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ACOUSTIC TESTS FOR LEVEL-DEPENDENT EAR-MUFFS

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ABSTRACT
The aim of the paper is to present the method and results of criterion levels measurements for level dependent ear-muffs (ear-muffs with an electronic sound restoration system). The test procedure met the requirements of draft prEN 352-4 Hearing protectors − Safety requirements − Part 4: − Level-dependent ear-muffs. The acoustic measurements were carried out in a reverberation room where the sound field of the test site complied with the requirements for diffusivity and spatial homogeneity of EN 24869-1. The spectra of three test signals (high, medium and low frequency), transfer functions for the subjects and measured data of H, M, L criterion levels of the level-dependent ear-muff models are presented.

1 - INTRODUCTION

The acoustic performance of level-dependent ear-muffs is achieved by fitting the ear-muffs' cups with an electronic sound restoration circuit. The level-dependent ear-muffs are designed to provide increased protection when the ambient noise level increases and act as an electroacoustic sound restoration system at low levels. Level-dependent ear-muffs have to meet acoustic and mechanical requirements of prEN 352-4: 1999 [1]. The acoustic measurements of level-dependent ear-muffs are carried out for their passive and active modes. Four specimens are tested during these tests. In the passive mode sound attenuation according to EN 24869-1 [2] is determined. The level-dependent ear-muffs under test with the sound transmission system turned on and set at full gain are tested to specify criterion levels H, M, L. Criterion levels H, M, L are A-weighted sound pressure levels of respective H, M, L − test noise signals for which the A-weighted equivalent diffuse field sound pressure level when a level-dependent ear-muff is worn first exceeds 85 dBA as a mean for four subjects. For these measurements the 'microphone-in-real-ears' technique (MIRE) according to ISO/CD 11904-1 [3] is used.
A-weighted equivalent diffuse field sound pressure level is calculated from a one-third octave band spectrum of the noise measured with a miniature microphone in the concha or in the ear canal of a given subject, corrected by subtracting the transfer function (which is specific for each subject).

2 - TEST EQUIPMENT

The test facility is situated in a reverberation room. The instrumentation for criterion level measurements is presented in Fig. 1. The sound diffused field at the test site meets the requirements of EN 24869-1 [2].
Three different generated test signals− high (H), medium (M) and low frequency (L) are based on pink and white noise. The spectra of test signals, A-weighted sound pressure levels and C-weighted sound pressure levels are presented in Fig. 2.
The receiving part of the electroacoustic equipment of the test facility is used for measurements at the test site. The sound pressure levels at the reference point of the test site and at the ear canal of each subject are measured. When the subjects (with or without tested level-dependent ear-muffs) take part in the measurements, they are placed at the test site.

3 - TEST PROCEDURE

The first step of the measurement procedure is determining the transfer function for each subject. The transfer function describes differences of sound pressure levels measured at the reference point (in the

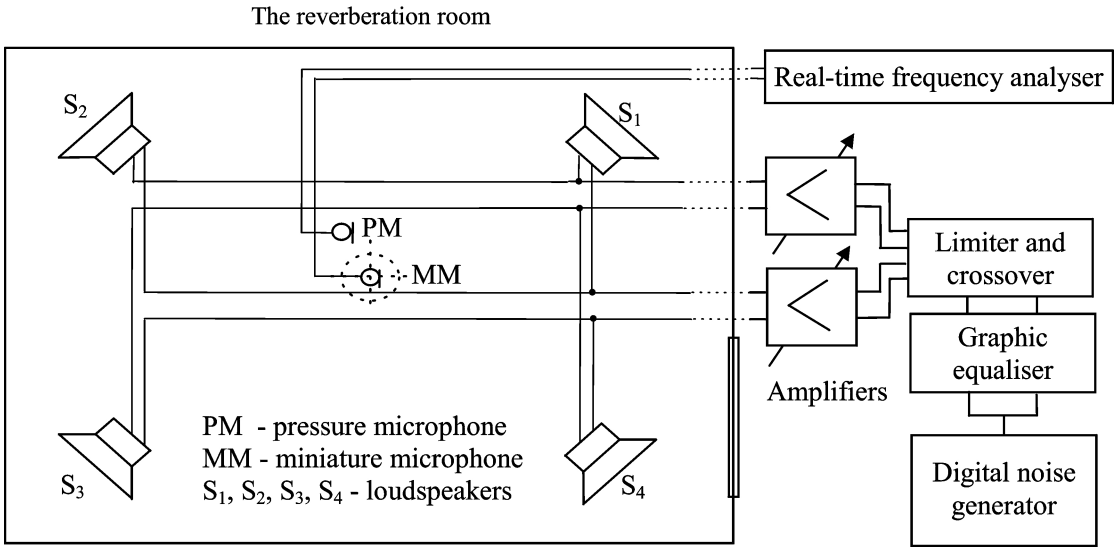

Figure 1: Instrumentation for criterion level measurements.

diffuse sound field) and at the given position of the microphone in the subject's ear. To calculate the transfer function for the subject, the one-third-octave band spectrum of the pink noise (with centre frequencies ranging from 100 Hz to 10 kHz) at the reference point is measured with a calibrated pressure microphone. Then the miniature microphone is inserted into the subject's ear. The subject has to be placed at the test site in such a way that the midpoint of the line between his/her conchae is at the reference point in the sound field. Using the same signal the one-third-octave band spectrum is measured again with the miniature microphone. Next, the difference between sound pressure levels measured at the reference point and at the subject's ear is calculated for each one-third-octave band.
In the following step of the procedure the tested level-dependent ear-muff with the electronic system in operation at full volume is placed on the subject's head without changing the miniature microphone position. Then the test signal H (M, L) at specified levels is generated. The minimum test signal sound pressure level is 50 dBA. The maximum level depends on the kind of the test signal: for the H-signal it is 120 dBA, for the M-signal 115 dBA, for the L-signal 110 dBA. The level of the test signals is increased by the 5 dB steps. For each signal level one-third octave band sound pressure levels at both ear canals of the subject are measured. After that, taking into account the previously determined transfer function, the A-weighted equivalent diffuse field sound pressure level is calculated.

4 - MEASURED DATA

The transfer functions for four subjects as the difference between one-third octave band sound pressure levels measured at the reference point (L_{ref}) and at the ear canal (L_{ear}) are presented in Fig. 3. The difference $L_{ref} - L_{ear}$ (in dB) determines the average value measured in the left and right ear of each subject.
The mean (four subjects, two ear canals each) A-weighted equivalent diffuse field sound pressure level ($L_{ear\ mean}$) as a function of the external A-weighted sound pressure level ($L_{external}$) for each type of test noise are presented in Fig. 4. Using the method of graphical interpolation the criterion levels are determined: H = 110.8 dB, M = 105.8 dB, L = 104 dB.

5 - CONCLUSIONS

Although the conditions required by the procedure of determining criterion levels in draft prEN 352-4: June 1999 are rigorous the measurements of criterion levels may be carried out in a typical acoustic laboratory.

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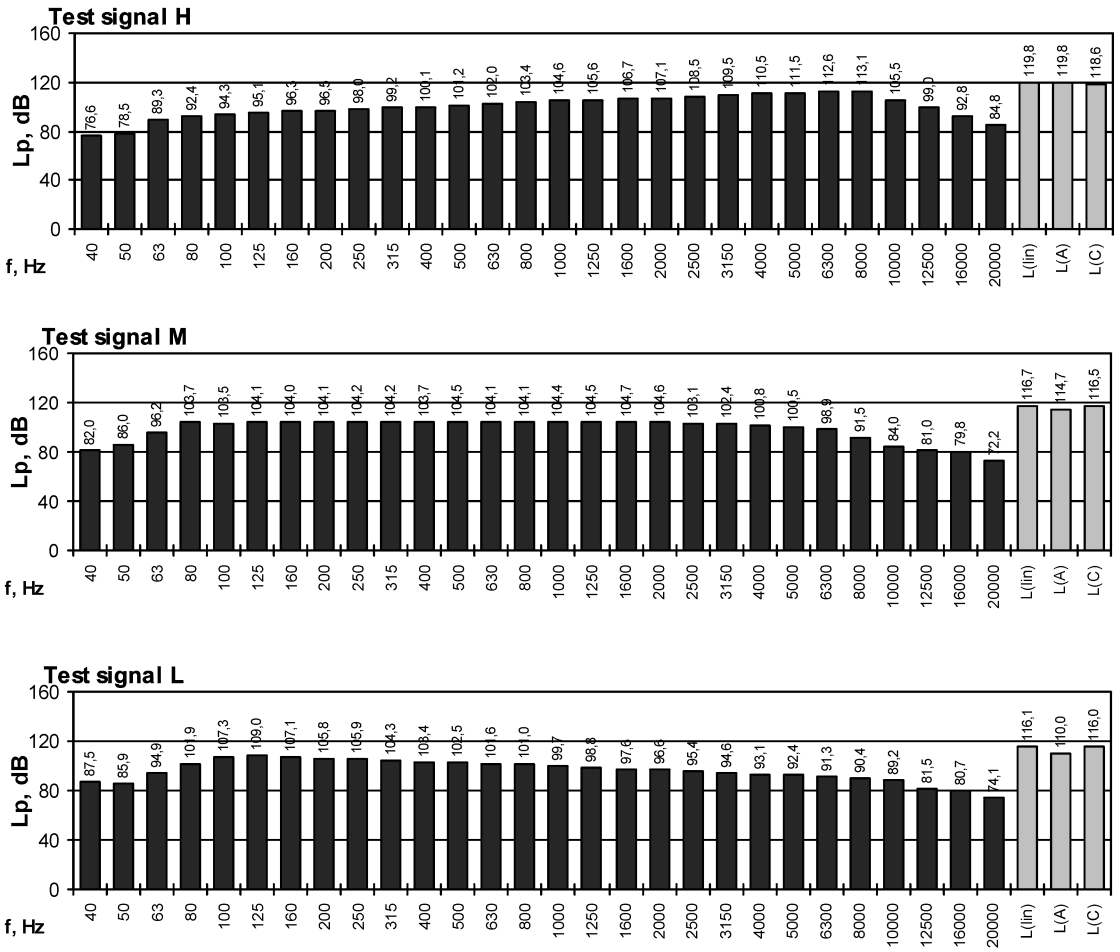

Figure 2: The test signal spectra.

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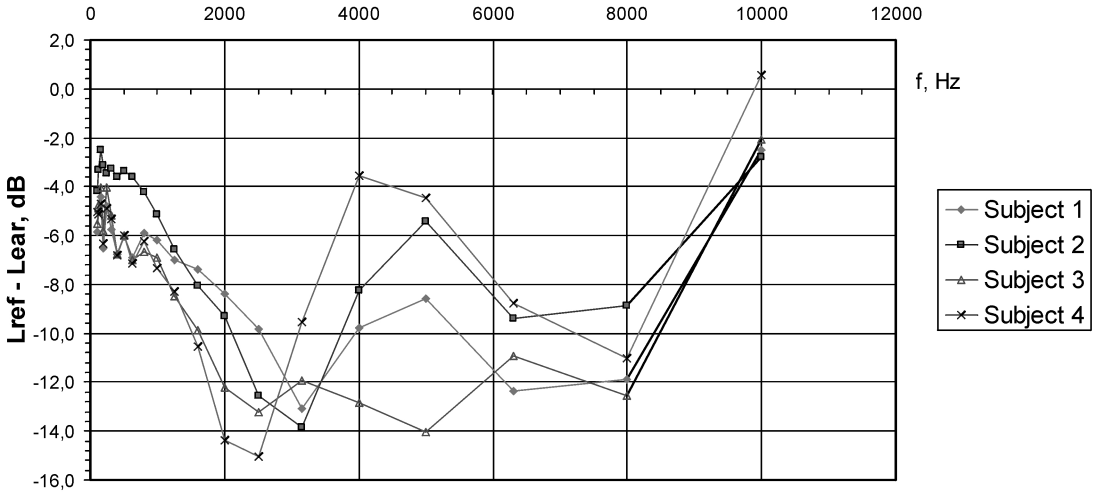

Figure 3: Transfer functions for the subjects.

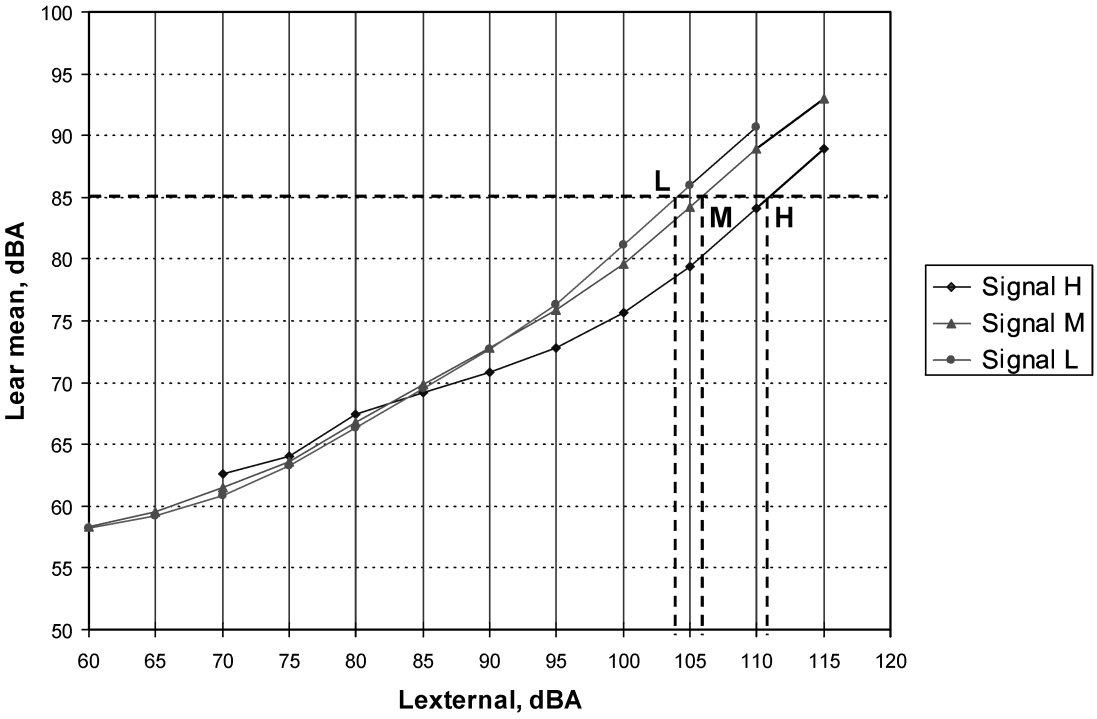

Figure 4: The A-weighted sound pressure level under the cup of the level-dependent ear-muff as a function of the external sound level.