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ANNOYANCE OF INFRASOUND

Jente Andresen and Henrik Møller

Institute of Electronic System,
Aalborg University,
Strandvejen 19, DK-9000 Aalborg, Denmark

INTRODUCTION

Infrasound at intensity levels that may cause annoyance is quite common in our daily surroundings, but though a few countries have introduced measurement procedures and hygienic limits, there is a deplorable lack of experimental facts on which to base these. Equal loudness curves have already been described for infrasound [1, 2]. However, weighting curves and environmental requirements ought not to be based exclusively on these; other factors should also be considered. The aim of this project is to contribute to the establishment of equal annoyance contours in the frequency range: 4 - 31.5 Hz.

METHOD

Subjects

Eighteen engineering students participated (17 men and 3 women; age range: 18-25). All were paid volunteers and had earlier participated in a project to establish equal loudness curves in the infrasound range. An audiometric test ensured normal hearing.

Sound conditions

The following 18 sound exposure conditions were used: 4 Hz at 120 and 124 dB; 8 Hz at 109, 114, 119, and 124 dB; 16 Hz at 95, 102, 109, and 116 dB; 1 kHz octave filtered pink noise at 20, 40, 60, and 80 dB.

Apparatus

The experiments were performed in a 16 cubic metre pressure chamber that was furnished as a doctor's waiting room. The infrasound was emitted via 16 electrodynamic loudspeakers driven by a B & K 2712 power amplifier. The 1 kHz noise was emitted via an equalized Hi-Fi sound reproduction system with the loudspeaker placed 140 cm from the subject. The experiment was controlled by an HP 21MX computer.

Experimental design
The experimental design was an 18 x 18 balanced latin square, which ensured that each treatment followed each other treatment only once. Each subject was exposed to one treatment a day for 18 days at the same hour.

Procedure
During the experimental session the subject was seated alone in an easychair in the experimental room. Communication with the subject took place via an intercom. The subject was supplied with two newspapers and was instructed to read during the next 20 minutes. The sound exposure began after 5 minutes silence and was continued for 15 minutes. After a delay of 15 seconds the subject indicated on a scale: 1) degree of annoyance experienced during exposure, 2) degree of annoyance that he would probably feel, if his neighbour produced the same type of sound for two hours. The scale was a 150 mm long horizontal line, the ends of which were labelled respectively "not at all annoying" and "very annoying". One minute after the sound exposure the subject was asked to adjust the sound of a 1 kHz octave filtered pink noise so that it was heard as annoying as the sound heard while reading.

RESULTS

As the experiment is still in progress and not all data are in, equal annoyance contours have not yet been worked out.
Degree of annoyance was registrated in mm. For each stimulus means and standard deviations for perceived annoyance during exposure have been calculated and are shown together with number of observations in table 1.
Curves indicating the relationship between annoyance and sound pressure level for each of the five frequencies are shown in figure 1. A point on a curve represents mean degree annoyance for a given frequency at a given sound pressure level. The curves are based on estimated mean values (ANOVA Multiple Classification Analysis) and as more than 90% of the values are included the remaining data will hardly change the general chape of the curves.
The curves show that with decreasing frequency a higher sound pressure is needed to provoke the same amount of annoyance.
Compared with the curve for 1 kHz noise, the curves for the infrasonic frequencies generally have a much steeper slope. This change in slope is already seen at 31.5 Hz, and becomes even more pronounced with decreasing frequency. Thus in the infrasound region relatively small changes in sound pressure may cause large changes in annoyance. From an environmental point of view this is important because a few dB's difference in sound pressure level can make all the difference to the acoustic environment.
It also shows that accuracy is crucial when measuring infrasound, and that specific demands must be made on the measuring equipment.

Table 1. Results from annoyance question 1.

Frequency (Hz)	SPL (dB)	Mean (mm)	SD (mm)	N
1000	20	7	8	16
	40	25	22	15
	60	54	36	18
	80	114	32	18
31.5	75	20	23	15
	84	40	39	17
	93	64	37	15
	102	98	38	16
16	95	22	29	17
	102	56	47	18
	109	80	38	18
	116	112	33	18
8	109	37	34	16
	114	61	41	18
	119	92	37	15
	124	104	40	16
4	120	24	30	15
	124	68	43	18

PROJECTED EXPERIMENTS

Because so little is known about annoyance caused by infrasound this study has been very limited in scope i.e. only pure tones have been used as stimuli and only young students as subjects. To extend the validity of the reported results it will be necessary to test older age groups and other occupational. We also plan to study the effect of infrasound on performance tasks, and as infrasound outside the laboratory is normally mixed with higher frequencies we wish to test to various combinations of infrasound and audiosound.

REFERENCES

[1] S.J. Collins, D.W. Robinson and L.D. Whittle, "The audibility of low frequency sound", J. of Sound and Vibration, Vol. 21, no. 4, 431-448, (1972).

[2] H. Møller and J. Andresen, "Loudness of infrasound", Proceedings of Internoise 83.

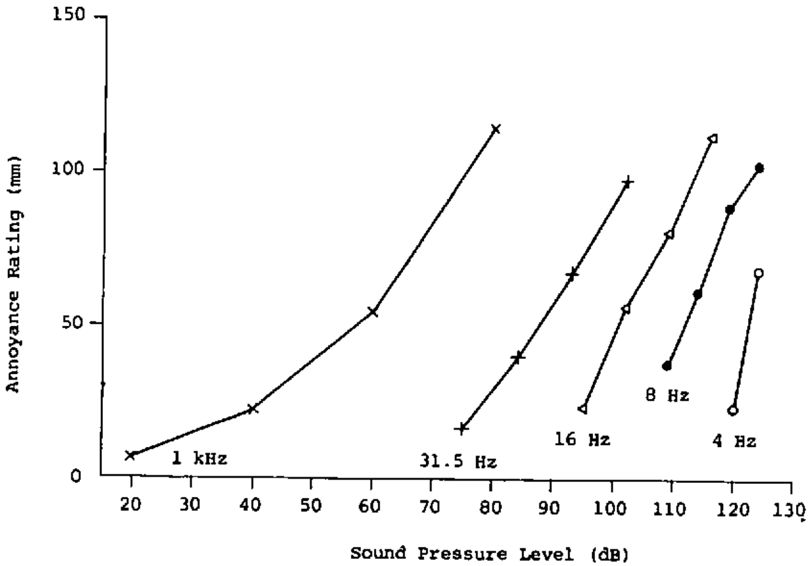

Figure 1. Relationship between sound pressure level and annoyance at five frequencies.