AIHA®

Noise Dosimetry

Fact Sheet

aiha.org

Version 1 | August 5, 2024

Sponsored and developed by the AIHA Noise Committee.

Why conduct noise dosimetry?

Hazardous noise is among the most common occupational health hazards in United States workplaces, with an estimated 22 million employees exposed to hazardous noise (Tak, S. et al., 2009). Exposure to hazardous noise may cause hearing loss and tinnitus, create physical and mental stress, reduce productivity, and interfere with communication and safety alarms, ultimately contributing to potential accidents and injuries (Meinke et al., 2022).

It is a legal requirement for employers to know if noise exposure levels exceed the Permissible Exposure Limit (PEL) or the Action Level (AL) and present a hazard to employees. Employers are legally required to prevent over-exposure, and employers are responsible for any hearing loss that results from over-exposure (OSHA, 1981).

Sampling Procedure

Calibration of Noise Dosimeters

Periodic Calibration. Factory-level testing detects shifts in performance that indicate gradual changes and adjusts for or repairs them. Software and firmware are updated as needed. By ensuring that the electronic components are in good order, the periodic factory calibration results in a calibration certificate documenting the standard of performance. Typically, the instrument will also receive a sticker indicating its last calibration date and when the next periodic calibration is due. Periodic calibration is usually done annually or as the manufacturer recommends. Do not use a noise dosimeter past its periodic calibration due date to ensure accurate and defensible data.

Pre- and Post-use Calibration. (Quest, 2023; Larson Davis, 2023; OSHA, 2022).

Successful calibration of a dosimeter before and after each use for a study confirms the instrument is working properly on the day it is used and validates that sound levels are measured correctly and consistently at the end of the day. Calibrating your dosimeter before and after running any study is considered mandatory in professional practice to ensure accurate measurement results. The steps for calibration are:

1. Remove the windscreen while the dosimeter is turned on and stopped (not sampling).
2. Slide the exposed microphone into the cavity of an acoustic calibrator. If applicable, ensure the appropriate diameter adapter is inserted into the calibrator for a better fit.
3. Turn on the calibrator. Set the Calibrator to 114 dB and 1000 Hz (if applicable) or as recommended by the manufacturer's user manual.
4. 'CAL' or 'Calibrating' on the display of the dosimeter indicates automatic detection of the calibration function.
5. Press the appropriate function to trigger the calibration screen, and for pre-calibration, begin adjusting the calibration value until it matches 114 dBA. Field notes should indicate that calibration was conducted. Post-calibration must document any change since the pre-calibration, and if it is different by more than 0.5 to 1 dBA, depending on organization policy, that day's data will be invalidated.
6. Once calibration is completed, exit the calibration screen.
7. Reattach the windscreen; the dosimeter is now ready for use.
8. Repeated occurrence of drift is sufficient to invalidate studies and requires factory service.

Dosimeter Placement

A noise dosimeter is either a one-piece device or it may have a separate microphone connected to the main device with a cable. The noise dosimeter microphone should be placed in the worker's "hearing zone" (OSHA, 2022). An area near the collar bone or upper shoulder is typically ideal for placement, and the microphone should be placed on the side of the body where there may be a higher overall noise dose, if that can be determined, and pointed upward.

Sample Duration

Wherever possible, full-shift sampling should be conducted for 8-hour shifts. For extended shifts, compliance officers will attempt to sample the loudest eight hours within the shift, either continuous or eight hours, summed across shorter periods (OSHA, 2022). An evaluation must be performed for employees who work longer than an 8-hour shift to determine compliance with the Action Level (AL) for hearing conservation. For compliance with the PEL, the PEL dosimeter channel and only eight hours of exposure are used, and any period of exposure summing eight hours within the work shift can be used (OSHA, 2022). Extended task or event sampling may be done by dosimeter, but if it is of short duration, sound level meters (SLMs) are preferred.

Dosimetry Settings

The dosimeter is placed on the employee for a representative sample of time of the employee's exposure (preferably a full shift). It will automatically accumulate the needed data and calculate the dose, a percentage criterion exposure, and other measures, including the time-weighted average (TWA). Most dosimeters can be set up to simultaneously calculate several doses based on different criterion levels and typically download all these various metrics to a computer.

There are modern criteria developed by the American Conference of Governmental Industrial Hygienists (ACGIH) and the National Institute for Occupational Safety and Health (NIOSH), which in 1998 developed a revised criterion for preventing hearing loss and which together have become industry standards for protecting employee hearing. Dosimeters can be set to calculate the Occupational Safety and Health Administration (OSHA) dose and the OSHA Hearing Conservation dose while calculating the NIOSH or ACGIH dose. This gives the best results, as OSHA's criteria are required but not as protective as the NIOSH or ACGIH criteria (See Table 1).

Table 1 shows an additional criterion level called the low-risk criterion level. It has several sources. In the Audible Sound Threshold Limit Value (TLV); Note 5, following Table 1 in the ACGIH TLV Booklet, states that time away from work is assumed to be under 70 dBA. When it is not, for example, when the individual's living spaces are part of overall workspaces, then "the average noise exposure over any 24-hour period should not exceed 80 dBA" (ACGIH, 2023). NIOSH (1998) considered this criterion in its document, "Criteria for a Recommended Standard - Occupational Noise Exposure," and addressed it as the degree of excess risk of material hearing impairment. An excess risk of hearing impairment for a working lifetime was 29% at 85 dBA average and 3% at 80 dBA, based on the NIOSH 1972 risk models from Table 3-1. Table 3-4 in the same document shows comparable results for several risk models, including the NIOSH 1997 risk models, and for several combinations of frequencies included in hearing loss evaluations. Where 1000 Hz, 2000 Hz, 3000 Hz, and 4000 Hz frequencies are included in the loss evaluation, the NIOSH calculations show 8% excess risk at 85 dBA average and 1% at 80. NIOSH recommends a 3 dB exchange rate but does not recommend a threshold. Ratliff (2009) conducted an analytical review of the NIOSH criteria and

proposed the title, 'low-risk criterion'. The 80 dBA/3 dB criterion is included in this fact sheet for the two reasons described. First, when off-work living quarters are above 70 dBA, such as on ships or off-shore rigs. Second, when an organization opts to manage noise exposure with lower risk.

Table 1. Noise Dosimeter Settings

Noise Element	*Exposure Limit*			
	OSHA PEL	**OSHA HCP**	**ACGIH TLV / NIOSH REL**	**Low Risk Criterion**
Criterion Level	90 dBA	90 dBA	85 dBA	80 dBA
Threshold	90 dBA	80 dBA	80 dBA	70 dBA*
Exchange Rate (ER)	5 dB	5 dB	3 dB	3 dB

REL = Recommended Exposure Limit
*For the Low Risk Criterion daily exposures should be below 70 dBA (ACGIH, 2024).

Noise dosimetry may be required depending on the exposure regulation being followed and whether it includes an Action Level that triggers protective steps before the Occupational Exposure Limit (OEL, which for OSHA is the Permissible Exposure Limit, PEL) is reached. For example, OSHA requires a Hearing Conservation Program (HCP) at exposure ≥85 dBA as an 8-hour time-weighted average, and noise measurement is required in workplace hearing conservation programs. Obtaining sound level measurements is useful in determining areas or processes that could present hazardous noise. When an employee's exposure to hazardous noise is expected to exceed the action level (AL), personal dosimetry is required to identify employees for inclusion in the HCP, and it can be used to identify similar exposure groups for noise engineering controls. This information is essential to determining appropriate noise control measures and the correct grade of required hearing protection devices (OSHA, 2023).

Interpretation of Results

Standard Practice

The OSHA Noise Standard, 29 CFR 1910.95, describes occupational noise regulatory requirements. When employee noise exposure exceeds the OSHA Permissible Exposure Limit (PEL) listed in Table 2, feasible administrative or engineering controls shall be utilized. The dose using the PEL channel must be compared to the PEL, and the dose using the Action Level must be compared to the Action Level. The industrial hygienist should not compare the dose from the Action Level to the PEL. If administrative or engineering controls do not reduce employee noise exposure below the PEL, Personal Protective Equipment (PPE) shall be provided and used to

control exposure below the PEL. The OSHA Hearing Conservation Program (HCP) requirements are discussed in 29 CFR 1910.95(c). When an employee's noise exposure exceeds 85 dBA as an 8-hour Time-Weighted Average (TWA), the employer shall administer a continuing, effective HCP (See Table 2). As an important note, using PPE should be considered as the last resort and does not preclude an employer's obligation to administer an effective HCP.

Best Practice

The ACGIH TLV and the NIOSH REL for noise exposure are both 85 dBA as an 8-hour TWA utilizing a 3 dB exchange rate and are used as the best practice. OSHA recognizes that many of its PELs are out of date (OSHA, 2023b). Particular attention should be paid to the combined exposure to noise and ototoxic chemicals, which may trigger the implementation of employer HCPs under lower noise exposure levels. Previous studies suggest that the risk of hearing loss is much greater for groups exposed to ototoxic chemicals (Chen, et al., 2017; ACGIH, 2016; Chen, et al., 2018).

Definitions

Action level - An 8-hour time-weighted average of 85 decibels measured on the A-scale, slow response, or equivalently, a dose of fifty percent. (OSHA 29 CFR 1910.95(c)(2))

Criterion level - The level of a sound, expressed in dB, which will produce a dose of 100% if continually applied for the criterion time. The criterion level is different from one standard to another. For example, the current OSHA criterion level is 90 dB. The current NIOSH and ACGIH criterion level is 85 dB. (Larson Davis, 2023)

> Alternate definition: That constant sound level in decibels (dB), which, if it continues for the criterion duration (usually eight hours), would provide 100% of an employee's allowable noise exposure (ANSI S12.19)

Decibel (dB)- unit of sound level. dB=10*log((sound pressure, Pa)^2/(reference pressure, 0.00002 Pa)^2)

The decibel [dB and dB(A)] is a logarithmic scale. (CCOHS, 2023).

Exchange Rate - The change in sound level corresponding to a doubling or halving of the duration of sound level that is considered to result in an equivalent amount of noise exposure (ANSI S12.19). Stated differently, the dose doubles every time the TWA increases by the exchange rate. The number of decibels increases which leads to a halving of allowable exposure time. A 3 dB increase in noise level leads to a doubling of energy (for example, a noise level of 85 dB has half as much energy as a noise level of 88 dB). An exchange rate of 3 dB is used for some standards and is the exchange rate used for L_{eq}. However, the exchange rate is not a universally agreed-upon value. Each standard, regulation, or directive will specify the exchange rate that should be used when making noise dose measurements. For example, in OSHA regulations, the exchange rate is set at 5 dB. So, when looking at OSHA Hearing Conservation regulations, a worker may be exposed to 85 dB for eight hours, but when the sound level is increased to 90 dB, the allowable exposure time is halved to four hours. (Larson Davis, 2023)

L_{avg} – The logarithmic average of the sound during a measurement duration (specific time period), using the chosen Exchange Rate Factor (Larson Davis, 2023).

LA_{eq}, or Equivalent Continuous Sound Pressure Level is the constant noise level that would result in the same total sound energy being produced over a given period.

Table 2. Next Steps Associated with OSHA Requirements

Criteria	Description	Requirements
Action Level ≥ 85 dBA 8-hour TWA or 50% of the noise dose. Note that the AL **is** reduced for extended shifts. ONLY use the AL channel dose for comparison to the AL.	Full shift noise exposure. The employer must have an HCP if one or more employees' exposure equals or exceeds this level once a year. (https://www.osha.gov/laws-regs/standardinterpretations/2004-02-13-0)	• Hearing conservation program, including audiometric testing • Provide hearing protection • Employer must require the use of hearing protection until a baseline audiogram is provided • Employer must require the use of hearing protection for employees with STS • Employee notification • Employee training • Recordkeeping
PEL >90 dBA 8-hour TWA or 100% of the noise dose. Note that the PEL **is NOT** reduced for extended shifts. ONLY use the PEL channel dose for comparison to the PEL.	8-hour noise exposure. The employer must include noise exposure controls if one or more employees' exposure exceeds this level.	• Feasible engineering and administrative controls to reduce noise exposure • Employer must require the use of hearing protection if controls do not reduce exposure to <90 dBA
115 dBA slow response.	Exposure to 115 dBA slow response for 1 second or more.	Employers must require the use of hearing protection.
140 dBC impact or impulse.	Exposure at or above 140 dBC or 140 dB impact or impulse noise.	Employers must require the use of hearing protection.

Noise dose - Sum of ratios expressed as a percentage of the total time of exposure to each noise level during the period studied divided by the time permitted at that noise level under the criterion used. A measure of the noise exposure expressed as a percentage. This is the value expressed on a noise dosimeter and is a function of selected threshold level, criterion level, and exchange rate (ANSI S12.19)

Noise dosimeter - An instrument that integrates a

function of sound pressure over a period so that it directly indicates a noise dose.

Representative exposure - Measurements of an employee's noise dose or 8-hour time-weighted average sound level is considered representative by the employer of exposures of other employees in the workplace.

Sound level - Ten times the common logarithm of the ratio of the square of the measured A-weighted sound pressure to the square of the standard reference pressure of 20 micropascals. Unit: decibels (dB). For use with OSHA, NIOSH, or ACGIH Criteria, SLOW time response is used in accordance with ANSI S1.4-1971 (R1976).

Sound level meter (SLM) - An instrument for the measurement of sound level, in dB.

Threshold Level - The threshold level is applied in hearing damage risk assessment. According to the ANSI S1.25 standard, it refers to the A-weighted sound level below which sound produces little or no dose accumulation. For that reason, measured sound below this level will be disregarded. The current OSHA threshold level is 80 dB. (Larson Davis, 2023)

Time-weighted average (TWA) sound level – "A-weighted average sound level with the 5-dB exchange rate and slow meter response, applied in OSHA/MSHA practice. The TWA is normalized to 8 hours. Contrast with L_{OSHA} for a non-normalized quantity." (Meinke et al., 2022).

> Alternate definition: A-weighted constant sound level that would, in the criterion duration (eight hours), expose a person to the same noise dose as did the actual time-varying sound level (ANSI S12.19) Note this is not the same as 'average sound level', or L_{avg}. The average sound level is the average over the measurement period, and if that measurement period equals eight hours, then L_{avg} = TWA using a 5dB exchange rate. If using a 3dB exchange rate, this average is called LA_{eq}.

References

ACGIH. (2023). Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices. https://www.acgih.org/science/tlv-bei-guidelines/

ANSI S12.19 - Measurement of Occupational Noise Exposure.

Canadian Centre for Occupational Health and Safety, CCOHS. (2023). Noise. Basic Information. https://www.ccohs.ca/oshanswers/phys_agents/noise/noise_basic.html. Accessed 10-22-2023.

Chen K, Yang JL, Zhang HB, Zhang WJ. (2017). Low level noise analysis in laboratory fume hood. J. Chem. Health Saf., 24(1), 2–7. DOI: 10.1016/j.jchas.2016.03.002.

Chen K, Zhang HB, Zhang WJ. (2018). Measures to alleviate fume hood noise. Am. Lab., 50(3), 10-13.

Dobie, Robert A. (n.d.) Noise-Induced Permanent Threshold Shifts in the Occupational Noise and Hearing Survey: An Explanation for Elevated Risk Estimates. Ear and Hearing 28(4):p 580-591, August 2007. | DOI: 10.1097/AUD.0b013e31806dc286 https://journals.lww.com/ear-hearing/abstract/2007/08000/noise_induced_permanent_threshold_shifts_in_the.13.aspx

Larson Davis. (2023). Spartan Model 730 Noise Dosimeter Reference Manual, P/N I730.01-IS Rev K., PCB Piezotronics, Provo UT, 104 pp.

Meinke, DK, EH Berger, DP Driscoll, RL Neitzel, K Bright, editors. (2022). The Noise Manual, 6th Edition. American Industrial Hygiene Association. Falls Church, VA., 599 pp.

Morata, T.C. and Johnson, A.C. (2012). Effects of exposure to chemicals on noise-induced hearing loss. In: Noise-Induced Hearing Loss: Scientific Advances, Springer Handbook of Auditory Research 40; Le Prell C.G., et al., Eds.; Springer Science+Business Media, LLC: Berlin; pp. 223–54.

National Institute for Occupational Safety and Health, NIOSH. (2023). Understanding Noise Exposure. https://www.cdc.gov/niosh/topics/noise/preventoccunoise/understand.html. CDC, NIOSH. Accessed 10-22-2023.

National Institute for Occupational Safety and Health, NIOSH. (1998). NIOSH Occupational noise exposure; criteria for a recommended standard, DHHS publication; No. (NIOSH) 98-126. https://stacks.cdc.gov/view/cdc/6376.

OSHA. (1981). 29 CFR 1910.95- Occupational noise exposure. https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.95. Accessed 07 August 2023.

OSHA. (2022). Noise. Section III, Ch. 5 in OSHA Technical Manual. https://www.osha.gov/otm. OSHA, The Directorate of Technical Support and Emergency Management. Salt Lake City, UT. Updated July 6, 2022.

OSHA. (2023). Occupational Noise Exposure. https://www.osha.gov/noise. Accessed 15 August 2023.

OSHA. (2023b). Permissible Exposure Limits – Annotated Tables. https://www.osha.gov/annotated-pels. Accessed 15 August 2023.

Quest. (2023). Edge 7 Personal Noise Dosimeter, Model EG7, User Manual, PN 6017049, Revision B, July 2023. https://tsi.com/getmedia/9e6fa260-d740-4f1d-a1fb-ea99a23640fe/Quest_Edge7_User_Manual_6017049-US-web?ext=.pdf

Ratliff, J.C. (2009). The OSHA Noise Regulations and More Protective Alternative Noise Strategies. Masters Capstone Project. Tulane University. New Orleans, LA. This paper is available to AIHA members in Catalyst, Noise Committee, Archives.

Ratliff, John. (n.d.). *4-Dosimeter SLM Calc Worksheet 7-21-09.* This paper is available to AIHA members in Catalyst, Noise Committee, Archives.

Schaal, CN, RA Salaam, M Stevens, A Stubner. (2019). Noise characterization of "effective quiet" areas on a U.S. Navy aircraft carrier. J Occup Environ Hyg 16(5):329-335.

Tak, S, RR Davis, GM Calvert. (2009). Exposure to Hazardous Workplace Noise and Use of Hearing Protection Devices Among US Workers—NHANES-1999-2004. Amer. J Indust.Med. 52:358-371.

United States Navy. (2021). Noise. Ch. 5, in Industrial Hygiene Field Operations Manual. Technical Manual NMCPHC-TM6290.91-2 11 FEB 2021. Navy and Marine Corps Publ. Heal. Center, Bu. Med. Surg. https://www.med.navy.mil/Navy-and-Marine-Corps-Force-Health-Protection-Command/Environmental-Health/Industrial-Hygiene/Program-Support/Industrial-Hygiene-Field-Operations-Manual-IHFOM/

Zang, Meibian, et. al. (n.d.). "New Metrics Needed in the Evaluation of Hearing Hazard Associated with Industrial Noise Exposure," Ear Hear. 2020 Aug 19; 42(2): 290–300, Published online 2020 Aug 19. doi: 10.1097/AUD.0000000000000942 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8963135/

Disclaimer

AIHA and the author(s) disclaim any liability, loss, or risk resulting directly or indirectly from use of the practices and/or theories presented in this publication. Moreover, it is the user's responsibility to stay informed of any changing federal, state, local, or international regulations that might affect the material contained herein, as well as the policies adopted specifically in the user's workplace.