

tested at 130, 150, and 170 dB peak sound pressure level with the Institute de Saint Louis heated and unheated fixture and the GRAS 45CB heated ATF. IPILs exhibited good agreement across all three fixtures for earplugs. Significant differences were observed between the fixtures for the earmuff-only condition. These differences were more evident for the double-protection condition. [Portions of this work were supported by the U.S. EPA Interagency Agreement DW75921973-01-0.]

9:15

3aNS4. Insertion-loss and transfer-function performance of two new acoustical test fixtures complying with ANSI S12.42-2010, relative to performance of prior test fixtures and to real-ear data. Elliott H. Berger, Ronald W. Kieper, and Michael E. Stergar (3M Occupational Health & Environ. Safety Div., 7911 Zionsville Rd., Indianapolis, IN 46268-1657)

The most recent American National Standards Institute (ANSI) standard for the measurement of the insertion loss of hearing protection devices (HPDs), ANSI/American Standards Association (ASA) S12.42-2010, specifies a new-concept acoustical test fixture (ATF). It is similar to some existing ATFs but differs in terms of the required ear canal length, inclusion of a simulated flesh lining the ear canal, and a heater to bring the test fixture to approximate body temperature. These features were deemed necessary to develop a device that provides insertion loss data with reasonable correspondence to performance on human heads, as the ATF is the preferred method in the standard for tests on certain electronic earplugs and for all impulse testing. Within a year of the issuance of the standard, at least two ATFs [one produced by G.R.A.S. Sound and Vibration and the other produced by the Institute of St. Louis] became available. The studies reported herein will provide an initial evaluation of these two heads compared to prior art, based on ATF insertion-loss measurements for a sample of passive earplugs and earmuffs versus real-ear attenuation at threshold per ANSI S3.19-1974. Additionally, the ATFs' transfer function of the open ear in a diffuse field will also be reported.

9:45

3aNS5. Attenuation performance of active noise reduction headsets using American National Standard s12.42 and the proposed U.S. Environmental Protection Agency Hearing Protector Labeling Regulation. Richard L. McKinley, Hillary L. Gallagher (Air Force Res. Lab., 2610 Seventh St. WPAFB, OH 45433, richard.mckinley@wpafb.usaf.mil), Melissa A. Theis (Oak Ridge Inst. for Sci. and Education, TN 37831), and Paul C. Schley (Ball Aerosp. and Technologies Corp., Fairborn, OH 45324)

The attenuation performance and noise reduction rating (NRR) of six commercially available active noise reduction (ANR) headsets was assessed using the proposed environmental protection agency (EPA) regulation. The passive attenuation results were collected using American National Standard Institute (ANSI) S12.6 method for measuring real-ear attenuation at threshold (REAT) of hearing protectors while the active attenuations results were collected using ANSI S12.42 methods for the measurement of insertion loss of hearing protection devices in continuous or impulsive noise using microphone-in-real-ear (MIRE) or acoustic test fixture procedures. ANSI/ASA S12.68 methods of estimating effective A-weighted sound pressure levels when hearing protectors are worn was used to compute noise reduction metrics including the noise reduction statistic A-weighted (NRSA) and the graphical noise reduction statistic (NRSG). The proposed NRR labels for the ANR headsets were computer per the guidance in the draft U.S. EPA regulation. The presentation will include the baseline passive, active, and total attenuation, the NRSA and the Graphical NRSG, and the proposed EPA labels for passive attenuation and total attenuation while in an active mode.

10:15–10:30 Break

Contributed Papers

10:30

3aNS6. 1. Comparison of the HPDLAB and REATMASTER software/hardware systems for ANSI S12.6 testing. David C. Byrne (NIOSH–Taft Labs., 4676 Columbia Parkway, MS C-27, Cincinnati, OH 45226, DByrne@cdc.gov), Caryn C. Perry (Univ. of Cincinnati, Cincinnati, OH 45267), and William J. Murphy (NIOSH–Taft Labs., Cincinnati, OH 45226)

The American National Standard Methods for Measuring the Real-Ear Attenuation of Hearing Protectors (ANSI S12.6-2008) requires a Békésy procedure for testing occluded and unoccluded thresholds. Since 2002, the National Institute for Occupational Safety and Health (NIOSH) has used the custom-designed HPDLAB software operating Tucker-Davis Technologies System 3 hardware. ViAcoustics, Nelson Acoustics, NASA, and NIOSH researchers recently developed REATMASTER which runs on National Instruments hardware in the LABVIEW environment. Ten subjects were trained by the experimenter on how to fit a passive earmuff and were qualified according to the requirements of ANSI S12.6-2008. The laboratory was configured such that diffuse sound field thresholds were tested with either the HPDLAB or REATMASTER hardware by flipping a toggle switch. The earmuff was not touched or re-positioned between test trials with the two different hardware/software systems. The test sequence for the order of open and occluded measurements was counterbalanced across occluded conditions and hardware system. Results from this testing were used to validate the REATMASTER system for its ability to produce accurate threshold data. Preliminary results indicate no significant differences between the two systems.

10:45

3aNS7. Calibration details for the impulse peak insertion loss measurement. William J. Murphy and Julia A. Vernon (Hearing Loss Prevention Team, NIOSH, 4676 Columbia Parkway MS C-27, Cincinnati, OH 45226-1998, wjm4@cdc.gov)

The American National Standard ANSI S12.42-2010 specifies the measurement of hearing protector performance in the presence of impulse noise. A series of calibration impulses are recorded from an acoustic test fixture (ATF) and a field microphone for peak sound pressure levels of 130, 150, and 170 dB. The averaged acoustic transfer function between the ATF and field microphone is calculated as follows:

$$\bar{H}_{ATF-FF}(f) = \frac{\overline{FFT}(P_{ATF,i}(t))}{FFT}(P_{FF,i}(t))$$

The transfer function is computed for each of the ranges of impulse levels and is applied to the field microphone measurements to estimate the unoccluded fixture levels of the ATF when hearing protection is being tested. This method allows a comparison between occluded and unoccluded waveforms. The calibration transfer function is affected by the time-alignment of the field impulse peaks, time-windowing of the impulses, and compensation for any dc bias. Time-alignment significantly affected the accuracy of predicting individual calibration levels with \bar{H}_{ATF-FF} . The prediction error variance was less at 170 dB than at 130 dB impulses. The time-window was varied from 2.5 to 100 ms preceding the peak of the field impulse. [Portions

11:00

3aNS8. Measuring, rating, and comparing the real ear attenuation at threshold of four earplugs. William J. Murphy, Mark R. Stephenson, and David C. Byrne (Hearing Loss Prevention Team, NIOSH, 4676 Columbia Parkway MS C-27, Cincinnati, OH 45226-1998, wjm4@cdc.gov)

The effect of training instruction, whether presented as the manufacturer's printed instructions, a short video training session, specific to the product, or as a one-on-one training session, was evaluated using four hearing protection devices with eight groups of subjects. The Howard Leight Fusion and Airsoft premolded earplugs and the Moldex PuraFit and EAR Classic foam earplugs were tested. Naïve subjects were recruited and tested using three different forms of training: written, video, and individual training. The differences between group averages for A-weighted attenuation were not statistically significant when compared between the video or the written instruction conditions, regardless of presentation order. The experimenter-trained A-weighted attenuations were significantly greater than the written and video instruction for most of the protectors and groups. For each earplug, the noise reduction statistic for A-weighting (NRSA) and the associated confidence intervals were calculated for the 90th and 10th percentiles of protection. Across subject groups for each protector, the differences between NRSA ratings were found to be not statistically significant. Several comparisons evaluating the order of testing, the type of testing, and statistical tests of the performance across the groups are presented. [Portions of this work were supported by the U.S. EPA Interagency Agreement DW75921973-01-0.]

11:15

3aNS9. ANSI S12.42-2010 measurements of impulse peak insertion loss for passive hearing protectors. Kevin Michael (Michael & Assoc., Inc., 2766 W. College Ave., St. 1, State College, PA 16801, kevin@michaelassociates.com) and Jeff G. Schmitt (ViAcoust., Austin, TX 78745)

Until recently, a standardized measurement procedure to determine peak insertion loss for hearing protectors was not available. This has led to confusion and uncertainty for hearing protector users who commonly use the devices in impulse noise, such as gunfire. Released in 2010, ANSI S12.42-2010 defines a test method and analysis procedure for measuring hearing protector impulse peak insertion loss. The required test fixture has recently become commercially available and laboratories are gaining experience making these measurements. Impulse peak insertion loss data will be presented for a variety of hearing protector types along with a description of the measurement procedure.

3aNS10. Real-ear attenuation of custom-fit earplugs with the communications earplug (CEP). Elmaree Gordon and Efreem R. Reeves (USAARL, Acoust. Branch, 6901 Farrel Rd., P.O. Box 620577, Fort Rucker, AL 36362-0577, elmaree.gordon@us.army.mil)

Hearing loss is one of the most common occupational injuries in the Department of Defense. One reason is limited access to adequate hearing protection during combat operations. Even if traditional pre-formed foam earplugs are used during combat, approximately 15% of the military population remains unprotected because the pre-formed earplugs do not adequately fit extremely small ear canals, extremely large ear canals, or ear canals with sharp turns. Custom-fit earplugs provide a potential solution for this hard-to-fit population. However, producing traditional wax-dipped custom-fit earplugs in a combat environment is not always practical. Fortunately, methodology exists to scan ear impressions to create a digital data set, transmit this data to a remote manufacturer via the Internet, and fabricate a set of custom-fit earplugs. The purpose of this study was to investigate how the attenuation provided by custom-fit earplugs created using the digital scanning technique compares to the attenuation provided by custom-fit earplugs created using the traditional wax-dipped technique when used with the CEP. Results show the digitally scanned custom-fit earplugs provide significantly poorer attenuation than the traditional wax-dipped custom-fit earplugs. Comply Canal Tip foam earplugs were also evaluated and shown to provide significantly greater attenuation than custom-fit earplugs manufactured by either method.

11:45

3aNS11. Noise surveys and hearing protection at the Royal Canadian Mint plant. (Jimmy) Jianping Yan (Corporate Eng., Royal Canadian Mint, 320 Sussex Dr., Ottawa, ON, K1A 0G8, Canada)

Royal Canadian Mint is a Crown Corporation to produce circulation and non-circulation coins for Canada and other countries. Noise measurements have been conducted regularly for production environment and before any new equipment operation in Royal Canadian Mint, and to protect our employee from hearing loss is one of our health and safety issues applied in whole plant. The formula used in the noise measurement is introduced in this paper, and the noise calculations are also discussed for the continuous noise sources, intermittent noise sources, and the combinations of individual noise sources. Some noise survey results are listed and analyzed, and the related hearing protective methods in our plant are also described.

WEDNESDAY MORNING, 2 NOVEMBER 2011

ROYAL PALM 3/4, 7:45 A.M. TO 12:00 NOON

Session 3aPA

Physical Acoustics: Theoretical and Computational Advances

Bonnie Schnitta, Chair

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Contributed Papers

7:45

3aPA1. Formulation and applications of an integral-equation approach for solving scattering problems involving an object consisting of a set of piecewise homogeneous material regions. Elizabeth Bleszynski, Marek Bleszynski, and Thomas Jaroszewicz (Monopole Res., 739 Calle Sequoia, Thousand Oaks, CA 91360)

The paper presents the formulation and selected applications of the surface integral equation approach for finding pressure, displacement, and

traction fields in a complex object consisting of a set of piece-wise homogeneous regions characterized by different Lamé material parameters. Representative applications of the approach are presented, which involve finding pressure field distribution inside human inner ear treated as an inclusion embedded in the surrounding inhomogeneous material. (the embedding region is treated with volumetric integral equations with suitable coupling to the inclusion). The method uses a set of coupled elastodynamics integral equations for two unknown fields: displacement and traction at each interface, which allow us to find displacement and traction field distribution inside a