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MILITARY STANDARD

PHYSICAL EAR NOISE ATTENUATION TESTING

AMSC N/A

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FOREWORD

PHYSICAL EAR NOISE ATTENUATION TESTING

1. This military standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be used in improving this document should be addressed to: U.S. Army Natick Research, Development, and Engineering Center, Natick, MA 01760-5017 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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1. SCOPE

1.1 Scope. This standard establishes the methodology and instrumentation requirements for quality assurance testing (QAT) for noise attenuation characteristics of hearing protective devices. The physical-ear method, intended as a quick economical screening technique, is set forth as a supplement to full real-ear testing. This method should not be used for design qualification testing or first article testing of hearing protective devices.

1.2 Application. The requirements defined herein apply to all circumaural hearing protective devices, to include but not limited to sound attenuating helmets, communications headsets, and earmuffs, purchased under contract for use by the Department of Defense.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issue of these documents are listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.1).

STANDARDS

MILITARY

MIL-STD-1472 - Human Engineering Design Criteria for Military Systems, Equipment and Facilities

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.1).

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S1.1 Acoustical Terminology (Including Mechanical Shock and Vibration)

ANSI S1.6 Preferred Frequencies, Frequency Levels, and Band Numbers for Acoustical Measurements

ANSI S1.8	Preferred Reference Quantities for Acoustical Levels
ANSI S1.11	Specification for Octave, Half-Octave and Third-Octave Band Filter Sets
ANSI S1.13	Methods for Measurement of Sound Pressure Levels
ANSI S12.6	Methods for Measurement of the Real-Ear Attenuation of Hearing Protectors

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018-3308.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Decibel (dB). A unit to express sound pressure level. The decibel is a unit of level when the base of the logarithm is the tenth root of ten, and the quantities concerned are proportional to power. The dB has meaning only when the referenced quantity is known. The internationally accepted reference pressure in acoustics is 20 micropascals which corresponds to 0 dB.

3.2 Frequency. The number of repetitions or cycles of pressure variations of a sound per unit time. The unit of measurement for frequency of tones is the hertz (Hz), the international symbol for cycles per second.

3.3 Noise. A sound having a complex character with numerous separate frequency components extending over a wide range of frequencies and not generated to convey meaning or information. Steady noise is a continuous random variation of these frequency components.

3.4 Physical-ear attenuation. The arithmetic difference (in decibles) between the one-third octave band pressure levels of the signals measured by the microphone in the subject's ears with and without the device being worn.

3.5 Random incidence field. A sound field in which the angle of arrival of sound at a given point is random in time.

3.6 Reverberation time. The time that would be required for the mean-square sound pressure level, originally in a steady state, to fall 60 dB after the source is stopped.

3.7 Sound spectrum. The pattern of distribution of energy or sound pressure in different bands along a frequency scale. One-third octave bands of noise will be used for tests conducted under this standard in accordance with ANSI S1.6. All one-third octave bands with center frequencies between 100 and 10,000 Hz will be included.

3.8 Additional definitions. Additional definitions and references may be found in ANSI S1.1.

4. GENERAL REQUIREMENTS

4.1 System requirements. The system requirements include all parts necessary to conduct the measurement of physical ear attenuation and ensure the calibration of that system.

4.1.1 Microphone requirements. The microphone used to measure the sound pressure level at the subject's ear shall be of minimum size and no greater than 7.25mm by 5.0mm. The open circuit frequency response shall not deviate more than 3 dB, referenced to 1000 Hz from 100 Hz to 10,000 Hz.

4.1.2 Sound field characteristics. A random incidence sound field, as approximated by the following conditions, is required for each one-third octave band test frequency from 100 to 10,000 Hz. The sound pressure level measured at six positions relative to the center of the subject's head (without subject), $\pm$ 15 cm (5.9 inches) in the front/back dimension, left/right dimension, and up/down dimension, shall remain within 6 dB for all test bands. The difference in sound pressure level between the right/left position shall not exceed 2 dB.

4.1.2.1 Reverberation time. The sound shall be generated whose reverberation time in the test space (without subject) shall be less than 1.6 seconds for each of the test bands.

4.1.2.2 Sound level. The band sound pressure level measured at the subject's head location for each test band frequency shall not be less than 85 dB with reference to 20 micropascals and will be at least 20 dB higher than the level of the test room ambient noise in each test band.

4.1.2.3 Sound pressure level. The sound pressure level shall be determined using methods described in ANSI S1.13.

4.1.2.4 Reference levels. Acoustic levels shall be referenced in accordance with ANSI S1.8.

4.1.3 Analysis system. The analysis system shall condition the signal from the in-the-ear microphones, analyze the microphone output signals into sound pressure levels for each one-third octave band, and display the results. The system shall meet the minimum requirements described in the following paragraphs.

4.1.3.1 Dynamic range. The dynamic range of the system shall provide a sub-range which is greater than 60 dB and which may be moved over a range of 40 dB with controlled amplification.

4.1.3.2 Input gain characteristics. The gain characteristics of the system shall be such that the microphone output will remain above the system's baseline noise level by more than 10 dB for any testing configuration.

4.1.3.3 One-third octave band characteristics. The filter characteristics shall meet the requirements of ANSI S1.11 order 3, type 1-B.

4.1.3.4 Integration time. The integration time to determine the sound pressure level of the microphone output shall be of such duration as to ensure that an estimate of the mean will be within 1 dB of the true mean with a 0.9 confidence limit.

4.1.3.5 One-third octave test band. The one-third octave test band shall be defined as having centers at the following frequencies; 125, 250, 500, 1000, 2000, 3150, 4000, 6300, and 8000 Hz.

4.1.4 Sound generation system. The sound generation system shall consist of a wide band noise source, power amplifier, and multiple speakers.

4.1.4.1 Noise source. The noise source shall provide an electrical noise signal which shall be either a uniform pink or white noise spectrum from 100 to 10,000 Hz.

4.1.4.2 Amplifier system. The amplifier shall be capable of driving the speakers sufficiently to provide the power required to attain sound pressure levels necessary to ensure a 10 dB signal to noise ration for all testing configurations.

4.1.4.3 Speaker system. The speaker system shall be capable of producing the sound pressure levels described in 4.1.2.2.

4.1.5 System calibration. The system shall be performed as necessary or specified to ensure the proper operation of the equipment and the accuracy of the data.

4.1.5.1 Sound field validation. The directionality of the sound field shall be evaluated using a directional microphone that exhibits at the third octave test bands at least 10 dB front-to-side rejection for a cosine microphone, or at least 10 dB front-to-back rejection for a cardioid microphone in its free field response. The sound field shall be considered satisfactory if the variation in the microphone output is less than the values shown in table I when the microphone is rotated about it's axis in each of the three major perpendicular planes of the room for each of the one-third octave test bands described in 4.1.3.5.

TABLE I. Allowable random incidence field response variation for corresponding mircophone free field rejections 1/

Microphone free-field rejection (dB)	Allowable random incidence field response variation (dB)
Greater than 25	6
20	5
15	4
10	3
Less than 10,	microphone not suitable

1/ The variation in microphone response as the microphone is rotated in a random incidence field is related to the directional characteristics of the microphone and the degree of randomness of the field. Allowable sound field response variations shall be presented in terms of the free field directional response of the microphone. The microphone free field rejection may be obtained by measurement or from the manufacturer.

4.1.5.2 Local variation. Variation of the sound pressure level of the noise at the subject's head location shall not exceed that described in 4.1.2 for each one-third octave test band.

4.1.5.3 System dynamic range. The system dynamic range for all measurement conditions shall be sufficient for a signal to noise ratio of no less than 10 dB for each frequency band from 10 to 10,000 Hz. Measurement conditions include sound field, analysis system, and hearing protector attenuation.

4.2 Subject's characteristics.

4.2.1 Head size. The head size of each subject shall be appropriate for the device being tested as specified by the military specification, or in the absence thereof, other government requirement documents. In the absence of a government document, appropriate head size shall be in accordance with the manufacturer's published guidelines. Special care must be taken to assure proper fit.

4.2.2 Hair length. Hair length shall be compatible with the device under test. When fitting the subject with a device, the hair shall be moved such that the ear pad will make maximum direct contact with the subject's skin around the piano.

4.2.3 Anthropometric data. Anthropometric data shall be measured in accordance to Head and Face Dimensions of MIL-STD-1472. The measurements obtained for each subject shall be reported in an appendix of the attenuation report. The following measurements are required:

a. Head circumference (at the largest diameter)
b. Head length
c. Tragion to wall
d. Head breadth
e. Bitragion breadth
f. Head height (tragus to top of head)

4.2.4 Disqualification. Subjects who satisfy the other requirements of this standard who obtain an adequate fit with the test device shall not be dismissed for producing small amounts of attenuation. All subjects disqualified for any reason shall be listed in an appendix to the report and a specific reason shall be given for such disqualifications.

4.3 Measurement procedures. The following procedures shall be followed for all physical ear tests accomplished under this standard.

4.3.1 Subject fitting. All subjects shall be required to wear insert hearing protectors during all tests conducted under this standard. The Silaflex moldable earplug, manufactured by Flentz Products, has been used successfully for this test. The earplug is used to occlude the ear canal, providing hearing protection for the subject while furnishing a mounting base for the measurement microphone.

4.3.2 Head position. Some means shall be used to provide a reference for maintaining the listener's head position (not a head rest; plum bob to the nose of the listener has proven acceptable). This device shall not transmit to the listener's head any vibration that might affect the measurement of present a reflective or absorptive surface that might alter the sound field.

4.3.3 Microphone fitting. The subject shall be fitted with a miniature microphone, described in 4.1.1, in the area of each ear canal opening. The microphone will be secured so the fitting of the hearing protector will not change it's position. The sensing surface of the microphone shall be directed away from the subject's head as much as possible. The wires from the microphone shall be of minimal diameter to reduce leakage of noise into the protector cavity.

4.3.4 Unoccluded measurement. The unoccluded measurement shall be one-third octave band analysis of each microphone output completed with each subject in the sound field. The measurement will be taken with the subject in the sound field. The measurement will be taken with the insert protector and microphone, and without the device under test, being worn by the subject.

4.3.5 Attenuated measurement. The attenuated measurement shall be a one-third octave band analysis of each microphone output completed while the subject is wearing the device under test while in the sound field. Three attenuated measurements shall be completed for each subject. The subject shall be refitted with the hearing protector between each of the attenuated measurements.

4.3.6 Calculation of noise attenuation. The attenuation of the left and right earcup of a circumaural hearing protector shall be the difference in dB of one-third octave band analysis fo the unoccluded and attenuated or measurements for each frequency for each ear of the subjects in the evaluation. The attenuation of the left and right earcup shall be reported independently. The attenuation of the hearing protector's left and right earcup shall be summarized and shall include mean and standard deviation for each of the frequencies described in 4.1.3.5. The mean shall be computed for each earcup by averaging all attenuation values for all observations at each test frequency. The standard deviation of the attenuation mean shall be computed using the number of observations minus one (N-1). Typically the number of observations will be 30 (10 subjects measured three times each).

4.4 Requirements for reporting and use of data.

4.4.1 Reporting of data. Raw data for each earcup attenuation shall be reported in tabular forms by each subject/observation at each frequency. Results of statistical analysis shall be reported by the one-third octave center frequencies described in 4.1.3.5.

4.4.1.1 Average attenuation data for each device. The mean and standard deviation of the attenuation results shall be reported for each one-third octave frequency described in 4.1.3.5.

4.4.1.2 Anthropometric data for each subject. The measurements described in 4.2.3 shall be reported for each subject used in the measurement.

TABLE II. Sample data report

	Attenuation in dB of the right ear protector Center Frequencies in Hertz								
Subject/ Observation	125	250	500	1000	2000	3150	4000	6300	8000
S1/1	8	12	23	26	30	36	40	41	35
S1/2	9	10	24	27	30	35	43	42	37
S1/3	8	11	23	28	31	32	40	40	36
S2/1	4	9	21	27	33	34	39	38	33
"									
"									
"									
S10/3	12	10	22	25	32	33	38	40	34
Mean	10.4	11.2	22.1	26.3	33.0	34.1	40.6	40.5	35.4
Std Dev	3.1	2.2	4.2	3.4	2.1	2.8	2.7	3.4	3.6

TABLE II. Sample data report (cont'd)

	Attenuation in dB of the left ear protector Center Frequencies in Hertz								
Subject/ Observation	125	250	500	1000	2000	3150	4000	6300	8000
S1/1	8	12	23	26	30	36	40	41	35
S1/2	9	10	24	27	30	35	43	42	37
S1/3	8	11	23	28	31	32	40	40	36
S2/1	4	9	21	27	33	34	39	38	33
"									
"									
"									
S10/3	12	10	22	25	32	33	38	40	34
Mean	10.4	11.2	22.1	26.3	33.0	34.1	40.6	40.5	35.4
Std Dev	3.1	2.2	4.2	3.4	2.1	2.8	2.7	3.4	3.6

5. DETAILED REQUIREMENTS

This section is not applicable to this standard.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Issue of DODISS. When this standard is used in acquisition, the applicable issue of the DODISS must be cited in the solicitation (see 2.1.1 and 2.2).

6.2 Subject term (key word) listing.

Acoustics testing
Hearing
Noise
Sound

CONCLUDING MATERIAL

Custodians:

Army - GL
Navy - AS
Air Force - 11

Review activities:

Army - CR, MD, MI

Preparing activity:

Army - GL

(Project HFAC-0032)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER	2. DOCUMENT DATE (YYMMDD)
	MIL-STD-912	1990 December 11

3. DOCUMENT TITLE

PHYSICAL EAR NOISE ATTENUATION TESTING

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (If applicable)	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY

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U.S. Army Natick RD&E Center	(1) Commercial 508-651-4531	(2) AUTOVON 256-4531
c. ADDRESS (Include Zip Code) Commander, U.S. Army Natick RD&E Center ATTN: STRNC-UXT Natick, MA 01760-5017	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340	