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'APPLIANCE NOISE'

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PROBLEMS OF MEASURING AND ASSESSING ELECTRICAL APPLIANCE NOISE

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The Electricity Council, through its appliance sales in Area Board showrooms, has a responsibility to the consumer for the quality of these appliances. For many years the safety aspect has been covered by testing to the relevant British Standards at the Appliance Testing Laboratories at Leatherhead. Since 1969 the practical performance of appliances has been assessed to an increasing degree, and one aspect of this performance is the annoyance level and fatigue resulting from noise emitted by the appliance.

As more and more appliances are now being used in the home, it is vital that the overall level of noise should be kept to a minimum.

Interest in this problem is also apparent in the international field; for example the IEC TC/59, which is responsible for preparing recommendations for standard methods of measuring the performance of appliances, is considering methods of assessing and expressing noise level as part of its work.

Most published information is on noise levels greater than 85 dB(A) i.e. aircraft, factories, etc. In the main however, appliance noise is in the range 50 - 85 dB(A), while some appliances have levels down to 25 dB(A). To obtain useful measurements down to this figure it is necessary to ensure an ambient noise level of less than 20 dB(A). We have obtained this by using an isolated anechoic room which has a measured level, including that generated within the instrumentation, of less than 18 dB(A) over the range 125 Hz to 40 KHz.

One problem of measurement at low levels is caused by changes in the noise generated within the instrumentation, and frequent calibration checking is required. Improved stability has been obtained by leaving the equipment, particularly the microphones, energized continuously throughout the year.

We have adopted a microphone to appliance distance of 1.0 metre, as recommended in ISO/R 495 and BS 4196, except for large appliances, where a distance of 0.3 metres is used. For this distance, 10 dB is subtracted from the readings to relate them to 1.0 metre.

The sound power of an appliance is calculated from $^1/3$ octave analysis from each of 13 microphone positions. Additionally, whole octave analysis is carried out in certain microphone positions to evaluate the 'N' rating.

As many electrical appliances are transportable and may be used in many different locations within the dwelling, simulation of the user environment is not readily obtained. We feel that use of an anechoic room, together with some factors, possibly along the lines proposed by Kosten and Van Os, are likely to provide the most satisfactory results.

Appliance noise can have strongly directional characteristics or have a uniform field. Fan heaters cause considerable air movement and the use of a microphone windscreen is required. The noise level of washing machines and spin dryers can change, dependent on the work load at the time of testing, and supplies of hot and cold water at various pressures, together with drain facilities are desirable. It would, however, be difficult to prevent external noise entering the room via these services. Thus certain limitations of testing conditions are imposed.

Many appliances have multi-programme facilities, such as combinations of heat and motor speed, changes in cycle time, etc., and measurements have to be made in each condition. The duty cycle of a washing machine or refrigerator can change within a programme, and irregular transient noises may occur. Other intermittent noises, unexpected by the user, can result in a reflex action which may be a hazard to safety. The noise level of appliances can change over long periods of use. The location and measurement of suitable examples has not, so far, been found to be easy.

From measurements taken to date, the following table shows typical noise levels.

Table 1

Appliance	Sample		dB(A)
Fan heater	1		52
" "	2		45
Food Mixer	1		75
" "	2		63
" "	3	(battery)	59
" "	4	"	45
Vacuum cleaner	1		93
" "	2		63
Refrigerator	1		40
"	2		20

(Typical spectrums will also be illustrated)

To evaluate an objective noise rating, use is made of the N rating curve (from Kosten and Van Os) widely published by B & K. For this purpose, the whole octave spectrum is recorded at various microphone positions. It has been found that for many appliances, the N rating number and d B(A) values are very similar, but in certain instances the figures have differed.

Typical values of N rating are shown in the following table.

Table 2

Appliance	Sample		N.rating at octave band (Hz)	
Fan heater	1		47	500
" "	2		44	500
Food mixer	1		77	2 K
" "	2		62	4 K
" "	3	(battery)	60	4 K
" "	4	"	45	1 K
Vacuum cleaner	1		95	2 K
" "	2		69	2 K
Refrigerator	1		37	500
"	2		30	500

For a subjective assessment, a small panel of laboratory staff, of various ages and both sexes, are invited to listen to appliances under test in the anechoic room. They are asked to report their opinion of the noise level as "noisy" "normal" or "quiet". It is appreciated that the panel is very small and that the results are conditioned by

(a) the degree of noise expected by the listener from the particular type of appliance related to the room in which it would normally be used.

(b) the conditions prevailing on the listener prior to the test taking place.

(c) the change of panel members inevitable over an extended period.

(d) the use of only three classes for the assessment.

(A table of typical results will be included).

The degree of annoyance experienced by a person seems to be dependent to some extent on whether the person is actually using the appliance. For the user, a high level (60 - 80 dB(A)) seems acceptable, e.g. hair dryer, vacuum cleaner, spin dryer. For the non user, however, a similar level is found objectionable and even comparatively low levels (30 - 50 dB(A)) can be considered annoying.

Kosten and Van Os, in their paper, suggest that noises of short duration can be of a higher level for the same rating. With certain types of intermittent noise however, the reverse conditions can apply. Problems have arisen with the intermittent switching cycle of refrigerators for example.

Whilst damage to hearing is very unlikely to be caused by any domestic electrical appliance and, in fact, some noise emission from an appliance, particularly motor driven, may be an advantage to warn a person that the equipment is in operation, an unwanted level can cause fatigue and annoyance. The problems of measuring and assessing appliance noise outlined above show that there is no simple method which can be adopted. However, providing that both manufacturers and users are constantly aware of these problems and the need to keep noise to a minimum, we feel that the situation will not get out of hand. By measuring and recording the levels and including the results in our reports to the manufacturers concerned, we are co operating with them to improve the environment of the domestic appliance user.

References

(1) KOSTEN C.W. and Van Os G.J.
Community Reaction Criteria of External Noises,
Proc. Conf. Control of Noise, HMSO London 1962.

(2) BRUEL and KJAER.
Acoustic Noise Measurements.

Directivity, too, is affected by the presence of a sound absorbing base, especially for a downward directional source. Figure 1 shows the directivity in two cross sections and two octave bands for vacuum cleaners. In the 250 Hz octave band the carpet has little effect whilst in the 4kHz band, where the carpet is more absorbing, radiation near the floor is considerably reduced. Build up in pressure at a reflecting plane causes an increase in directivity at floor level. This is also shown in Figure 2, giving the directivity of a spin drier on reflecting floor.

Directivity factors of over 6 have been measured for a vacuum cleaner with a very pronounced pure tone component. The shape of the directivity pattern obviously depends on the positions of the various noise sources within the appliance, as well as on its dimensions. Appliances blowing out air in a particular direction generally have pronounced lobes in that direction, especially in high frequency bands. A circular extractor fan, for instance, may have dipole-type directivity pattern with lobes pointing axially out from its centre, front and back. In this particular case the presence of the baffle in which the fan would normally be fixed would have little effect on the directivity pattern. The directional characteristics of an electric fan heater are shown in Fig. 3.

Table 2 summarises power and directivity measurements on a range of electrical appliances.

TABLE 2. ACOUSTIC POWER (μW) AND MAXIMUM DIRECTIVITY FACTOR(Q)

APPLIANCE			Octave Band Hz	125	250	500	1k	2k	4k	8k	Total Power
FAN HEATER	A	Fan Only	μW	0.061	0.023	0.090	0.018	0.006	0.003	0.002	0.20
			Q	6.7	2.0	2.0	2.8	4.0	3.3	4.8	
		Max Heat	μW	0.082	0.056	0.17	0.024	0.007	0.002	0.001	0.34
			Q	2.5	2.3	2.4	2.8	5.3	3.3	3.3	
	B	Fan Only	μW	0.11	0.014	0.17	0.028	0.020	0.010	0.006	0.26
			Q	4.8	3.3	4.4	2.9	3.6	4.1	4.7	
		Max Heat	μW	0.025	0.12	0.26	0.06	0.07	0.018	0.006	0.59
			Q	2.3	1.7	2.0	3.8	3.7	2.8	6.6	
SPIN DRIER	C		μW	140	37	19	9.3	2.8	3.3	0.60	210
			Q	1.7	2.0	3.9	2.5	2.6	1.8	1.9	
ELECTRIC RAZOR	D		μW	0.16	0.66	2.2	1.9	2.5	4.2	3.3	15
			Q	6.4	2.5	3.0	6.2	3.3	2.8	3.2	
	E		μW	0.078	0.055	0.039	0.20	0.86	2.4	2.7	6.3
			Q	2.4	4.2	1.5	1.9	1.7	2.7	2.1	
EXTRACTOR FAN	F		μW	0.042	0.090	0.25	0.12	0.078	0.021	0.004	0.61
			Q	2.8	2.6	2.3	2.0	1.7	2.0	2.0	
	G		μW	0.095	0.11	0.75	0.46	0.17	0.024	0.003	1.6
			Q	4.9	4.1	4.9	4.0	3.4	3.0	5.3	
VACUUM CLEANER	H		μW	6.5	400	25	14	5.0	1.7	0.56	450
			Q	4.0	4.6	3.0	6.1	4.7	4.9	4.7	
	I		μW	28	250	120	66	34	21	5.7	530
			Q	2.1	2.7	3.5	3.5	3.8	4.4	5.1	
	J		μW	1.1	14	59	34	44	27	5.7	185
			Q	2.2	1.8	2.5	3.0	4.0	5.4	5.2	
	K		μW	6.5	11	13	23	5.8	1.8	0.15	61
			Q	2.3	3.9	2.9	4.0	3.6	6.3	3.8	