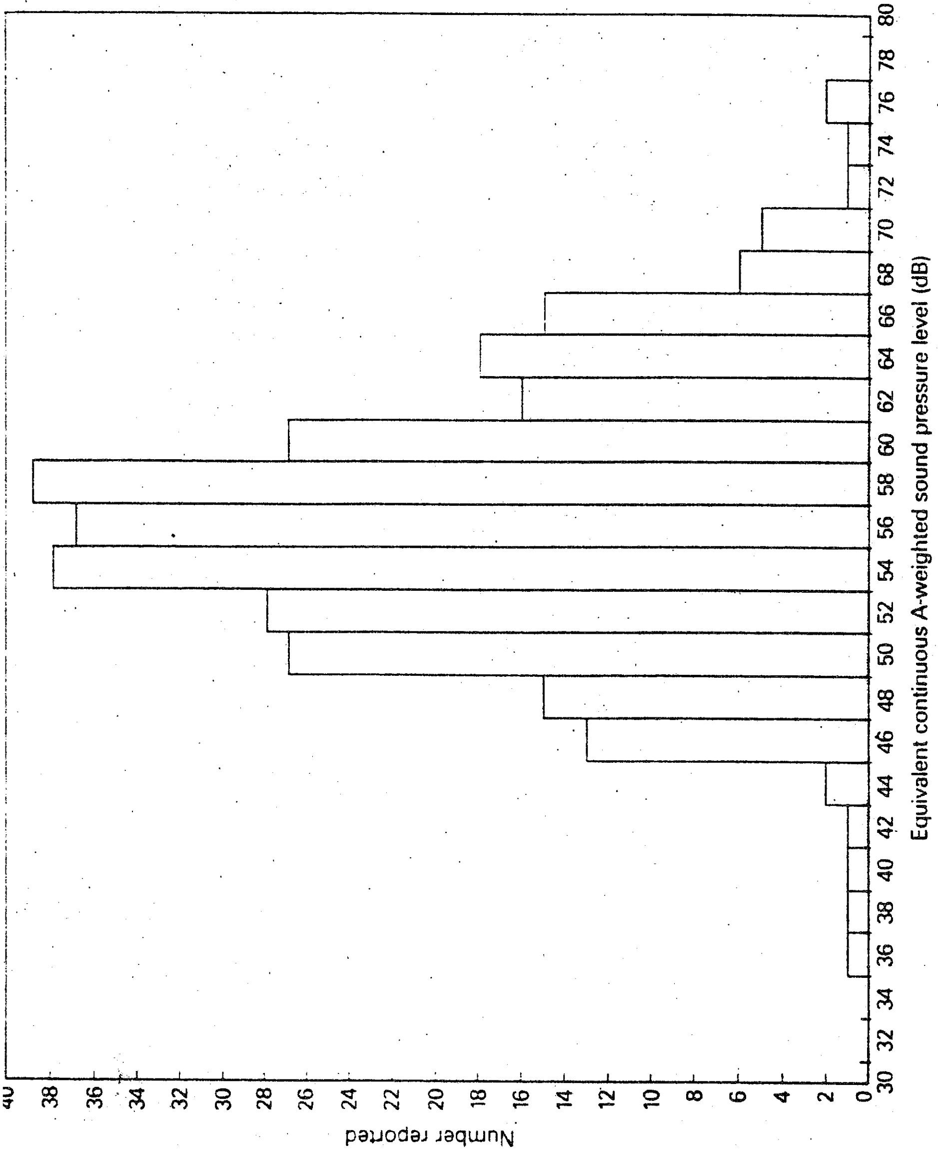

Figure 1 Television listening levels as reported by students (n= 297)

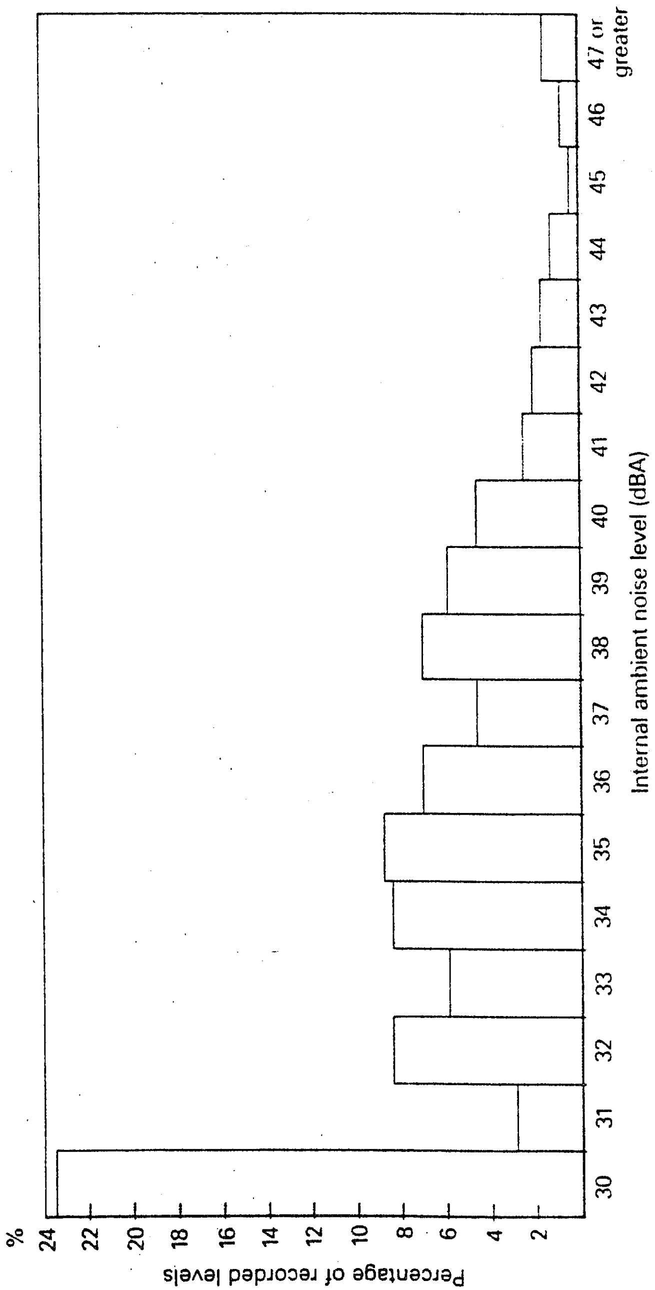

Figure 2 Internal ambient noise levels recorded by students (n = 238)