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MEASUREMENT OF THE SOUND PRESSURE LEVEL OF LEVEL DEPENDENT MUFFS WITH THE ISO ACOUSTIC TEST FIXTURE

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1. INTRODUCTION

The draft technical report ISO/TR 4869-4 [1] for the measurement of effective sound pressure levels for sound restoration ear-muffs measures the A-weighted level from the muffs in a diffuse field of continuous pink noise stepped from 50 to 110dB(A) in 10dB intervals. The measurement is made using the ISO acoustic test fixture (ATF) [2], with the measured level corrected using a frequency dependent transfer function to give the equivalent level in an open, undisturbed space.

Previous measurements, with two sound restoration muffs, had shown MIRE (microphone in real ear) techniques and measurements using the ATF and the Knowles Electronics Manikin for Acoustic Research (KEMAR) were within 2dB, while restored sound dominated under the muff cup. Following closely the ISO/TR 4869-4 procedure, testing continued with thirteen different sound restoration muffs to check the performance of muffs currently available. Measurements were made using the ATF and the KEMAR to confirm the previous consistency of result, and in addition three active noise reduction (ANR) muffs were tested to see if a similar procedure would be valid.

2. THE TEST PROCEDURE

The measurements were made in a diffuse field of pink noise. The sound pressure level was within 1dB for octave bands from 63Hz to 8kHz, however the variation between third octave bands and the diffuseness of the field were outside the exact specifications of ISO/TR 4869-4. One example of each muff was used and measurements were made on both cups. Eleven of the thirteen sound restoration muffs, and the three ANR muffs were tested on both the ATF and the KEMAR. (Two muffs were unavailable for testing with KEMAR.)

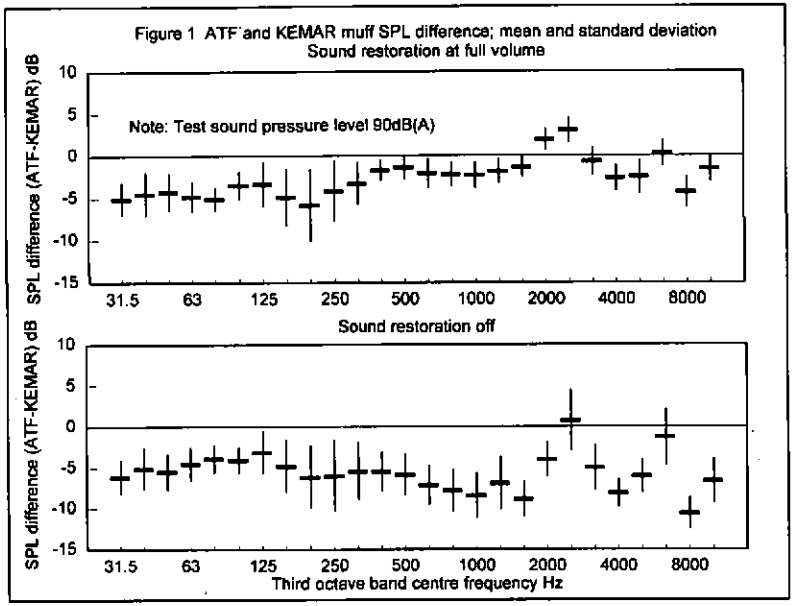
Transfer functions were determined for the ATF and the KEMAR by subtracting the measured third octave band spectra obtained with each device at the centre of the test sound field, with that measured by a Brüel & Kjær 4134 microphone in the same position. All measurements with the ATF and the KEMAR were then corrected in third octave bands using the transfer functions to give the equivalent level in an open, undisturbed space.

Using the ATF, measurements were made of the corrected A-weighted sound level under the muff cup with the restored sound at full volume, or with the ANR on. The level of the test sound field was varied from 61 to 110dB(A) in 5dB steps. Each cup was tested three times with the muffs being refitted between measurements. Between each muff test the sound field was checked by taking measurements without muffs fitted.

In a test sound field of 90dB(A) the corrected third octave band levels with the restored sound at full volume and off, and with the ANR on and off were measured with both the ATF and KEMAR.

3. COMPARING RESULTS FROM THE ATF AND KEMAR

Figure 1 shows the difference between the sound pressure level measured under the muff using the ATF and the KEMAR for eleven sound restoration type muffs. The upper plot shows the mean and standard deviation of the difference in third octave bands with the sound restoration at full volume; the lower plot gives the result with the sound restoration off.



At frequencies above 250Hz the difference given by the two devices is substantially reduced when the sound restoration is on, compared to when it is off. This corresponds to the onset of the restored sound above 250Hz (figure 2). The mean difference in A-weighted level measured with the ATF and KEMAR with the restored sound at full volume is 0.7dB compared to 5.7dB without restoration. The corresponding standard deviations are 1.9dB and 5.7dB respectively. Clearly when the sound pressure level under the muff is dominated by restored, rather than attenuated, sound the type of test head is less critical.

For all ANR muffs the additional ANR attenuation was apparent both with the ATF, as well as subjectively. However attempts to use the KEMAR with the ANR muffs failed; two of the three ANR muffs produced a loud humming noise when fitted on the KEMAR, and with the third device the ANR gave no measurable contribution to the attenuation.

4. MUFF PERFORMANCE RESULTS

Sound restoration muffs

Figure 2 Mean sound restoration gain, on ATF, over attenuated level
Sound restoration at full volume

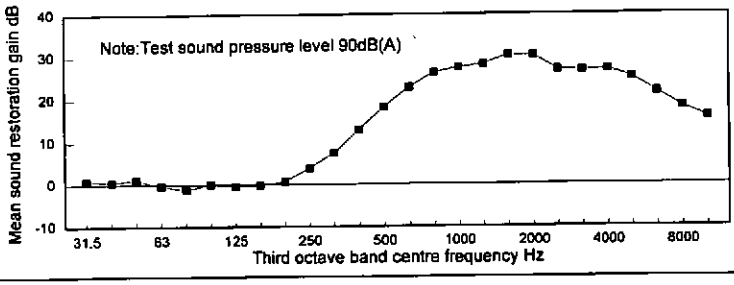


Figure 3 A-weighted level under muff on ATF, mean and standard deviation
Sound restoration at full volume

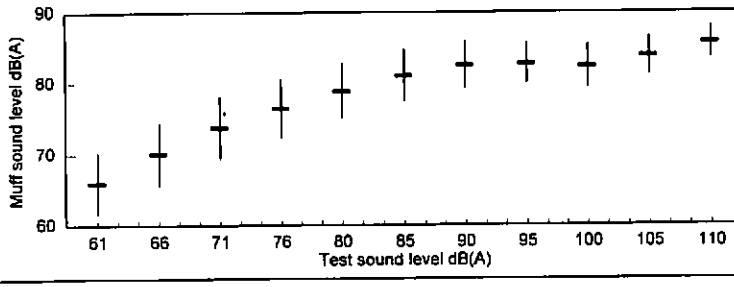


Figure 2 shows the mean sound restoration gain, against frequency, of the thirteen sound restoration muffs. On all muffs the sound restoration reinforced the higher frequencies (above 250Hz) necessary for clarity of speech.

Figure 3 shows the mean A-weighted under muff level for the same sound restoration muffs, at the different test sound pressure levels. Predictably the level under the muff cup rises more slowly than the outside test level, demonstrating the non-linearity of the muffs. The standard deviation is over 7dB for test levels below 90dB(A) and this reflects differences both in the sound restoration gain and the non-linearity of the muffs. Three of the muffs tested produced sound above 85dB(A), for test levels from 75dB(A), a further two exceeded 85dB(A) for test levels from 85dB(A). Two muffs limited the level of restored sound to 93 and 95dB(A). These muffs are a potential hearing hazard. Two of the sound restoration muffs also showed an irregular non-linear response, with the maximum level under the muff cup occurring at 90dB(A), rather than the maximum test level.

The mean difference in the A-weighted level of restored sound in the right and left muff cups, measured on the ATF with an outside level of 90dB(A), was1.8dB. The greatest difference was 7dB.

ANR muffs

All the ANR muffs tested remained linear at the levels used for this test. Non-linearity is expected at higher sound pressure levels, when the ANR cancellation reaches the limit of its output.

5. CONCLUSIONS

Sound restoration muffs can produce hazardous levels. The maximum output of the sound restoration system does not always occur at the highest test level and is not always the same in both cups. By testing both cups over a range of levels the ISO/TR 4869-4 procedure can identify those muffs capable of producing hazardous sound pressure levels. Higher test sound pressure levels, than those specified in ISO/TR 4869-4, are required to determine the non-linear response of ANR muffs.

The design of the head does not significantly effect the measured A-weighted level under the muff cup while restored sound is dominant. Measurements with the ATF will therefore approximate to those likely to be obtained on people. The KEMAR, in its current design, is not suitable for the assessment of ANR muffs. Further work is necessary to see if the ATF can give a valid assessment of ANR muff attenuation on people.

References

[1] "Acoustics - Hearing protectors - Part 4: Method for the measurement of effective sound pressure levels for sound restoration ear-muffs", International Organisation for Standardisation ISO/TR 4869-4 (1995 draft).

[2] "Acoustics - Hearing protectors - Part 3: Simplified method for the measurement of insertion loss of ear-muff type protectors for quality inspection purposes", International Organisation for Standardisation ISO/TR 4869-3:1989.