Chapter 5 – Noise

1. General

a. This chapter provides the basic information necessary to evaluate and document employee noise exposure and to assist with determining compliance with Department of Defense (DoD) noise instructions. For more detailed information, see references.

b. Forms for noise surveys and noise dosimetry are listed in Section 12 Forms, of this chapter.

c. Information on enrollment into and execution of a Hearing Conservation Program can be found in References 5-1, 5-2, and 5-3.

2. Definitions

a. Continuous Noise. Noise where any intervals between impulses are less than 0.5 second, except for short bursts of automatic weapons fire, which are considered impulse noise (Reference 5-1).

b. Crest Factor. For steady–state repetitive sound wave form, it is equal to the ratio of peak acoustic pressure to the root-mean-square (RMS) sound pressure level (SPL) for a given noise measurement situation. The crest factor characterizes a sound measuring instrument's ability to accurately measure transient or impulse SPLs. Instruments should have a crest factor capability adequate to handle the noise waveform (Reference 5-4).

c. Criterion Level. The continuous equivalent A-weighted SPL which constitutes 100 percent of an allowable exposure. For DoD purposes, this is 85 dBA as an 8-hour time-weighted average (TWA) in a 24-hour period (Reference 5-1). The dosimeter readout can be used to calculate both the continuous equivalent A-weighted SPL (L_A) and the 8-hour TWA for the time period sampled, using the following equations:

$$L_A = 85 + \left(10 \times \log\left[\frac{D}{12.5 \times T}\right]\right)$$

Equation 5-1

$$TWA = 85 + \left(10 \times \log\left[\frac{D}{100}\right]\right)$$

Equation 5-2

Where:
L_A = continuous equivalent A-weighted SPL, in decibels, for the time period sampled, if the Criterion Level is 85 dBA as an 8-hour TWA exposure and the Exchange Rate is 3 dB
D = dosimeter read-out in percent noise dose
T = sampling time in hours
For impact or impulse noise, the criterion level is 140 dB peak dBP SPL (Reference 5-1).

d. Decibel (dB). The unit of measurement for SPL. The SPL, in dB, is equal to 20 times the common logarithm of the ratio of the existing sound pressure to a reference sound pressure of 20 micro-pascals.
    (1) A-Weighted Sound Level (dBA). SPL (in decibels) measured using a sound level meter with an A-weighting network. The A-weighted response is maximum at 2500 Hz and drops rapidly as frequency decreases below 1000 Hz and gradually decreases above 4000 Hz, thereby approximating the frequency dependent human response to moderate sound levels (Reference 5-5). See Reference 5-6 for definition of A-weighting filter characteristics.
    (2) C-weighted Sound Level (dBC). SPL (in decibels) measured using a sound level meter with a C-weighting network. It is generally used to limit the low and high frequency response of the instrument so that the instrument will not respond to signals outside the human hearing frequency range at high sound levels (Reference 5-5). See Reference 5-6 for definition of C-weighting filters.
    (3) Decibel, Peak (dBP). Instantaneous SPL when measured by a sound level meter (SLM) using an impulse or peak hold circuit having a rise time constant not exceeding 35 milliseconds. See also the following definition of Peak SPL in chapter 3 of Reference 5-4.

e. Dosimeter. An instrument worn by personnel for determining their accumulated workplace noise exposure with regard to SPL and time according to a pre-determined integration formula. This instrument shall meet the requirements of Reference 5-7.

f. Dosimeter Threshold Level. Threshold level is the A-weighted SPL at which a noise dosimeter begins to integrate the noise into the measured exposure. For DoD purposes this is 80 dBA. All sound levels from 80 dBA to 130 dBA, at a minimum are integrated (Reference 5-1).

g. Exchange Rate. The exchange rate is a trade-off between the SPL in dB and the duration of exposure in hours. The DoD exchange rate is 3 dB (Reference 5-1.) Each 3 dB increase in SPL (above the 85 dBA 8-hour TWA criterion level) can be balanced by a 50% reduction in unprotected exposure duration.

h. Impact Noise. Noise produced by a single collision of one mass in motion with a second mass, generally less than one second in duration and which repeats no more than once per second. (Reference 5-4).

i. Impulse Noise. Impulse noises are usually considered to be singular noise pulses, each less than one second in duration, or series of repetitive noise pulses that may last longer than 1 second (Reference 5-5). Also defined as a change of sound pressure of 40 dB or more within 1 second (Reference 5-1).

j. Meter Response. The motion of the SLM’s needle or digital output resulting from an excitation (stimulus). To allow the user to follow the movement of the results, “slow” and “fast” averaging circuits are built into the sound level meter. In practical terms, the “slow” circuit allows visual tracking of the average SPL and the “fast” circuit allows visual tracking of the variability of the SPL. SLMs should usually be set for “slow” response, which has an exponential time averaging constant of 1,000 milliseconds. Type 0, 1 and 2 SLMs are also equipped with a "fast" response setting which has an exponential time averaging constant of 125 milliseconds. Some SLMs are equipped with an "impulse" response setting which has an exponential rise time averaging constant of 35 milliseconds. The "impulse" setting also has a decay constant of 1,500 milliseconds which is sufficiently slow to allow a user to manually record the maximum reading before it disappears from the display. The "impulse" response setting is not sufficiently fast to measure true peak SPLs due to impulse or impact noise (Reference 5-4). See Section 3 Noise Measurement Instruments, for instruments needed to measure impact and impulse noise.

k. Noise. An undesired sound; may be either intermittent or continuous.

l. Noise Dosimeter. An instrument used to measure, store and integrate SPLs over a time period which meets the requirements of Reference 5-7. By integrating the SPL measurements, noise dosimeters can provide a cumulative noise-exposure measurement for a given period of time.

m. Noise Reduction Rating (NRR). A single-number that represents the attenuation index of the hearing protection device (HPD). The Environmental Protection Agency (EPA) developed this number in the laboratory in 1979 and it was pre-calculated by the HPDs Manufacturers and provided on their packages (Reference 5-4).

NOTE: Although HPDs are recommended for protection against impulse noise, the NRR is based on the attenuation of continuous noise and may not be an accurate indicator of the protection attainable against impulsive noise (Reference 5-8).

n. Pulse Range. It is the average of isolated and repetitive impulses of a sound wave. The crest factor and pulse range only rate the ability of an instrument to average or integrate sound waveforms (Reference 5-4).

o. Peak Sound Pressure Level. The maximum instantaneous SPL that occurs during a specified time interval. The peak detector in Type 0 SLMs provides acceptable measurements of 50 microsecond duration impulse/impact noise and in Type 1 and 2 SLMs for 100 microsecond duration impulse/impact noise (Reference 5-4).

p. Rise Time. The time required for a sound to reach its maximum level during a stated time period.

q. Root Mean Square (RMS). Square root of the arithmetic mean of the squares of a set of instantaneous amplitudes, or a set of values of a function of time or other variable.

r. Sound Level Meter (SLM). An instrument used to measure SPLs which meets the requirements of Reference 5-6.

s. Sound Pressure Level (SPL). The RMS value of the pressure changes above and below atmospheric pressure when used to measure steady state noise.

3. Noise Measurement Instruments

SLMs and noise dosimeters are used to assess an employee's exposure to noise. Octave band analyzers (OBA) are used to identify the frequencies at which the noise is generated and are mainly used to aid in selecting engineering controls.

a. Sound Level Meters (SLM). All SLMs used by the Navy will conform, as a minimum, to the Type 2 requirements cited in Reference 5-6, which set performance and accuracy tolerances. The SLM will be electroacoustically calibrated and certified annually. An acoustical calibrator, accurate to within one dB, will be used to calibrate the instrument before each survey and to revalidate the calibration at the conclusion of the survey. Acoustical calibrators will be electroacoustically calibrated and certified annually. See Industrial Hygiene Field Operations Manual (IHFOM) Chapter 8, Equipment Maintenance and Calibration for specifics on calibrating all noise measuring instruments.

(1) Types of SLMs.

(a) Type 0. Laboratory standard. Used as a high precision reference in the laboratory; not intended for field use.

(b) Type 1. Precision SLM. Can be used in the field and laboratory.

(c) Type 2. General purpose SLM. Designed to have less stringent tolerances than Type 1; used for field measurements.

(d) Type S. These SLMs may have some but not all of the features required of a specified type. They are not generally acceptable for Navy Industrial Hygiene (IH) work.

(2) Continuous or intermittent noise will be measured in dBA with a SLM set for slow response with the following weighing scales:

(a) The A-weighting scale approximates the equal loudness perception characteristics of human hearing for pure tones relative to a reference of 40dB SPL at 1 KHz (i.e. the 40-phon curve). (See References 5-5 and Reference 5-6.) This scale discriminates against acoustic energy in the low frequency ranges (Reference 5-4).

(b) The C-weighting scale approximates the equal loudness perception characteristics of human hearing for pure tone relative to a reference of 100 dB SPL at 1KHz (i.e. the 100 phone curve). (See References 5-5 and Reference 5-6.) It responds with little discrimination against low frequencies, detects more energy and may result in higher measurements than the A scale. For this reason, C-weighted SPL measurements should be taken and used to determine hearing protector performance (see Reference 5-4).

(3) Impact or impulse noise, from non-weapons fire, shall be measured as dBP SPLs with SLMs which have an impulse or peak hold circuit, a rise time constant not exceeding 35 milliseconds and the capability to measure peak SPLs of at least 140 dBP (Reference 5-1).

(4) Impulsive noise, from weapons fire, shall be measured according to the requirements outlined in Reference 5-9, which indicates measurement procedure and recording equipment criteria with respect to the kiloPascal (kPa) or dB level.

b. Noise Dosimeters. Specifications for noise dosimeters are provided in Reference 5-7. For Navy use, the dosimeter must meet, as a minimum, class 2A-85/80-3 where:
   (1) "2" means that the dosimeter has tolerances that correspond to those for a Type 2 SLM (Reference 5-7).
   (2) "A" means the A-frequency weighting network,
   (3) "85" means a 85 dBA slow criterion level,
   (4) "80" means a 80 dBA threshold level, and
   (5) "3" means a 3 dB exchange rate.
   (6) Additionally, dosimeters shall be capable of accurately measuring impulse noise between 80 dB and 130 dB (Reference 5-1).
   (7) Also, when a noise dosimeter requires programming of an upper limit, it shall be set as high as the instrument is capable of reliably measuring but in no case less than 130 dB (Reference 5-1).
   (8) Although not required, a data-logging capability which will allow collection of time history data is strongly recommended when dosimetry results will be used to devise noise control strategies. The ability to field select different criterion levels and exchange rates is also desirable but not required.

c. Octave Band Analyzers (OBA). OBAs are used to determine where sound energy lies in the frequency spectrum. This is important for recommending engineering controls for noise. Always follow the manufacturer's instructions when taking OBA measurements. These measurements usually require several minutes to complete, therefore, the sound being measured must be steady state and of a long enough duration to complete the measurements.

4. Noise Measurement Records

Reference 5-2 requires that noise measurement records be kept for 40 years after the data is collected. Reference 5-3 requires that noise measurement records be kept for 50 years after the data is collected. References 5-1 and 5-10 require that noise measurement records be kept for the duration of employment plus 30 years. Also refer to Reference 5-11, which dictates longer retention times for some records (e.g., Section SSIC 6200.2a dictates some occupational health, industrial and environmental control program records not be destroyed until after 75 years, though they can be archived after 5 years). As a minimum, records must include:

a. Number, type and location of the noise sources;

b. Number and identification of personnel in the work area and their daily noise exposure and duration (dosimetry only);

c. Type, model, serial number of test equipment and calibration data;

d. Location, date and time of noise measurement;

e. SPLs measured in dBA and/or SPLs measured in dBP;

f. Hazard radius (both to 85 dBA and 104 dBA if necessary); if applicable this can be performed for impulse or impact noise (both to 140 dBP and 165 dBP if necessary);

g. 8-hour TWA noise exposure in dBA, if the measurements are sufficient to calculate it (e.g., dosimetry data or many sequential measurements over the work-shift with an SLM);

h. Name and signature of the person(s) who performed the survey.

5. Sampling Protocol

a. Noise measurements will be taken by industrial hygienists, audiologists, IH technicians, workplace monitors or others suitably trained. An industrial hygienist is responsible for making noise exposure assessments and designating noise hazardous areas and equipment based on noise measurements and associated information as part of the IH survey.

b. Types of Surveys:

(1) General survey. Conducted to determine the locations and boundaries of hazardous noise areas and equipment. The Type 2 SLM is adequate for this type of survey.

(2) Noise Control Survey. A Type 1 SLM with an octave band filter is used to obtain engineering-type data to aid in selecting a course of action for noise control or to certify audiometric testing booths.

(3) Noise Dosimeter Survey. Dosimeters are used to assess individual noise exposure. Noise dosimeters with a data logging capability are typically used to determine which processes during the work shift are the major contributors to noise exposure so noise control efforts can be focused where the most benefit will be derived.

c. SLM. Always follow the manufacturer's instructions. For practical purposes, the procedure below would typically be followed for SPL measurements.

(1) Continuous and Intermittent Noise.

(a) The SLM should be set to slow response.

(b) Measurements should be taken using the "A" weighting network (dBA).

(c) Additional “C" weighting network dBC measurements can be taken.

(2) Impulse/Impact noise measurements should be taken using the no weighting/Z/peak setting dBP.

(3) Ensure windscreen is used where needed.

(4) Obtain SPL measurements at the noise source.

(a) Record locations of sources on a diagram.

(b) Record the Noise hazard radius.

1. If SPL measurements at the noise source exceed 85 dBA, determine the distance from the noise source where the SPL falls to 85 dBA. Repeat several times and record on the diagram. This is the hazard radius. If SPL measurements at the noise source exceed 104 dBA, the distance from the

noise source to where the SPL falls to 104 dBA should also be measured in addition to the hazard radius to 85 dBA.

2. If applicable, this can also be performed for impulse or impact noise sources - for the distance from the noise source where the SPL falls to 140 dBP. If SPL measurements at the noise source exceed 165 dBP, the distance from the noise source to where the SPL falls to 165 dBP should also be measured in addition to the hazard radius to 140 dBP.

(5) Obtain SPL measurements at the worker location.

(a) The microphone should be held in the person's hearing zone (defined as a sphere with a two foot diameter surrounding the head) and oriented in accordance with the manufacturer's recommendations (i.e., either perpendicular or parallel to the noise source).

(b) Select the ear closest to the noise source. When noise levels measured at each ear for a single individual are different, the higher level should be used for compliance purposes.

(c) Repeated measurements are required during a single day and/or different days of the week to account for the variation in noise levels produced by changes in operation schedules and procedures. Measurements should be collected during the different phases of work performed by the employee during the shift, taking enough measurements to identify work cycles. Remember that noise levels will vary during the day and work operation.

(d) Sufficient SLM measurements would have to be obtained to determine an actual exposure; therefore, noise dosimeters are the instruments of choice for monitoring personal noise exposure.

b. Noise Dosimeters. Always follow the manufacturer's instructions. For practical purposes, the procedure below would typically be followed for dosimeter measurements.

(1) The noise dosimeter should be set to parameters meeting Reference 5-1. Ensure windscreen is used where needed.

(2) Clip the microphone to the employee's collar at the top of the shoulder, as close as possible to the employee's ear that is closest to the noise source. The microphone should be in the person's hearing zone (defined as a sphere with a two foot diameter surrounding the head). Considerations of practicality and safety for each survey location will dictate the actual microphone placement. Care should be taken to ensure that the microphone is in a vertical position. Placement of ear clips should be in accordance with the manufacturer's instructions.

(3) Ensure the microphone is not covered, obstructed or brushing against anything.

(4) Position and secure any excess microphone cable to avoid snagging or any inconvenience to the employee. The cable can be taped directly to the employee's outer clothing.

(5) Inform the employee that the dosimeter should not interfere with normal duties, and emphasize that the employee should continue to work in a routine manner.

(6) Explain to each employee being surveyed the purpose of the dosimeter and that it is not a speech recording device.

(7) Instruct the employee being monitored to not remove the dosimeter unless absolutely necessary, and to not cover the microphone with a coat or other garment or work equipment.
(8) Inform the employee when and where the dosimeter will be removed.
(9) Make sure that the dosimeter is in recording mode before starting the survey.
(10) The dosimeter should be checked periodically to ensure that the microphone is oriented properly.
(11) Additionally, take and record SLM measurements during the different phases of work performed by the employee during the shift, taking enough measurements to identify work cycles. SLM and dosimeter measurements taken during the same shift should be comparable.
(12) For dosimeter results to be meaningful, a log of the employee's activity shall be maintained by the person conducting the survey so that exposure data can later be correlated with different locations and activities, thereby identifying noise sources.

NOTE: Do not leave the dosimeter unattended in the field.

6. Factors That Effect Instrument Performance

a. Temperature. Sound measuring equipment should be used within the manufacturer's design specifications. Store sound measuring equipment in accordance with the manufacturer's recommendations.

b. Humidity. Sound measuring instruments perform accurately as long as moisture does not condense or deposit on the microphone.

c. Atmospheric Pressure. When checking an acoustical calibrator always apply the corrections for atmospheric pressure and temperature as directed in the manufacturer's instructions.
(1) In general, if the altitude of the measurement site is less than 10,000 feet above sea level, the correction is negligible and need not be considered further.
(2) If the measurement site is at an altitude higher than 10,000 feet above sea level, or if the site is pressurized above ambient pressure, use the following equation to correct the instrument reading:

$$C = 10 \times \log\left(\sqrt{\frac{460 + t}{528}} \times \left(\frac{30}{B}\right)\right)$$

Equation 5-3

Where:
C = correction to be added to the measured SPL (dB)
t = temperature (°F)
B = barometric pressure (inches Hg)

NOTE: For high altitude locations, C will be positive; for hyperbaric conditions, C will be negative.

d. Wind. Wind blowing across a microphone produces turbulence which may cause positive error in the measurement. Use a wind screen for all out-of-doors measurements and where there is significant air movement inside a building (e.g., cooling fans or gusty wind through open windows).

e. Magnetic Fields. Devices such as heat sealers, induction furnaces, generators, transformers, electromagnets, arc welders, radars and radio transmitters generate electromagnetic fields which may induce current in the electronic circuitry of SLMs and noise dosimeters causing erratic readings. If SLMs or dosimeters must be used near such devices, attempt to determine if the effect of the magnetic field is significant. Follow the manufacturer's instructions for use around magnetic fields.

f. Impulse/Impact Levels. The presence of impulse/impact noise in the vicinity of a noise dosimeter may overload the noise dosimeter. This is due to the fact that the noise dosimeter suffers from microphone limitations and lacks measurement parameters that have been associated with characterizing impulse noise and its effect on the auditory system (see Reference 5-12). When using an SLM for weapons fire measurement ensure an appropriate meter and microphone are used for the expected level in accordance with Reference 5-9, and refer to References 5-12 and 5-13 to understand instrument limitations.

g. Microphone Placement. For SLMs and noise dosimeters that use omnidirectional microphones, the effects of microphone placement and orientation are negligible in the typical reverberant environment. As a general rule, the SLM should be held at arm's length to reduce the body-baffling effect. To minimize body shielding effects on microphones, consult the manufacturer for recommended placement. If the measurement site is non-reverberant and/or the noise source is highly directional, consult the manufacturer for recommended microphone placement and orientation. Also, ensure the microphone is not directed toward reflective surfaces. This would result in higher SPL measurements.

7. Criterion Levels

The DoD criterion levels for occupational exposure to noise, per References 5-1 and 5-3, are:

a. 85 dBA as an 8-hour TWA in a 24-hour period.

b. For periods of less than 16 hours in any 24-hour period, the allowable exposure in dBA, can be determined from the following equation:

$$dBA = 3\left(\frac{log\frac{16}{T}}{\log 2}\right) + 82$$

Equation 5-4

Where:
T = exposure time (hours)

c. For a given SPL, the allowable exposure period follows:

$$T = 8 \times 2^{\left(\frac{85-L}{3}\right)}$$

Equation 5-5

Where:
T = permissible exposure time in hours (decimal)
L = Measured SPL in A-weighted decibels dBA

d. When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect must be considered. If the sum of the following expression exceeds one, then the combined exposure exceeds the DoD criterion level:

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \cdots + \frac{C}{T_n}$$

Equation 5-6

Where:
C = total time of exposure at a specified SPL
T = time of exposure permitted at that level

e. 140 dBP SPL for impact or impulse noise.

f. When exposures to steady-state noise below 130 dBA occur simultaneously within the same 24-hour period as exposure to impulse noise above 130 dB C-weighted peak, apply the hazard criteria separately (i.e., the allowable exposure to steady-state noise (e.g., engine noise) shall not be reduced because of exposure to impulse noise [e.g., weapon firing]).

8. Hazardous Noise Areas/Equipment and Use of Hearing Protection

The designation of hazardous noise areas and equipment and use of hearing protection is based on the following criteria:

a. Any work area or equipment where the SPL is 85 dBA or above (continuous or intermittent) shall be considered noise hazardous (Reference 5-1).

b. Any work area or equipment where the SPL is 140 dBP or greater (impulse or impact) shall be considered noise hazardous (Reference 5-1).

c. The administrative control of limiting exposure time (i.e., implementing a stay time) shall be used when HPDs do not provide sufficient attenuation to reduce exposures below the OEL (References 5-1 and 5-2).

d. In accordance with References 5-1, 5-2 and 5-3, areas or equipment where the SPLs are 85 dBA or greater, but less than 104 dBA, shall be labeled and shall require the use of single hearing protection (approved ear plugs or circumaural muffs). Areas or equipment where the SPLs are 104 dBA or greater shall be labeled and shall require the use of double hearing protection (approved ear plugs and circumaural muffs). Labels should include the type of hearing protection to wear (i.e., single or double), and administrative maximum stay times if hazardous noise exceeds hearing protection NRRs.

e. In accordance with References 5-1, 5-2, and 5-3, areas or equipment where the SPLs are 140 dBP or greater, but less than 165 dBP, shall be labeled and shall require the use of single hearing protection. Areas or equipment where the SPLs are 165 dBP or greater shall be labeled and shall require the use of double hearing protection. Labels should include the type of hearing protection to wear (i.e., single or double), and administrative maximum stay times if hazardous noise exceeds hearing protection NRRs.

f. In accordance with References 5-1, 5-2 and 5-3, all personnel exposed to gunfire or artillery fire in test or training environments (e.g., weapons qualifications, simulated combat sounds, artillery, or missile fire) shall wear HPDs.

9. Types of Hearing Protection

References 5-1, 5-2, 5-3 and 5-14 provide guidance and requirements for hearing protection.

a. Fitted Inserts.
   (1) Most are elastomeric.
   (2) Sized non-disposable insert devices can only be fitted and stocked by trained medical department personnel.
   (3) Sizing gauge is useful, but does not take the place of actual fitting.
   (4) Are available in various sizes, depending upon the type. Occasionally, a different size must be fitted to each ear.
   (5) Attenuation is approximately 20 dB. NRR varies by manufacturer and product, and in real world situations is rarely as high as the manufacturer’s label.

b. Disposable Type Inserts.
   (1) Moldable, does not require fitting, provides a very good seal if properly inserted, conforms to the shape of the ear canal.
   (2) Attenuation is approximately 20 dB. NRR varies by manufacturer and product, and may not reach the level measured under laboratory conditions.

c. Circumaural Muffs.
   (1) Cup-like plastic domes that cover the entire ear, connected by a spring band.
   (2) Attenuation varies between manufacturers and products, and is approximately 20-30 dB.

d. Canal Caps.
   (1) Block the ear canal only.
   (2) Attenuation is low, typically 12-18 dB. Primary value lies in portability and ease of insertion/removal for intermittent exposures.

10. Personal Attenuation Rating of Hearing Protection

a. Hearing Protective Devices (HPDs). Reference 5-1 requires that personal hearing protection be worn to attenuate the occupational noise exposure of employees to within the limits of the occupational exposure limit. The actual effectiveness of any individual hearing protector cannot be determined under workplace conditions. Hearing protectors are evaluated under rigorous laboratory conditions specified in ANSI/Acoustical Society of America (ASA) S12.6-2016 and ANSI/ASA S12.42-2010. However, Occupational Safety and Health Administration's (OSHA) experience and the published scientific literature indicate that laboratory-obtained real ear attenuation for hearing protectors can seldom be achieved in the workplace. When using the NRR to assess a HPDs adequacy for hearing conservation purposes, the attenuation calculations below should be applied (Reference 5-15).
   (1) Single Protection (i.e. muffs or plugs):
      (a) Obtain the NRR which is on the packaging of the HPD.
      (b) Subtract 7dB from the NRR to correct for using A-weighted measurements. For C-weighted measurements no correction is needed.
      (c) Exposure estimation for Single Protection:
      Estimated Exposure dBA = TWA dBC - NRR, or
      Estimated Exposure dBA = TWA dBA - (NRR - 7)
   (2) Dual Protection (i.e. muffs and plugs).
      (a) Obtain the NRR for the higher rated hearing protector (NRR_h)
      (b) Subtract 7dB from the NRR to correct for using A-weighted measurements. For C-weighted measurements no correction is needed.
      (c) Add 5 dB to the field-adjusted NRR to account for the use of the second hearing protector.
      (d) Exposure estimation for Dual Protection:
      Estimated Exposure dBA = TWA dBC - [NRR_h + 5], or
      Estimated Exposure dBA = TWA dBA - [(NRR_h - 7) + 5]

b. Derating NRR. Derating NRRs is the reduction of the NRR by a 50% safety factor. While current guidance (Reference 5-16) does not require derating the NRR to assess the adequacy of HPDs for hearing conservation purposes, it is important to do so:
   (1) When considering whether engineering controls are to be implemented (Reference 5-16), or

(2) When evaluating HPD adequacy for military or civilian personnel who experience an STS (Reference 5-2).

If using the NRR to assess a HPDs adequacy in these two situations, the OSHA attenuation and derating calculations below should be applied.

(1) Single Protection (i.e. muffs or plugs):
Estimated Exposure dBA = TWA dBC - [NRR x 50%], or
Estimated Exposure dBA = TWA dBA - [(NRR - 7) x 50%]

(2) Dual Protection (i.e. muffs and plugs):
Estimated Exposure dBA = TWA dBC - [(NRR_h x 50%) + 5], or
Estimated Exposure dBA = TWA dBA - {[(NRR_h - 7) x 50%] + 5}

11. Noise Control Engineering

a. Noise control engineering is the best means of limiting noise exposure and the primary means of protecting personnel from workplace noise. Administrative controls also can be effective. Hearing protection is considered an interim measure while engineering control measures are being explored, and a permanent measure only if engineering or administrative controls are not feasible. However, most workplace noise continues unabated by engineering controls, due to limited funds and low priority.

b. DoD risk assessment coding is being used to set priorities for noise control projects at a variety of Navy activities. Most of the projects are new construction or modernization of existing buildings where noise control was factored into the projects.

12. Certification of Audiometric Chambers

a. Audiometric test booths used for air-conduction hearing tests require annual certification by an industrial hygienist, audiologist or IH technician. Protocols differ for medical surveillance purposes and for clinical audiometric testing. The requirements in Table 5-1 apply to audiometric test booths used for medical surveillance and physical examinations. Reference 5-17 provides the requirements that apply to audiometric test booths used for clinical testing in a sound field (ears uncovered) and those that apply to audiometric test booths used for clinical testing using headphones (ears covered) and no sound field certification requirements of all types of audiometric test booths assumes that the audiologist/examiner is only going to test as low as 0 dB hearing level (HL), although audiometers are typically calibrated down to -10 dB HL. If testing down to -10 dB HL under headphones or with insert earphones (which is frequently the case with children), then ears-covered ambient noise levels in the booth must be at least 3 dB lower than maximum permissible ambient noise levels (MPANLs).

Table 5-1

Maximum Allowable SPLs in Audiometric Test Booths for Medical Surveillance Hearing Tests

Octave Band Center Frequency (Hz)	500	1000	2000	4000	8000
Maximum SPL (dB)*	27	29	34	39	41

*Reference 5-1

b. All audiometric booths require, at minimum, annual certification (365 day interval). External and internal conditions that would prevail during normal use should be duplicated at the time of certification. For example, a shipboard booth that has been certified pier-side cannot be utilized underway until it has been evaluated under representative underway conditions. Any significant new noise (inside or outside of the booth) or relocation of the booth requires recertification.

c. At a minimum, a Type 1 SLM with octave band filters is required to measure the SPLs inside the booth during normal operational conditions. The SLM must be capable of measuring at least 3 dB below the appropriate MPANLs. The SLM, OBA, microphone and calibrator must each have been professionally calibrated within one year.

d. Audiometric test booth certifications are valid only when interior ambient noise levels are sufficiently low to comply with the MPANL requirements, as appropriate. Audiometric exams, conducted under conditions exceeding the allowable SPLs, as appropriate, are invalid.

e. Steps to take to certify a stationary audiometric test booth are outlined below. These procedures do not apply to Mobile Hearing Conservation and Audiometric Trailers (MOHCAT) and Mobile Hearing Conservation Audiometric Vehicles (MOHCAV), which will be discussed in another section.
   (1) Conduct the certification at a time when external noise/activity conditions are representative of anticipated test conditions. That also applies to internal conditions (overhead fan, lights). Document those conditions on the certification form.
   (2) Perform pre and post-calibration of the SLM. Document make/model and calibration dates on the certification form.
   (3) Sit in the patient's chair with SLM held away from your body and at head height. Select the desired octave band, dial in slow response and take the measurements. Record the range of values if variable or the modal value if fairly stable. Record results for each required octave band.
   (4) For multiple station booths, check levels at seats closest and furthest from the door and record the higher of the two sets of values.
   (5) Record external levels for information value only. Levels will typically be quite variable, so it may preferable to simply record typical dBA and dBC levels.
   (6) At some point during the process, have someone talk outside the booth to see if the booth is certifiable under that condition. If external conversation precludes valid

testing, be sure to annotate that fact on the certification form. This will often be the case with single-wall booths.

(7) Record all values; complete and post the certification on the exterior of the booth or on an adjacent wall. Keep a file copy.

f. <u>MOHCATs and MOHCAVs Certification:</u>

(1) MOHCAV or MOHCAT booths require annual certification the same as stationary booths. The certification procedure should take place at the location most often used (the major customer). Realistic external noise/activity should be in effect for an accurate and meaningful certification.

(2) It is typically NOT practical to re-certify mobile booths each time they are moved to a different location. However, measurements can be taken at each of the primary customers.

(3) The current model MOHCAVs have a second wall of attenuation in the form of the body of the vehicle that works fairly well. However, cross-traffic, generators, flyovers and small crafts pier-side all have the potential to invalidate test results. Below are three alternatives to ensure test validity:

(a) Conduct and document booth certification at each prospective test location, under worst-case test conditions. You need not repeat the certification for subsequent deployments to the same location.

(b) An alternate option is to do a self-test audiogram at each location prior to seeing patients (assuming the hearing thresholds of the listener are all 0 to 5 dB HL). Make sure the test is taken during representative exterior noise conditions.

g. <u>Troubleshooting:</u>

(1) If a booth will not certify in low frequencies, re-check ambient levels with the fan turned off. If fan noise is determined to be the problem, then initiate repair immediately. Replacement of the fan is typically required, as most of them are sealed units with no first echelon maintenance.

(2) Electrical lighting will occasionally be a source for low frequency noise in the form of 60-cycle hum, with harmonics migrating into the 500 Hz test range. This is fixable. Do not make customers sit in a dark room to take their hearing test. It is unprofessional and encourages napping.

(3) The jack panel is a recurring source for ambient noise interference. Some booths simply pass headphone and hand switch wiring though a hole in the jack panel. Sound attenuating material should be carefully packed around the wiring to seal the opening. The jack panel is also a good place to start when troubleshooting intermittent biological calibration difficulty. Biomedical repair personnel should be contacted to do continuity checks and clean/replace jacks and plugs as needed.

(4) Door seal problems are inevitable after a few years of use. The foam seals harden, wear out and must be replaced. Often a door is hung improperly to begin with, or develops a problem and must be shimmed carefully. A properly hung door will slowly swing shut by itself. A properly sealed door will offer light resistance to a dollar bill that is pulled through the seal.

(5) If the above actions do not solve the problem, consider removing/relocating external noise sources, relocating your booth or adding vibration dampers
(6) In high traffic areas, aviation environments or aboard ship, plan on a double-wall booth. Remember that even a single-wall one-man booth weighs 1800-2000 pounds and a double-wall weighs (and costs) twice as much.
(7) Finally, internal noise sources can be as problematic as external noise. Make sure that chairs or stools are sturdy metal types that will not squeak. Curtains between multiple test stations will muffle sound and inhibit distractions. Carpeting or rubber mats further dampen noise.

h. A form for certification of audiometric test booths is detailed in Section 12 Forms, of this chapter.

13. Forms

a. NMCPHC 5100/12, Audiometric Test Booth Certification Form

b. NMCPHC 5100/17, Industrial Hygiene Noise Survey Form

c. NMCPHC 5100/18, Industrial Hygiene Noise Dosimetry Survey Form

14. References

5-1 DODI 6055.12 Series, DoD Hearing Conservation Program

5-2 OPNAVINST 5100.23 Series, Chapter 18, Hearing Conservation and Noise Abatement.

5-3 OPNAVINST 5100.19 Series, Chapter B4, Hearing Conservation Program.

5-4 The Noise Manual, edited by Elliot H. Berger MS, INCE Bd. Cert.; Larry H. Royster, PhD; Dennis P. Driscoll, MS. PE; Julia Doswell Royster, PhD; Martha Layne. AIHA Press. Revised Fifth Edition.

5-5 MIL-HDBK-1908B, Definitions of Human Factors Terms, 1999.

5-6 ANSI/ASA. American National Standard Electroacoustic- Sound Level Meters. ANSI/ASA S1.4-2014/Part 1/IEC 61672:1-2013, ANSI/ASA S1.4-2014/Part 2/IEC 61672:2-2013, and ANSI/ASA S1.4-2014/Part 3/ IEC 61672:3-2013. American National Standards Institute (ANSI), Acoustical Society of America (ASA).

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5-8 40 C.F.R Part 211 Subpart B (§211.204-4) Environmental Protection Agency (EPA).

5-9 MIL-STD-1474E, Department of Defense Design Criteria Standard Noise Limits, 2015.

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5-11 SECNAV M-5210.1 Series, Department of Navy Records Management Program.

5-12 C.A. Kardous and R.D Wilson, Limitation, of integrating impulse Noise when using dosimeters, Journal of Occupational and Environmental Hygiene 1(7), 456-462, 2004.

5-13 Measurement of Exposure to Impulsive Noise at Indoor and Outdoor Firing Ranges During Tactical Training Exercises, U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, and National Institute for Occupational Safety and Health, 2014.

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5-16 OSHA Technical Manual, Noise. Appendix E. OSHA.

5-17 ANSI/ASA. Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms. ANSI S3.1-1999 (R2018). New York, NY: Reaffirmation 2018. ANSI, ASA.