研　究　速　報
特　集　3
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Perception of the Vehicle Pass-by Noise on Different Road Surfaces

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1. INTRODUCTION

It has been shown [4], that different types of road surface may influence the traffic noise by up to 11 dB(A). It is also known that low noise road surface is a result of the high acoustic absorption provided by the surfaces with good drainage properties [1]. In this study two road surfaces (with different drainage properties [2]) and one normal road surface (asphalt concrete pavement) were tested with single vehicle noise sources. Noise produced by two vehicles (passenger car and heavy vehicle) running at speed 50 and 80 km/h was recorded outside and inside the vehicle. Three types of analysis were performed: objective noise measurements, psychoacoustics quantities measurements, subjective preference test. The aim of the research reported in this paper was to determine whether, the choice of the low-level road surface based on the objective noise measurements is in agreement with the choice based on psychoacoustic quantities and how it correlates with the subjects' judgements.

2. NOISE MEASUREMENT ON THREE DIFFERENT ROAD SURFACES

Measurements of noise from passing vehicles were made in a way described in the international standard ISO 362: 1994(E). Description of the tested surfaces is presented in Table 1. For the outside noise, the sound exposure level (SEL), and maximum sound level with the time constant "F", LAmax, F, of the vehicle pass-by noise on three different asphalt road surfaces was measured. For inside noise, equivalent continuous A-weighted sound pressure level, LAeq, was measured. In Figure 1 sound exposure level in 1/3 octave bands are plotted for three surfaces and two

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Table 1. Description of the tested surfaces

Surface	Maximum grain size of aggregate	Percentage of void	Pavement depth
Asphalt pavement (I), as(I)	10 mm	20%	5 cm
Asphalt pavement (III), as(III)	20 mm	20%	5 cm
Asphalt concrete pavement, acp	13 mm	5%	5 cm

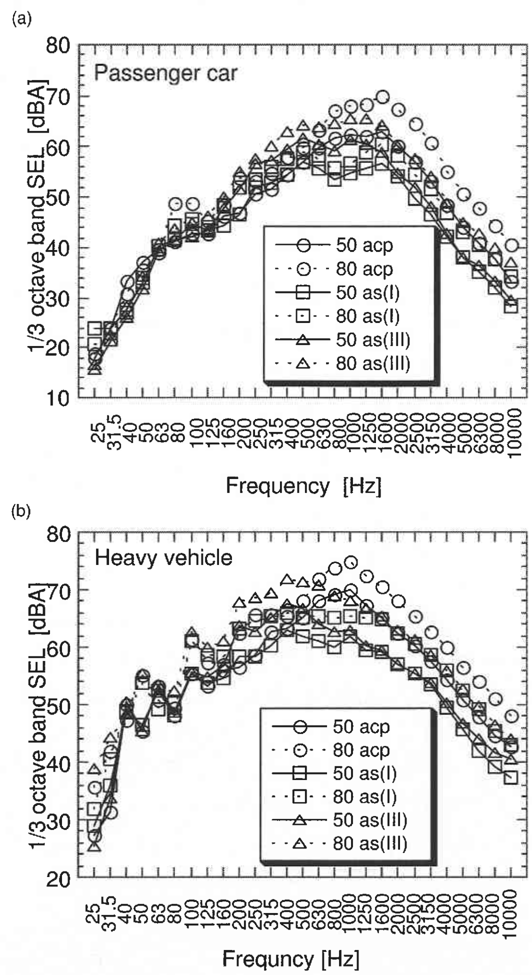


Figure 1. 1/3 octave band SEL (a) for a passenger car, (b) for a heavy vehicle.

speeds.

3. PSYCHOACOUSTIC QUANTITIES OF NOISE

With the help of Akustik Workstation, CF85, pscychoacoustics quantities such as total loudness, N, N10 (this indicates the loudness value, which is exceeded for a 10% of the total measurement period), sharpness, and fluctuation strength, were calculated for all experimental stimuli.

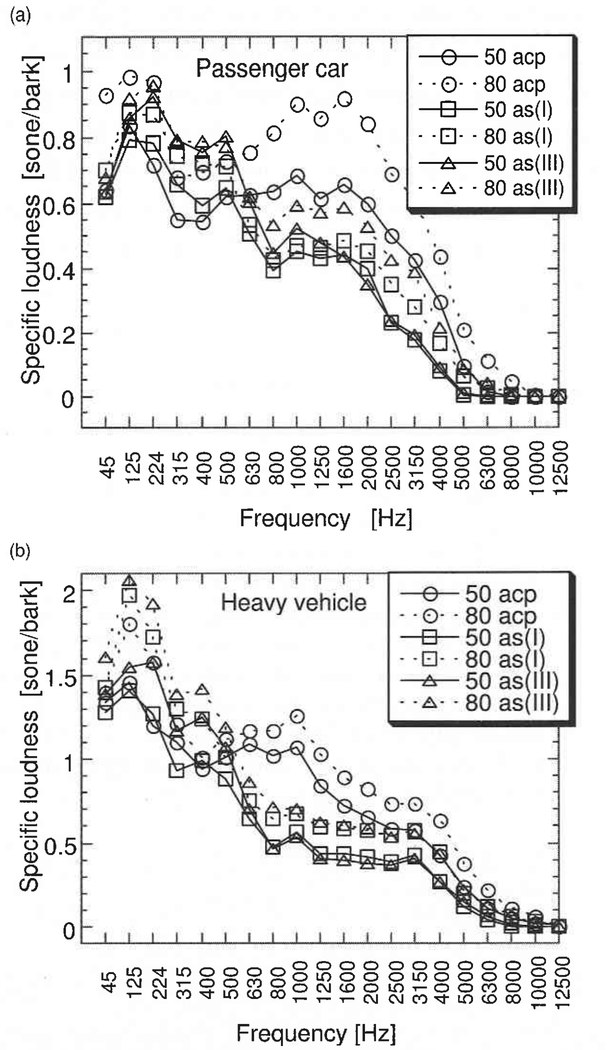


Figure 2. Loudness pattern versus frequency (a) for a passenger car, (b) for a heavy vehicle.

Based on these values the unbiased annoyance (UBA) proposed by Zwicker [6] and the environmental noise annoyance formula (EAN) proposed by Preis [3] were calculated. In Figure 2 loudness pattern versus frequency is presented. In Table 2 values of SEL, LA max, F, UBA, EAN, N and N10 are presented.

Table 2. Calculated values of SEL, LAmax, F, N10, UBA, EAN, LAeq, N for all stimuli.

	Surface	Outside					Inside			
		SEL	$L_{Amax,F}$	N10	UBA	EAN	L_{Aeq}	N	UBA	EAN
Car	50 acp	70.5	66.6	17.7	49.2	7.68	58.5	9.6	19.2	22.9
	50 as(I)	65.3	61.1	12.7	32.2	4.94	57.5	8.4	17.5	20.0
	50 as(III)	70.0	67.6	17.6	49.9	5.27	62.9	12.9	33.7	30.5
	80 acp	76.4	73.8	27.5	106	10.4	63.1	16.4	38.9	39.2
	80 as(I)	68.5	66.3	16.4	54.1	6.03	62.0	13.8	31.4	32.8
	80 as(III)	74.1	73.7	23.6	90.2	7.36	66.2	18.1	45.1	42.7
Heavy vehicle	50 acp	76.9	73.5	29.7	111	11.2	64.0	17.9	44.9	42.7
	50 as(I)	71.5	68.9	22.2	74.9	7.54	63.6	17.6	43.1	42.0
	50 as(III)	75.0	72.5	26.7	91.8	7.85	64.5	18.4	47.9	43.7
	80 acp	81.4	79.8	40.2	213	14.0	72.6	32.0	101	74.8
	80 as(I)	76.2	74.8	30.7	149	10.4	73.0	33.0	104	77.2
	80 as(III)	79.9	78.9	37.8	190	11.1	72.6	32.2	109	75.3

4. SUBJECTIVE ASSESSMENT OF NOISE PRODUCED BY SINGLE VEHICLE SOURCES

In subjective experiment subjects were asked to imagine the following situation: they are talking with someone while they hear the noises. Their task was to rank three noises according to the degree of their disturbance, giving the numbers: (1) to the most disturbing, number (2) and (3) to the less disturbing noises. Results obtained from 7 subjects are presented as a percentage of a given rank for each noise. Results are presented in Figure 3 and in Figure 4.

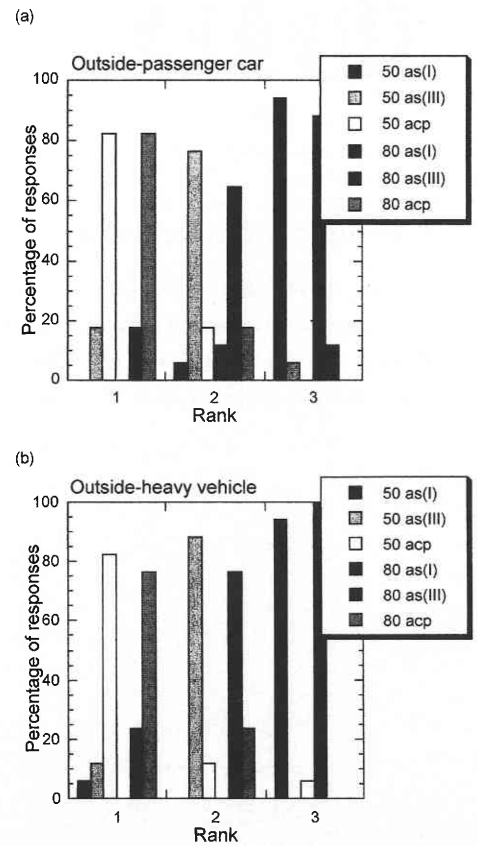
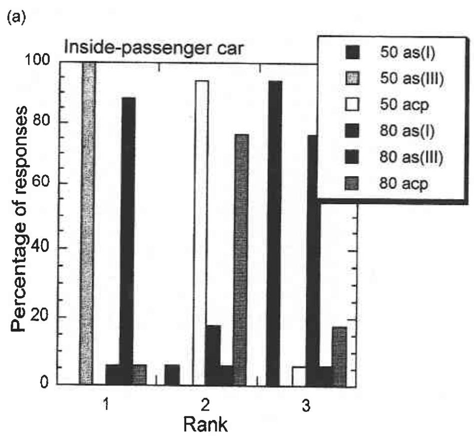


Figure 3. Subjective assessment of outside noise: (a) passenger car, (b) heavy vehicle.



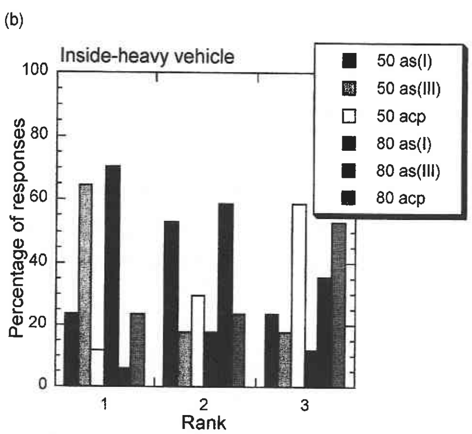


Figure 4. Subjective assessment of inside noise: (a) passenger car, (b) heavy vehicle.

5. RESULTS AND CONCLUSIONS

When listening to the outside noise subjects judged as number (3) the as(I) surface, as number (2) the as(III) surface and the most disturbing, number (1) was the acp surface. The choice of as(I) surface was with agreement with all indices. The LAmax, F, fails as a predictor of the second best surface in all cases. SEL, and N10 do not show the difference between the second and third subjects' choice in all cases. SEL spectra do not reveal the differences in the low frequency range while the loudness pattern do. Although there are differences in the UBA and EAN values which follows the subjects assessment, the lack of experimental data do not allow to show the smallest difference in their values which is not significant (like for example 1 dB in SPL values). Based on the noise recorded inside the passenger car, again the as(I) surface was chosen as a best surface but the second best was the acp surface while the worst was as(III). There is an agreement for all indices in this case. Different surfaces do not influence the subjects perception in case of the noise recorded inside the heavy vehicle. It seems that noise produced by heavy vehicle itself is loud enough and the changes depending on the surface type are too small to be perceived by the subjects. This result is also confirmed by all indices.

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6. REFERENCES

1) P.M. Nelson and P.G. Abbott, Applied Acoustics, "Low noise road surfaces", 21, 119-137, (1987).
2) Y. Oshino, J. Acoust. Soc. Jpn., "Tire/noise variation caused by difference of road texture", 54, 314-319, (1998).
3) A. Preis, Archives of the enter for sensory research, "Noise annoyance and its components", 2, 1-54, (1995).
4) U. Sandberg, Applied Acoustics, "Road traffic noise-the influence of the road surface and its characterization", 21,97-118, (1987).
5) G.R. Watts, Journal of Sound and Vibration, "Perception of exterior noise from traffic running on concrete and bituminous road surfacings", 191, 415-430, (1996).
6) E. Zwicker and H. Fastl, Psychoacoustics (Springer-Verlag, Berlin 1990).