CSA APPENDIX ON MEASUREMENT OF NOISE EXPOSURE FROM HEADSETS

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1. INTRODUCTION

Several national and international standards, such as CSA Standard Z107.56 [1], provide procedures for the measurement of occupational noise exposure. They concentrate on situations where sources are far from the worker's ears. In some situations, the sound source is close to or even occludes the ears (e.g., headsets) and measurements have to be performed using different equipment and techniques. A new appendix to CSA Standard Z107.56 is currently being developed to cover measurements of noise exposure from employees wearing headsets for communication. This paper reviews different assessment methods for this application.

Standardized methods to measure sound levels directly under the device include the use of acoustic manikins, artificial ears and real-ear procedures [2-4]. For the final assessment, occluded-ear measurements must be converted to equivalent far-field levels. This conversion is required to compare the noise exposure under the occluded ear to the applicable regulatory limit (e.g. 85 dBA), the latter being referred to the exposure at the position of the worker and not inside the ear.

An alternative indirect calculation method is proposed here that includes the main determinants of exposure as input parameters into the assessment, such as the background noise around the worker, the attenuation of the device and the expected signal-to-noise ratio under the device. This method has the advantage that it facilitates the implementation of solutions or treatments to reduce exposure.

2. EXISTING MEASUREMENT STANDARDS FOR HEADSETS

2.1 ISO 11904

ISO 11904 describes a set of two related standards for the measurement of sound levels from sources located close to the ear.

ISO 11904-1 specifies acoustic measurements in the real ears of human subjects using miniature or probe microphones (MIRE technique) [2]. Acoustic measurements must be performed in 1/3-octave bands and transformed to equivalent A-weighted free or diffuse sound levels. The measurement microphone or probe can be located anywhere from the ear canal entrance to the eardrum, under open or blocked ear canal conditions. Transfer functions are provided to transform measurements to free or diffuse-field equivalent sound levels for predefined microphone measurement locations. A main advantage of this method is that it provides the most direct estimate of sound exposure for the worker. There is no need for a duplicate matched headset/headphone or modifications to the electrical connections to the device. The main disadvantages are that the method is invasive and may restrict head and body movements, and thus is difficult to implement in a real workplace for a sustained period of time. Sound leakages are also possible due to electrical wires or flexible tubing breaking the seal of the device against the ear or head, and flanking background noise through the flexible tubing outside the device may be an issue in some cases.

ISO 11904-2 specifies sound measurements on a manikin modeling the mechanical parameters and acoustical effects of the human ear, head and torso (manikin technique) [3]. The microphone is located in the ear simulator of the manikin. Acoustic measurements must again be performed in 1/3-octave bands and transformed to equivalent A-weighted free or diffuse sound levels. A main advantage of this method is that it is not invasive. The main disadvantage is that it typically requires parallel measurements using separate matched headsets for worker and manikin. Also, the equipment is not widely available and can be cumbersome to use in the workplace. Another limiting factor may be the difficulty to fit or couple the device to the pinna simulator and ear canal extension in a realistic manner owing to the different shape and mechanical properties between the manikin and ears of the workers under study.

2.2 AS/NSZ 1269.1

The Australian/New Zealand Standard AS/NZS 1269.1 contains Appendix C: "*Recommended procedures for measurement of sound pressure levels from headphones or insert earphones*" [4]. It describes several measurement methods. The primary method requires that an identical type of headphone or earphone (with similar response characteristics) be connected in parallel to the signal source

(with proper matching impedance network) used for the headphone or earphone of the worker. This additional headphone is applied to a wide-band artificial ear or an acoustic manikin in the case of headphones, or to an occluded-ear simulator in the case of insert earphones. The headphone signal applied to the measuring device is deemed identical to the one applied to the worker.

The advantage of the AS/NZS 1269.1 method is that it allows using an artificial ear or occluded-ear simulator that is inexpensive, easy for transportation and to be used in the workplace. However, there are several issues that largely affect the accuracy of the measurements. Also, the authors are not aware of a study that compares measurement results obtained using the manikin with the wide-band artificial ear or occluded-ear simulator.

3. CALCULATION METHOD

The calculation method provides a simpler approach which can be carried out by an industrial hygienist or safety officer using the same equipment used to measure noise exposure. In most cases, the listener adjusts the sound level under the device to be able to communicate properly. The signal-to-noise ratio (SNR) is usually set at around 10-15 dB. This fact provides another way of assessing the noise level at the ear, by measuring the room background noise, subtracting the attenuation of the headset (if there is any) and then correcting for the expected SNR and speech signal duration [5].

In practice, the measurement procedures are the same as used for employees without headsets. For a regulated limit of 85 dBA, this would mean that the combination of the background noise coming through the headset and the expected noise produced by the headset signal should be no louder than a sound-field equivalent level of 85 dBA. Most headsets provide little or no protection against external noise. Accordingly, the noise reduction of the headset is assumed to be zero unless the manufacturer can provide user fit octave band attenuation data. The calculation must also account for the duration the headset signal is ON.

An example of a simple calculation is given in Table 1, where the headset attenuation is assumed to be zero. Note that unless the use of the headset is extremely intermittent, the L_{ex} from the noise inside the headset is much lower than the signal from the headset. If the headset is used more than 1 hour per day, the background noise has less than 1 dB effect on the result. In such cases, the exposure under the headset can be calculated by simply adding 15 dB to the L_{ex} measured outside the headset (corrected for headset signal duration) and subtracting the NR of the headset (which is zero for most general purpose headsets). Thus, the L_{ex} under the headset equals the L_{ex} outside the headset (corrected for duration) plus 15 dB, provided the headset is used for more than 1 hour per day and no standardized attenuation data is available for the headset, which covers most applications.

Table 1. Example exposure calculation

	SL (dBA)	Duration (hr)
Room background noise level	70	8
Headset attenuation (NR)	0	
Background noise under headset	70	
Headset signal level when ON	85	
Hours headset signal is ON		1
Hours headset signal is OFF		7
Lex from background noise	**70**	**8**
Lex from headset signal	**76**	**8**
Total Lex	**77**	**8**

4. CSA WG

The Canadian Standard Association (CSA) has produced Standard Z107.56 "*Method for the measurement of occupational noise exposure*" [1]. It does not contain provisions for the measurement of noise from sources located close to the ear of the exposed person. In 2007, an ad hoc Working Group (WG) was created to prepare an Annex to the Standard that will deal specifically with the measurement of noise exposure from headsets. Members of the WG, selected from a broad range of practitioners and academia, are as follows:

Alberto Behar – University of Toronto
Art Thansandote – Health Canada
Christian Giguère – University of Ottawa
Christine Harrison – WorkSafeBC
Hans Kunov – University of Toronto
Hilmi Dajani – University of Ottawa
Joe Principato – RCMP/GRC
Marshall Chasin – Musician Clinic
Michael Sharpe – HCCA Ltd.
Stephen Keith – Health Canada
Warwick Williams – National Acoustic Labs (Australia)

It is expected that a first draft of the Annex will be prepared before the end of 2008. The authors of the present paper acknowledge the contributions by all members of the WG.

REFERENCES

[1] CSA Z107.56, *Procedures for the Measurement of Occupational Noise Exposure* (Canadian Standards Association, 2006).

[2] ISO 11904-1, *Acoustics – Determination of sound immission from sound sources placed close to the ear: Part 1: Technique using a microphone in a real ear (MIRE technique)* (International Organization for Standardization, 2002).

[3] ISO 11904-2, *Acoustics – Determination of sound immission from sound sources placed close to the ear: Part 2: Technique using a manikin (manikin technique)* (International Organization for Standardization, 2004).

[4] AS/NZS 1269-1, *Occupational noise management Part 1: Measurement and assessment of noise immission and exposure* (Standards Australia and Standards New Zealand, 2005).

[5] Giguère and C. Laroche, "Hearing loss prevention program in the military environment," *Canadian Acoustics* **33**(4), 21-30 (2005).