TESTING OF ANR EARMUFFS

Jie Cui[1], Alberto Behar [1], Hans Kunov[1,2], Willy Wong[1,2]
[1]IBBME, University of Toronto, 4 Taddle Creek Road, Toronto, ON, Canada M5S 3G9
[2]Department of ECE, University of Toronto, 10 King's College Road, Toronto, ON, Canada M5S 3G4

1. INTRODUCTION

Although originally patented as early as in 1930s [1], the technique of Active Noise Reduction (ANR) did not find practical application in the hearing protection field for a long period of time. Only in the last 20 years has ANR been introduced in the industry of hearing protectors, primarily due to advances in signal processing technology. An ANR hearing protector has its low frequency attenuation increased by electronic means, by employing a feedback-processing loop, where the intruding signal is re-introduced with a 180-degree phase shift. As a result, the sound pressure level is significantly reduced at those frequencies.

ANR is only effective in the low frequency range, below 500 Hz, because of technical limitation. It is well known that the sound energy that damages the hearing of noise-exposed people is found in the frequency above 500 Hz. Therefore the mere use of ANR does not reduce the risk of hearing loss. However, it does reduce the upward spread of masking effect [2]. By doing so, it increases significantly the speech intelligibility, thus improving oral communication in environments such as airplane and helicopter cabins, armored cars, engine rooms, etc.

Several characteristics of the headsets can be measured. They are the attenuation at different sound levels, intelligibility as perceived by the wearer and the comfort. Although testing of those characteristics is something manufacturers as well as authorities are interested in, there are still no test methods standardized or even recognized.

The objective of the study was to examine the feasibility of using an Acoustic Test Fixture (ATF) for the measurement of insertion loss (IL) of ANR headset. Using the IL results, the attenuation canbe easily calculated.

2. MATERIALS AND METHODS

A total of five headsets were employed in this study: two supra-aural and three circum-aural. **Headset-1**: A supra-aural type headset, used mainly as a comfort device in airplanes. It included a plug connecting to the airplane entertainment center or to sound reproducing equipment. Manufacturer's brochure claimed up to 10 dB cancellation at 300 Hz and a cancellation range of 40 – 1,500 Hz. **Headset-2**: Same characteristics as Headset-1. From the manufacturer's brochure, the cancellation range was 20 – 1,500 Hz and the reduction was 15 dB between 150 and 300 Hz. **Headset-3A and 3B**: Both of the circum-aural type. No technical specifications regarding the ANR performance were published in the manufacturer's brochure. **Headset-4**: A circum-aural type aviation headset. No technical specifications regarding the ANR performance were published in the manufacturer's brochure either.

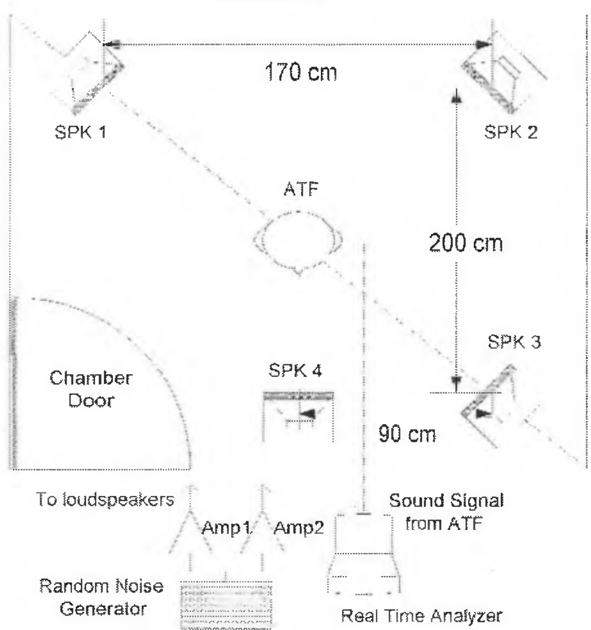

Fig. 1 Measurement set-up

Headsets were mounted on the ATF, a binaural implementation of a mannequin with one instrumented ear [3]. Features of the mannequin include circum-aural areas, pinna and auditory canals fabricated with simulated skin and tissue that retains the correct dynamic mass and textural properties of human flesh. The auditory canal is terminated in Zwislocki type DB100 coupler and Bruel & Kjaer type 4134 microphone, which simulate the acoustical impedance of human ears. The measurements were performed using the instrumented ear.

Tests were carried out in an IAC double wall, double room Audiometric Cabin (measurement set-up shown in Figure 1). A pink noise signal, generated by a General Radio Random Noise Generator Type 1382, was amplified by two Rotel Stereo Integrated Amplifiers type RA-930AX (50W) and fed into the room via four Mirage Speakers Type M-90IS and four horn-loaded piezoelectric loudspeakers Motorola type KSN1016. The signal entering the ear of the ATF was detected by the microphone in the coupler and analyzed by a Bruel & Kjaer type 2144 Real Time Analyzer (RTA). Measurements were performed in 1/3-octave bands at the center frequencies between 20 and 8000 Hz.

Measurements were carried following three steps: a) The Open-Ear Spectrum (OE) was measured with the sound signal on and no headset on the ATF; b) Without changing the sound signal, the Passive-Protected-Ear Spectrum (PP) was measured with the headset donned. The ANR system of the headset was off at this step; c) The Active-Protected-Ear Spectrum (AP) was measured with the ANR system switched on, while keeping other conditions same as in step b). Steps b) and c) were repeated 20 times in each measurement session, without altering the sound signal. The purpose was to examine the changes of the insertion losses resulting from repeatedly donning and doffing the headset. A study of those variations is in progress.

From the spectra in steps a) through c), the following IL was calculated for each one of the 1/3-octave band frequencies. **Passive Insertion Loss** (IL_P): the insertion loss of the headset with the ANR off, IL_P = OE PP (dB); **Active Insertion Loss** (IL_A): the insertion loss due to the effectiveness of ANR only, IL_A PP – AP (dB); **Total Insertion Loss** (IL_T): the total insertion loss of the headset with the ANR on, IL_T OE – AP (dB).

3. EXAMPLE OF RESULTS

Figures 2 4 show insertion losses IL_P, IL_A and IL_T calculated from 20 measurements of Headset 1 [4].

At each frequency point, the maximum and minimum values of the 20 measurements are shown as the upper and the lower bar.

4. DISCUSSION AND CONCLUSION

It was observed that there were significant variations among the calculated values of different ILs at different frequencies. As is expected, however, the high frequency range of the noise is attenuated by passive insertion loss of the headsets. On the other hand, the low frequency is attenuated by active noise reduction. Thus this ANR headset obtained broadband noise attenuation both in low and high frequency band, as is shown in Figure 4.

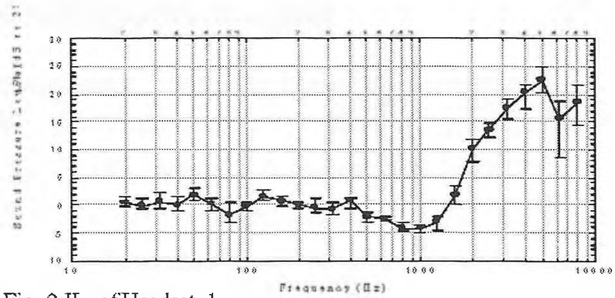

Fig. 2 IL_P of Headset -1

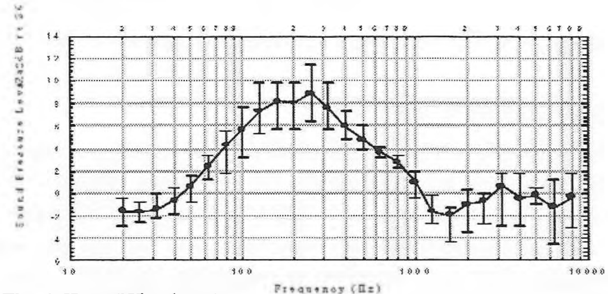

Fig. 3 IL_A of Headset-1

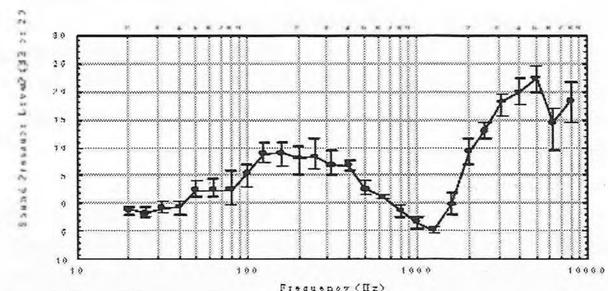

Fig. 4 IL_T of Headset -1

The method allows for a minimum of instrumentation and is relatively simple to implement. It requires an audiometric booth, a signal generator, speakers, and an ATF. The ATF is an essential part of the instrumentation. The background noise inside the booth is not important, since measurements are implemented at a level of approximately 80 dBA. In addition, non-involvement of human subjects reduces the overall cost and makes the tests easy to perform. As an example, the 20 IL tests of one headset were completed within an hour. Therefore, the method becomes especially useful for testing prototypes, since it allows for quick modifications of device for a subsequent re-test. It can be also useful in the case of quality control, because it allows for testing large quantity of headsets in a short time.

References

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