CHAPTER 5

NOISE SURVEYS

1. **GENERAL.** This chapter provides the basic information necessary to evaluate and document employee noise exposure and to assist with determining compliance with Navy noise instructions. For more detailed information, see references 5-1, 5-2, and 5-3.

Noise survey and dosimetry forms are provided in Appendix 5-A.

2. **DEFINITIONS.**

a. Crest factor. The arithmetic difference between the peak sound pressure level and the root-mean-square (RMS) sound pressure level for a given noise measurement situation. The crest factor characterizes a sound measuring instrument's ability to accurately measure transient or impulse sound levels. Instruments should have a crest factor capability adequate to handle the noise waveform.

b. Criterion level. The continuous equivalent A-weighted sound level which constitutes 100 percent of an allowable exposure. For Navy purposes, this is 84 dB(A) for 8 hours in a 24-hour period. The dosimeter readout can be used to calculate both the continuous equivalent A-weighted sound level (L_A) and the 8-hour time-weighted average (TWA) for the time period sampled, using the following equations:

$$L_A = 84 + \left[13.3 \times \log\left(\frac{D}{12.5 \times T}\right)\right]$$

Equation 5-1

$$TWA = 84 + \left[13.3 \times \log\left(\frac{D}{100}\right)\right]$$

Equation 5-2

Where:

L_A = continuous equivalent A-weighted sound pressure level, in decibels, for the time period sampled, if the

Criterion Level is 84 dB(A) for 8 hours exposure and the Exchange Rate is 4 dB
D = dosimeter read-out in percent noise dose
T = sampling time in hours

c. Decibel (dB). The unit of measurement for sound pressure level. The sound pressure level, 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 micropascals.

d. Decibel, A-weighted (dB(A)). Overall sound pressure level where the intensity contribution from each frequency is not equal but is adjusted (i.e., weighted) according to the values in Reference 5-4.

e. Dosimeter threshold level. Threshold level is the A-weighted sound pressure level at which a noise dosimeter begins to integrate the noise into the measured exposure. For Navy purposes this is 80 dB(A).

f. Exchange rate. The exchange rate is a trade-off between the sound level in decibels and the duration of exposure in hours. The Navy exchange rate is 4 dB. Each 4 dB increase in sound level (above the 84 dB(A) 8-hour permissible exposure limit) can be balanced by a 50% reduction in unprotected exposure duration.

g. Impact noise. Noise produced by a single collision of one mass in motion with a second mass, generally of less than 0.5 second in duration and which repeats no more than once per second.

h. Impulse noise. Impulse noises are usually considered to be singular noise pulses, each less than one second in duration, or repetitive noise pulses occurring at greater than 1 second intervals. Also defined as a change of sound pressure of 40 dB or more within 0.5 second.

i. Meter response. The motion of the sound level meter's needle (or other output) resulting from an excitation (stimulus). To allow the user to follow the movement of the indicating needle, "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. Sound level meters 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 sound level meters 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" setting is not sufficiently fast to measure true "peak" SPLs due to "impulse" or "impact" noise.

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

k. Peak sound pressure level. The maximum instantaneous sound pressure level 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.

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

m. 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.

n. Sound level meter (SLM). An instrument used to measure sound pressure levels which meets the requirements of Reference 5-4.

o. Sound pressure level (SPL). The root-mean-square value of the pressure changes above and below atmospheric pressure when used to measure steady state noise.

3. **NOISE MEASUREMENTS.** Noise measurements will be taken by industrial hygienists, audiologists, industrial hygiene technicians, workplace monitors or others suitably trained. An industrial hygienist is responsible for making noise exposure assessments and designating noise hazardous areas based on noise measurements and associated information as part of industrial hygiene surveillance programs.

a. Instruments. Sound level meters and noise dosimeters are used to assess an employee's exposure to noise. Octave band analyzers are used to identify the frequencies at which the noise is generated and are mainly used to aid in selecting engineering controls.

(1) Sound level meters (SLM). All SLM used by the Navy will conform, as a minimum, to the Type 2 requirements cited in

reference 5-4, which sets performance and accuracy tolerances. The SLM will be electroacoustically calibrated and certified annually. An acoustical calibrator, accurate to within one decibel, 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 Chapter 8, Industrial Hygiene Equipment Maintenance and Calibration for specifics on calibrating all noise measuring instruments.

(a) Types of sound level meters:

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

(ii) Type 1: Precision sound level meter. Can be used in the field and laboratory.

(iii) Type 2: General purpose sound level meter. Designed to have less stringent tolerances than Type 1; used for field measurements.

(iv) Type 3: This was a type of survey instrument listed in the 1971 version of Reference 5-4. It is mentioned here since some of these SLMs may still be in use. Their accuracy was less than the Type 2 and they were, therefore, not acceptable for Navy industrial hygiene noise measurements. This type meter was dropped from the ANSI standard in 1983.

(v) 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 work.

(b) Continuous or intermittent noise will be measured in dB(A) with a sound level meter set for slow response.

(i) The A-weighting scale approximates the ear's response for sound levels below about 55 dB and discriminates against energy in the low frequency ranges just as the ear does.

(ii) The C-weighting scale approximates the ear's response for sound levels above 85 dB and may be used to evaluate hearing protective device effectiveness. It responds with little discrimination against low frequencies, detects more energy, and may result in higher readings than the A scale. C-weighted sound level measurements should be taken and used to determine hearing protector performance.

(c) Impact or impulse noise will be measured as dB peak sound levels with sound level meters which have an impulse or peak hold circuit, a rise time constant not exceeding 35 milliseconds, and the capability to measure peak sound levels up to 140 decibels, inclusive (peak).

(2) Noise dosimeters. Specifications for noise dosimeters are provided in Reference 5-5. For Navy use, the dosimeter must meet, as a minimum, class 2A-84/80-4 where:

(a) "2" means that the dosimeter has tolerances that correspond to those for a Type 2 sound level meter (reference 5-4).

(b) "A" means the A-frequency weighting network,

(c) "84" means a 84 decibel slow criterion level,

(d) "80" means a 80 decibel threshold level, and

(e) "4" means a 4 decibel exchange rate.

Additionally, dosimeters shall be capable of accurately measuring impulse noise between 80 dB(A) and 130 dB(A) (i.e., have a crest factor of at least 50 dB) and integrating it into the daily noise dose.

Although not required, a datalogging capability which will allow collection of time history data is 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.

(3) 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 readings. These readings 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.

b. Noise measurement records. All noise measurements and pertinent information is documented on NEHC 5100/17, "Industrial Hygiene Noise Survey Form," or NEHC 5100/18, "Industrial Hygiene Noise Dosimetry Form." Reference 5-1 requires that noise measurement records be kept for 50 years after the data is collected. As a minimum, records must include:

(1) Number, type and location of the noise sources;

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

(3) Type, model, serial number of test equipment and calibration data;

(4) Location, date, and time of noise measurement;

(5) Noise levels measured and hazard radius (both 84 dB(A) and 104 dB(A)); and

(6) Per Reference 5-6, the 8-hour time-weighted average exposure in dB(A), if the measurements are sufficient to calculate it (e.g., dosimetry data or many sequential measurements over the workshift with a SLM).

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

4. **SAMPLING PROTOCOL.**

a. Types of surveys.

(l) General survey - conducted to determine the locations and boundaries of hazardous noise areas. This survey is usually done with the Type 2 SLM.

(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 datalogging capability may be used to determine which processes during the workshift are the major contributors to noise exposure so noise control efforts can be focused where the most benefit will be derived.

b. Sound level meters. Sound level measurements should be taken following the manufacturer's instructions. For practical purposes, the procedure below should be followed for all sound level measurements:

(l) The SLM should be set to slow response. Measurements should be taken using the "A" weighting network.

(2) The microphone should be held in the person's hearing zone and oriented in accordance with the manufacturer's

recommendations (i.e., either perpendicular or parallel to the noise source). Select the ear closest to the noise source. 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. Dosimeters are the instruments of choice for monitoring personal noise exposure.

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

(4) Note SLM measurements 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. Sufficient measurements will have to be obtained to determine an actual exposure.

(5) Obtain sound level measurements at the noise source. Record locations of sources on a diagram. Determine the distance from the noise source where the sound level falls to 84 dB(A). Repeat several times and record on the diagram. This is the hazard radius.

c. Noise dosimeters. Always follow the manufacturer's instructions. For practical purposes, the procedure below should be followed for all dosimeter measurements:

(l) 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.

(2) When the dosimeter is positioned (normally in the shirt pocket or at the waist), 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. 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) 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.

(4) 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.

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

(6) Instruct the employee being monitored not to remove the dosimeter unless absolutely necessary, and not to cover the microphone with a coat or other garment. Inform the employee when and where the dosimeter will be removed.

(7) Make sure that the dosimeter is in recording mode before starting the survey. The dosimeter should be checked periodically to ensure that the microphone is oriented properly.

(8) Take and record SLM measurements during the different phases of work performed by the employee during the shift, taking enough readings to identify work cycles. SLM and dosimeter readings taken during the same shift should be comparable.

(9) 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. **Do not leave the dosimeter unattended in the field.**

5. **EFFECTS OF THE ENVIRONMENT ON 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.

(l) 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 sound level (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 sound level meters 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.

6. **EFFECTS OF SOUND ON INSTRUMENT READINGS.**

a. Microphone placement. For sound level meters 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 sound level readings.

b. Impulse noise.

(l) In evaluating impulse noise, determine the crest factor for the noise to be measured. The noise crest factor should be less than the measuring instrument's crest factor capability.

(2) The crest factor of a given sound measurement situation can be determined by first obtaining the peak SPL and the average SPL using an impulse precision SLM. The crest factor is determined by subtracting the average SPL from the peak SPL. By true definition, the crest factor is the peak SPL minus the RMS SPL, however, for practical purposes, the RMS and average SPL are the same. Consult the instrument instruction manual if there is difficulty determining the crest factor.

(3) Compare the noise crest factor with the crest factor for the instrument. This information will be found in the specifications section of the manufacturer's literature provided with the instrument.

(4) Audio dosimeters with impact noise capabilities are available. Check with the manufacturer for information as to the applicability to specific situations.

7. **PERMISSIBLE EXPOSURE LEVEL.** The Navy permissible exposure levels for occupational exposure to noise are:

a. 84 dB(A) for 8 hours in a 24-hour period.

b. For periods of less than 16 hours in any 24-hour period, the permissible exposure in dB(A), can be determined from the following equation:

$$dB(A) = 4\left[\frac{\log\left(\frac{16}{T}\right)}{\log 2}\right] + 80$$

Equation 5-4

Where: T = exposure time (hours)

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

$$T = \frac{16}{2^{[(L-80)/4]}}$$

Equation 5-5

Where,

T = time (hours)
L = sound pressure level (dB(A))

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 Navy permissible exposure limit:

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \ldots + \frac{C_n}{T_n}$$

Equation 5-6

Where:

C = total time of exposure at a specified noise level
T = time of exposure permitted at that level

e. 140 dB peak sound pressure level for impact or impulse noise.

8. **HAZARDOUS NOISE AREAS**. The designation of "hazardous noise areas" is based on the following criteria:

a. Any work area where the 8-hour time-weighted average sound pressure level is greater than 84 dB(A);

b. Any work area where the peak sound pressure level (impulse or impact) exceeds 140 dB; and

c. Areas where the sound pressure levels are greater than 84 dB(A) 8-hour TWA, but less than 104 dB(A) 8-hour TWA should be labeled to require single hearing protection (approved ear plugs or circumaural muffs). Areas where the sound pressure levels are 104 dB(A) 8-hour TWA or greater should be labeled to require double hearing protection (approved ear plugs and circumaural muffs).

9. **TYPES OF HEARING PROTECTION**. References 5-1 and 5-2 provide guidance and requirements for hearing protection.

a. Fitted inserts.

(1) Most are elastomeric.

(2) Sizing gauge is required.

(3) Are available in five sizes: extra small, small, medium, large, extra large. Occasionally, a different size must be fitted to each ear.

(4) Attenuation is approximately 20 dB. Noise reduction rating varies by manufacturer and product.

b. Disposable type inserts.

(1) Moldable, does not require fitting, provides a very good seal, conforms to the shape of the ear canal.

(2) Attenuation is approximately 20 dB. Noise reduction rating varies by manufacturer and product.

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) Cover ear canal only

(2) Attenuation is low, typically 12-18 dB

CAUTION: Field evaluations of hearing protective devices suggest the direct use of the manufacturer's published noise reduction ratings will overestimate hearing protector performance. The Occupational Safety and Health Administration has instructed field compliance inspectors to derate the noise reduction rating by 50%. When applying noise reduction ratings (NRRs) to measured SPLs, remember that NRRs may be subtracted directly from dB(C) SPLs but an 7 dB must be subtracted from a db(A) SPL before the NRR is subtracted to arrive at the SPL expected at the wearer’s ear.

10. **NOISE CONTROL ENGINEERING**.

a. Although noise control engineering is the best means of limiting noise exposure, most workplace noise continues unabated due to limited funds and low priority.

b. Department of Defense 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.

c. For more information contact:

Commanding Officer
Navy Environmental Health Center
Occupational Medicine Directorate, Occupational Audiology
2510 Walmer Avenue
Norfolk, VA 23513-2617

11. **CERTIFICATION OF AUDIOMETRIC CHAMBERS**.

a. Audiometric test booths used for air-conduction hearing tests require annual certification by an industrial hygienist, audiologist or industrial hygiene technician. At a minimum, a Type I SLM with octave band filters is required to measure the sound pressure levels inside the booth during normal operational conditions. The SLM must be capable of measuring at least 10 decibels below the values listed in Table 5-1.

b. The sound pressure levels measured inside audiometric test booths used for air-conduction hearing tests must not exceed the levels in Table 5-1.

Table 5-1. Maximum Allowable Sound Pressure Levels (SPL) in Audiometric Test Booths Used for All Air-Conduction Hearing Tests.

Octave band center frequency (Hz)	500	1000	2000	4000	8000
Maximum SPL (dB)*	27	29	34	39	41

* DOD 6055.12 (1996)

Audiometric test booth certifications are valid only when background noise levels are sufficiently low to comply with the requirements in Table 5-1 above. Audiometric exams conducted under conditions where these limits cannot be attained are invalid.

c. Appendix 5-B provides a form which should be used to document certification of audiometric test booths.

12. **REFERENCES**.

5-1 OPNAVINST 5100.23 Series, Chapter 18, *Hearing Conservation and Noise Abatement.*

5-2 OPNAVINST 5100.19 Series, Chapter B4, *Hearing Conservation Program.*

5-3 NAVMEDCOMINST 6260.5 Series, *Occupational Noise Control and Hearing Conservation.*

5-4 ANSI. *Specifications for Sound Level Meters*. ANSI S1.4-1983 (R1994). New York, NY: American National Standards Institute. 1994.

5-5 ANSI. Specifications for Personal Noise Dosimeters. ANSI S1.25-1991. New York, NY: American National Standards Institute. 1991.

5-6 DODI 6055.12 Series, *DoD Hearing Conservation Program (HCP)*

APPENDIX 5-A

NOISE SURVEY AND NOISE DOSIMETRY FORMS

1. **FORMS**. The standard forms to be used when conducting a noise survey or when performing noise dosimetry are listed below. These forms are in Adobe Acrobat Reader PDF format and require Adobe Acrobat Reader to be installed on your computer in order to open them. To open each form, click on the blue hyperlink.

a. Instantaneous Sound Level Surveys. Noise surveys conducted with hand-help sound level meters to document instantaneous sound pressure levels should be documented on an Industrial Hygiene Noise Survey Form, NEHC Form 5100/17.

b. Noise Dosimetry. Noise dosimetry measurements should be documented on an Industrial Hygiene Noise Dosimetry Form, NEHC Form 5100/18.

APPENDIX 5-B

AUDIOMETRIC TEST BOOTH CERTIFICATION

Command Owning Booth: _____

Date Measurements Were Made: _____

Audiometric Test Booth Data		
Mfr.:	Model:	Serial #:
Check One - Single-walled Double-walled		Door seals OK? Yes No
Booth Location:		
Significant Operating Conditons:		

OBA / SLM Data	Microphone Data	Octave Band Filter Data (If separate)	Calibrator Data
Manufacturer:	Manufacturer:	Manufacturer:	Manufacturer:
Model #:	Model #:	Model #:	Model #:
Serial #:	Serial #:	Serial #:	Serial #:
ElectAcoust Cal. Date:	ElectAcoust Cal. Date:	ElectAcoust Cal. Date:	ElectAcoust Cal. Date:

Field Pre-Cal OK? Yes No	Field Post-Cal OK? Yes No

Field Measurements			
Octave Band Center Frequency (Hz)	Maximum SPL for All Tests, (dB)	Octave Band SPL Inside Booth (dB)	Octave Band SPL Outside Booth (dB)
500	27		
1000	29		
2000	34		
4000	39		
8000	41		

This booth IS IS NOT certified for audiometric testing. (Check one)

_____ _____

Printed Name of Certifier Signature of Certifier

Certifier's Command: _____ Date: _____