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IMPULSIVENESS OF DISCOTHEQUE EXPOSURES

A. JAROSZEWSKI and A. JAROSZEWSKA

Laboratory of Music Acoustics,
F. Chopin Academy of Music
(00-368 Warszawa, ul. Okólnik 2, Poland)

Long term average spectra, cumulative distribution functions and impulsiveness in terms of $L_{\text{peak}} - L_{\text{eq}}$ and in terms of kurtosis were determined for 8 Warsaw discotheques. The results are discussed with reference to hearing damage risk.

1. Introduction

In one of the Medical Research Council reports [17], a number of discotheque attenders in the United Kingdom is estimated at 2 to 6 mln. These persons spend in the discotheques from 156 to 234 hrs in a year, over a period of 5 to 7 years on the average. The equivalent sound pressure level L_{eq} (A) for a year amounts in these discotheques from 80 to 95 dB. In the polish society of youngsters attending the discotheques, a number of visits to the discotheque amounts on the average to 30 in a year. This number gives from 120 to 220 hrs of the discotheque exposure in a year at an equivalent sound pressure level L_{eq} (A) for a year amounting from 84 to 97 dB. The number of discotheque attenders in Poland is unknown but estimated at 3 mln approximately.

The effects of such exposures were investigated by many researchers but the results of these investigations are in substantial measure controversial. Fearn and Hanson in numerous investigations carried out over a period of 27 years, FEARN and HANSON [4, 6–9]. FEARN [5, 10, 11], reported substantial hearing loss of 10 dB in the whole auditory range, 15 dB or more at 4 kHz and 20 dB or more at 6 kHz in large proportion of the tested persons (7–30%) in the examined samples in age categories of mainly 11–25 years.

In the samples of musicians working in the discotheques and youth clubs a proportion of persons with such hearing loss reaches 50.5% according to FEARN [11]. These data are in agreement with the data from AXELSSON and LINDGREN [2] for example, who found hearing loss in 13–30% of the exposed subjects, and the data from AXELSSON *et al.* [1] who found hearing loss of 20 dB or more at various frequencies in 15% of the examined sample, while WEST and EVANS [21] found poorer frequency resolution in 15% of the sample of exposed subjects. In the data from JAROSZEWSKI *et al.* [13] hearing loss of

18.8 dB on average at 6 kHz was found in 60% of the examined sample of 98 musicians, while JAROSZEWSKI and RAKOWSKI [12] found hearing loss 20 to 50 dB deep in the whole sample of the tested group of pop/rock musicians.

On the other hand CARTER *et al.* [3] in investigation carried out in Australia and MEYER–BISCH [16] in France did not observe differences between audiometric data from exposed and unexposed persons. However, their opinion was based on estimation of the averages in large samples of the examined population. Here an observation from FEARN and HANSON [6] should be cited: "*What we are concerned with is the top 5 – 10% of the affected population. For this purpose the average is too insensitive for judgement.*" It should also be noted that in the results from Carter and Meyer–Bisch, hearing loss of from 9.4 dB at 6 kHz to 13 dB at 12 kHz is present in the data from both exposed and control group of subjects.

A distinct disproportion appears in comparison of the depth of the measured hearing loss with the measures of exposures from which this loss resulted. Namely, these losses are substantially larger than those predicted on the grounds of the measures of the exposition and number of years of exposure. In many cases hearing loss of 10 – 15 dB in the upper part of auditory range, and selective hearing loss of V-dip type (notch) of 15 – 40 dB, are found after only 25 to 70 exposures in the discotheques in a period of only one to two years. It should be stressed however, that this observation does not pertain to averages for the tested samples, but only to from 15 to 25% of the affected.

According to the working hypothesis larger damaging effect of the discotheque exposures than this predicted on the grounds of the equal energy hypothesis and equivalent sound pressure levels may result from partially impulsive character of these exposures. This possibility was been pointed out in the earlier publication, JAROSZEWSKI *et al.* [14] in which "impulsiveness" was determined for ten Warsaw discotheques, a measure never applied to the discotheque exposures before. The present report is a continuation of this investigation and contains statistical analysis of the impulsiveness of sound pressure levels in discotheques in terms of $L_{\text{peak}} - L_{\text{eq}}$ and in terms of kurtosis.

2. Procedure and apparatus

Material used in the analysis was obtained from 8 routine presentations in 8 Warsaw discotheques. The duration of these presentations typically equalled to from 4 ½ to 9 hrs, usually without breaks or with very short breaks of 1 to 2 min. All presentations were recorded full length on magnetic tape using digital magnetic recorder DAT SONY type TCD-D10 PRO-II and omnidirectional condenser microphone Bruel & Kjaer type 4155. Sound pressure levels were determined with the use of Bruel & Kjaer Precision Integrating Sound Level Meter type 2230 with 1/2" condenser microphone type 4155.

The raw data containing 4 hrs of recorded music was next analysed typologically with the use of computerised procedure. With that procedure 63 selections of the recorded music, 5 min each were selected, characteristic for the whole presentations in all discotheques examined. For these selections of recorded music, long term average spectra (LTAS) in 1/3 octave bands, sound pressure levels L_{50}, L_1, L_{eq} and the impulsiveness distribution functions, defined as a difference $I = L_{\text{peak}} - L_{\text{eq}}$ were determined. Also were determined distribution functions of the instantaneous sound pressure levels and the values of kurtosis as an alternative measure of the impulsiveness.

Statistical analysis and spectral analysis were carried out with the use of HP class PC minicomputer and of the MATLAB program procedures. Kurtosis was determined with the use of WaveStat program prepared in this laboratory.

3. Results

The results of the analysis in terms of LTAS, and cumulative distribution functions are presented in Fig. 1 to Fig. 3 for the discotheque with the largest equivalent sound pressure levels and in Fig. 4 to Fig. 6 for the discotheque with the smallest sound pressure levels. Distribution functions of the instantaneous sound pressure levels and the values of the kurtosis are given in Fig. 7 and Fig. 8. Statistical characteristics of the presentations in eight examined discotheques are given in Table 1.

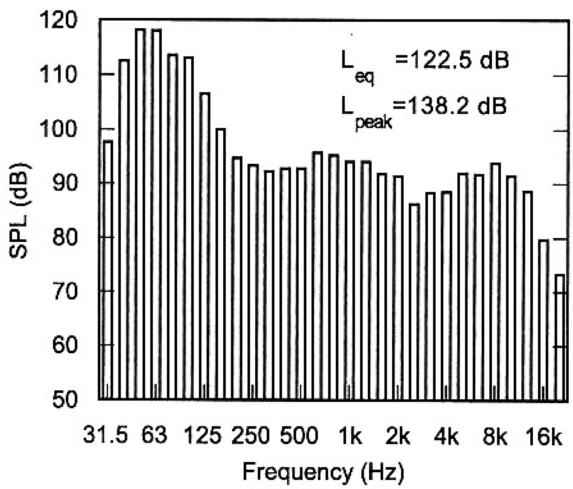

Fig. 1. The averaged 1/3 octave sound pressure spectrum for the discotheque with the largest equivalent sound pressure level.

Table 1. Statistical characteristics of presentations in 8 Warsaw discotheques.

Discotheque	L_{eq} (dB)	L_{peak} (dB)	β_2	L_1 (dB)	L_{10} (dB)	L_{50} (dB)	CF* (dB)	I (dB)
Akwarium	112.8	133.9	5.5 – 6.3	122.7	117.2	106.5	9.9	21.1
Colosseum	122.5	138.2	3.5 – 5.2	132.2	127.1	116.8	9.7	15.7
Hades	113.5	131.6	3.1 – 5.6	123.0	117.8	108.8	9.5	18.1
Hybrydy	113.7	133.6	3.6 – 5.5	123.7	118.1	107.8	10.0	19.9
Klub Medyka	109.0	130.1	4.2 – 6.0	119.9	112.9	102.2	10.9	21.1
Park	108.7	135.3	4.4 – 5.8	119.3	112.9	102.0	10.6	26.6
Remont	117.3	139.0	3.4 – 8.0	127.4	121.4	111.6	10.1	21.7
Stodoła	112.5	129.4	4.0 – 5.7	122.7	116.6	107.2	10.2	16.9
Mean over all	116.1	139.0	3.1 – 8.0	127.9	119.5	107.8	11.8	22.9

* CF – crest factor

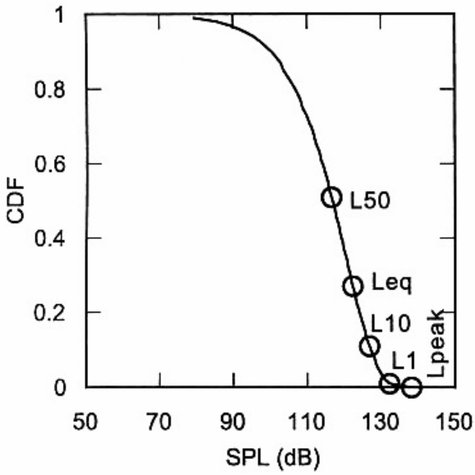

Fig. 2. Cumulative distribution function of the instantaneous sound pressure levels for the discotheque with the largest equivalent sound pressure level.

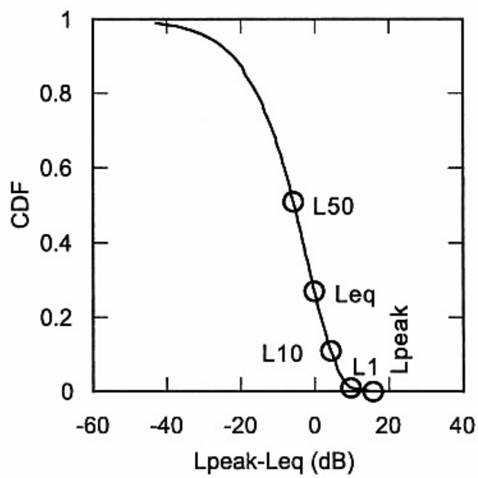

Fig. 3. Impulsiveness in the discotheque with the largest equivalent sound pressure level.

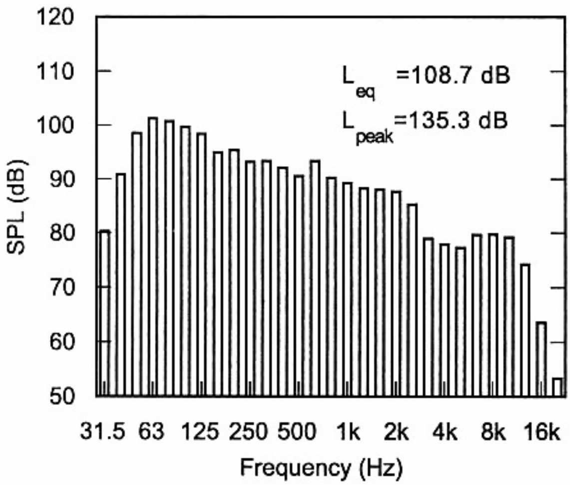

Fig. 4. The averaged 1/3 octave sound pressure spectrum for the discotheque with the smallest equivalent sound pressure level.

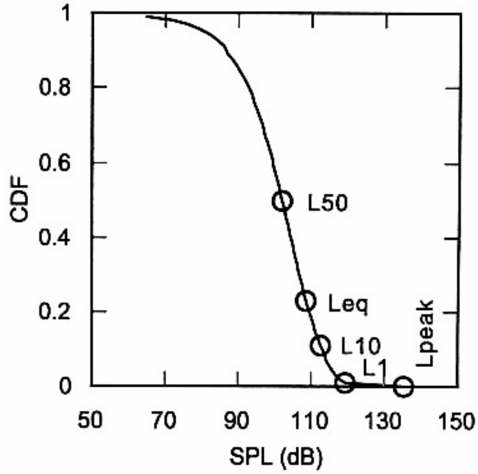

Fig. 5. Cumulative distribution function of the instantaneous sound pressure levels for the discotheque with the smallest equivalent sound pressure level.

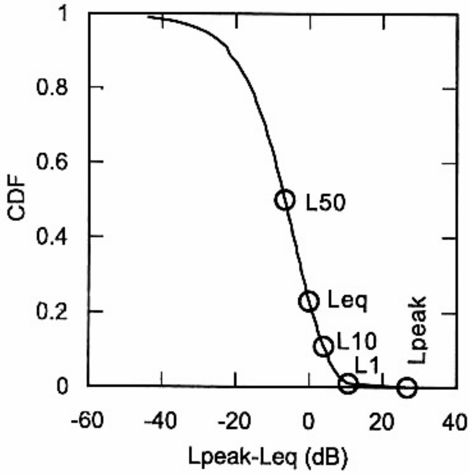

Fig. 6. Impulsiveness in the discotheque with the smallest equivalent sound pressure level.

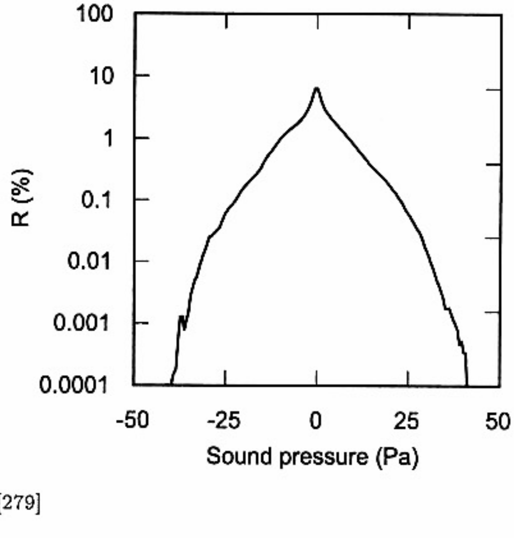

Fig. 7. Distribution of the instantaneous sound pressure levels in the sample recorded in the discotheque with the largest equivalent sound pressure level, kurtosis $\beta_2 = 4.8$.

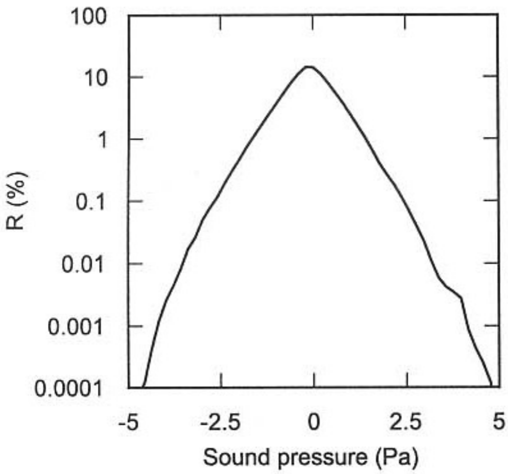

Fig. 8. Distribution of the instantaneous sound pressure levels in the sample recorded in the discotheque with the smallest equivalent sound pressure level, kurtosis $\beta_2 = 4.7$.

4. Discussion and conclusion

In the results obtained the impulsiveness was found to be at a level of 20 – 26 dB in terms of $L_{\text{peak}} - L_{\text{eq}}$ determinant, and at a level of 4.7 in terms of kurtosis. These values correspond to the values of impulsiveness, which in industrial exposures are recognised as leading to hearing damage larger than those from the stationary continuous noise, e.g. Thiery and Meyer–Bisch [20]. It should be observed however, that Thiery and Meyer–Bisch determined damaging effects of the partially impulsive exposures at a level of 87 – 90 dB (A), whilst in the case of Warsaw discotheques the sound pressure levels amount to from 100 to 110 dB (A). Thus the damaging effect may be larger in spite of the relatively lower values of impulsiveness.

In estimation of the results presented it should be recognised that the measurements were carried out with the use of apparatus and tools functioning in the range of frequencies up to only 20 kHz. From the recent reports by Rogowski *et al.* [18, 19] and Jaroszewski *et al.* [15] it appears that the examination of the impulsiveness in the music material should be performed in the frequency range up to 100 kHz at least, because a power spectral density for cymbals for example remains at a level of 90 dB up to approximately 60 kHz. The preliminary experimental data by the present authors indicate that the supersonic components of the spectrum may have substantial contribution in the damaging effects of the exposure. Therefore, the results presented supply only preliminary estimation of the effects of impulsive exposure in the discotheques.

Acknowledgements

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