NOISE EXPOSURE FROM COMMUNICATIONS HEADSETS: THE EFFECTS OF ENVIRONMENTAL NOISE, ATTENUATION AND SNR UNDER THE DEVICE

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1. INTRODUCTION

A Working Group (WG) was created to prepare an extension to CSA Standard Z107.56 [1] to cover situations when the worker is wearing communication headsets or other listening devices placed close to the ear. Currently, the CSA standard describes noise measurement and assessment procedures that are restricted to situations where the sources are far from the ears. With the increasing use of headsets in the workplace, these general procedures are unsuitable in a growing number of cases such as found in call centers, retail stores and fast food outlets, airport ground and control tower operations, the military and law-enforcement agencies, etc.

The new appendix will likely include a variety of methods to measure sound levels directly under the listening devices, through the use of manikin, artificial ear or real-ear procedures. While these specialized methods provide the most direct assessment of exposure, they require equipment, expertise and field logistics well beyond the usual range for industrial hygienists and safety personnel. To make the appendix as widely used as possible, the WG is exploring simpler survey methods that could be carried out using the same equipment as for general noise surveys, namely a sound level meter or noise dosimeter [2].

Headset users are exposed to both the environment background noise around them and the audio signals from their device. These two sources are not independent. Users will typically adjust their headset to ensure proper reception of speech and audio signals above the noise entering the device. This suggests an alternative way of assessing headset exposure by measuring the environment background noise around the worker, correcting for the device attenuation and then accounting for the expected signal-to-noise (SNR) under the device. This indirect assessment procedure is referred to as the calculation method [2].

This paper reviews earlier Canadian studies on headset exposure, primarily the surveys of Dajani et al. (1996) at several industrial sites and Crabtree (2002) in military aircraft. The purpose of this review is to gain more insight into the main determinants of headset sound exposure and to provide an empirical basis for the new calculation method under development by the CSA WG.

2. REVIEW OF CANADIAN STUDIES

2.1 Inst. of Biomaterials and Biomedical Eng. (IBBME) of the University of Toronto

Under the leadership of Hans Kunov, a major research effort on the development and application of acoustic manikins was undertaken at IBBME circa 1985-1995. The basic test fixture consisted of a modified KEMAR manikin, adapted to increase the sound isolation and to provide artificial skin lining around the circumaural area and ear canal [3]. While initially designed for the objective evaluation of hearing protectors, the manikin was also used for headset exposure assessments through a series of contracts with Labour Canada [4-5].

The field method required two similar communication headsets, one worn by the worker to carry out normal tasks and one placed on the manikin to measure sound levels under the device. This necessitated the design of a special splitter box to duplicate the electric signal to the headsets or the availability of parallel output connectors in the audio console. The manikin was positioned near the worker, and measurements of the environment background noise were taken in addition to manikin recordings. Manikin data were transformed into diffuse-field equivalent levels using a 1/3-octave band calculation procedure [4] or through a filter module connected to the recording equipment [5].

Figure 1 shows the relationship between the headset diffuse-field transformed sound levels and the background noise around the user. The data set includes 2 measurements from [4] and 31 measurements from [5] covering 9 workplaces in a variety of settings (telephone operators, cable maintenance, control towers, ground crew) in 3 provinces (ON, SK, AB). The distribution of headset types was as follows: 9 intra-aural, 14 supra-aural and 10 circumaural.

The correlation coefficient in Figure 1 is 0.77, indicating that about 59% of the variation in headset sound level can be explained by the environment background noise around the user. The regression equation gives the predicted headset sound level (y) given the background noise level (x). The standard deviation of the headset level from the regression line is 5.2 dB. This can be used to establish empirically-based environment background noise levels that should not be exceeded to ensure compliance with the regulatory limit (e.g. 85 dBA). The thin lines above the regression line (50th) depict the 90th and 95th percentile headset exposure given the background noise. At the 95th criterion, headset sound levels do not exceed an equivalent 85 dBA exposure limit if the background noise is below 69.6 dBA. At the 90th criterion, the maximum background noise is 74.1 dBA.

In Figure 1, the slope of the regression line is 0.42, well below 1. Thus, headset exposure rose by only 0.42 dB for each 1 dB increase in background noise over the data set. Analysis of headset selection in the different work sites reveals that low-attenuation intra and supra-aural devices were used in quieter settings (e.g. office) while high-attenuation circumaural devices (Peltor, David Clark) were chosen in the noisier settings (e.g. airport ground crew). As a result, the difference between headset equivalent sound levels and the background noise was about +12 to +15 dB in the quieter settings (50-65 dBA) and around -5 to 0 dB in the noisier settings (75-95 dBA). Figure 2 summarizes this data. Device attenuation appears to be an important determinant of exposure.

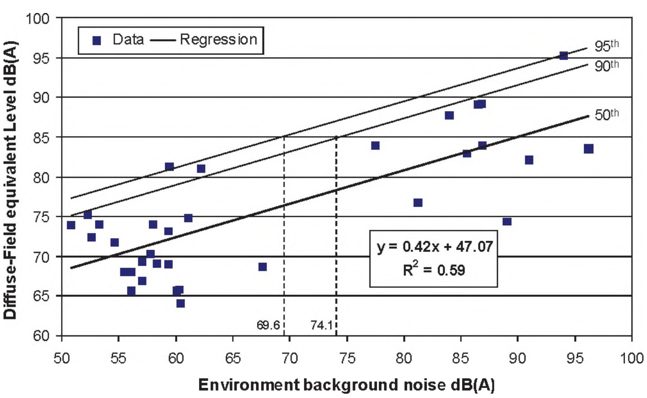

Fig. 1: Correlation between headset diffuse-field equivalent level and the environment background noise. Data from [4-5] (n=33).

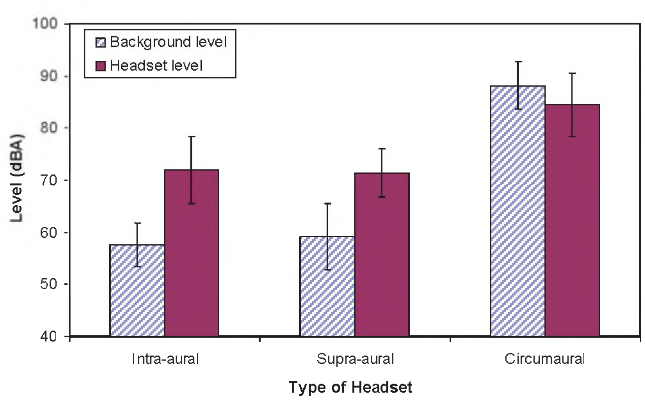

Fig. 2: Background and headset level in relation to headset type.

2.2 Defense Research and Development Canada (DRDC)

The evaluation of communication headsets for military applications has been an ongoing research stream at DRDC Toronto, using manikins and real-ear procedures. In one study [6], at-ear sound levels were measured using miniature microphones under 5 passive and active communication devices worn by 3 crew members inside a Hercules Aircraft. The crew members were asked to adjust the listening volume of the audio channel for adequate speech discrimination and comfort. Measurements were carried out both during communications (ON) and when no communications took place (OFF), allowing estimating the effective SNR under the device. From these data, a mean SNR of 13.8 dB and standard deviation of 6.7 dB across devices and crew members (n=22) can be calculated.

The result above can be used to further analyze the data from Figure 2. If we assume an SNR of +13.8 dB under the devices, the estimated attenuation of intra and supra-aural devices is -2 to +1 dB (as expected from general purpose headsets without rated attenuation) and about 18 dB for circumaural devices (in line with listed NRR).

3. CONCLUSIONS

This paper reviewed two earlier Canadian studies on communication headset exposure, covering both civil and military workplace settings. The headset equivalent sound level appears well correlated with the environment background noise around the user. Typical SNR under the device is in the order of 12-15 dB. Altogether, the studies provide good support for an indirect calculation method for CSA Z107.56 based simply on the measurement of background noise around the user and an estimate of the attenuation of the headset. The total exposure also depends on the proportion of time that audio communications take place during use of the device [2]. A similar approach was recently proposed in a review of the hearing loss prevention program for the Canadian military [7].

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