AIHA®

Sound Level Meters

Fact Sheet

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Version 1 | August 7, 2025

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Sponsored and developed by the AIHA Noise Committee.

Introduction

The sound level meter (SLM) is used to measure sound pressure levels (in Pascals) in the environment, which the device converts to decibels (dB). The first handheld SLM was designed in the 1960s and has continued to evolve with today's technology (Hottinger Brüel & Kjær, n.d.). An SLM consists of a digital readout, an analog meter, meter response circuits, frequency weighting filters, an amplifier, a preamplifier, and a microphone (Bruce et al., 2011; Meinke et al., 2022). This fact sheet is intended for new Occupational and Environmental Health and Safety (OEHS) professionals to learn the basics of the function, use, and interpretation of data collected by an SLM.

Why Use a Sound Level Meter and Not a Dosimeter?

While dosimeters are useful for measuring the cumulative personal noise exposure of highly mobile workers, they are not a perfect solution for understanding occupational noise exposure at a specific moment or location (NIOSH, 1998; IEC, 2013). Noise dosimeters record measurements throughout the sampling period; however, it is often difficult for the OEHS professional to identify specific tasks or machinery that significantly contribute to a worker's noise dose. These types of measurements can be easily accomplished with SLMs. Assessing exposures this way allows the OEHS professional to identify specific sources of noise contributing to personal noise dose and recommend controls (Meinke et al., 2022). Some SLMs offer a dosimetry function that can be used during task measurement. Similarly, SLMs are useful for gathering individual area measurements that can be used to construct a noise map. Some SLMs can be equipped with octave band filters, allowing the user to understand the frequency characteristics of the noise and assist in selecting the most appropriate controls.

Which Type to Use

In the U.S., the Occupational Safety and Health Administration (OSHA) requires that the SLMs used to assess compliance adhere to the American National Standards Institute (ANSI) S1.4-2014 standard for accuracy and precision (OSHA, 2022). These standards outline specific performance criteria that the SLM must meet, including a defined linear operating range, frequency response, and the ability to operate accurately across a specified temperature range. These criteria ensure the device's accuracy and precision for measuring sound levels in various professional applications, making it suitable for environments where accuracy is critical. The current ANSI standard is identical to the International Electrotechnical Commission (IEC) 61672-1:2013 for SLMs, which is widely used in other countries. Briefly, the two SLM specifications relevant to OEHS professionals are:

- Type 1 – for precision measurements in the field (Precision: ± 1 dB)
- Type 2 – for general purpose measurements (Precision: ± 2 dB)

Typically, Type 2 SLMs are sufficient for OEHS use. Type 1 SLMs should be considered when dealing with high-frequency noise, such as sources of compressed air, or when selecting engineering controls to mitigate this type of noise. The difference in error tolerance between the two types is summarized in Figure 1.

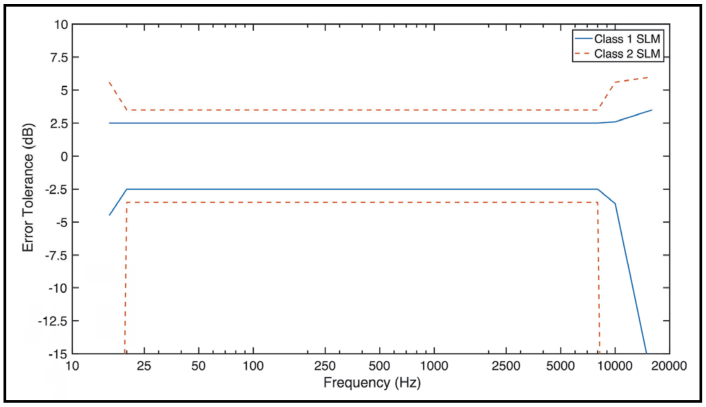

Figure 1. Error tolerances for the frequency response of Class 1 (solid line) and Class 2 (dashed line) sound level meters (SLMs).

There are other SLMs available that may not adhere to the ANSI/IEC standard or are app-based. While these can be useful screening tools, their accuracy and precision can vary. As a result, they cannot be used for compliance measurements (Roberts and Neitzel, 2017).

In summary, in most cases, a Type 2 SLM is sufficient to meet the needs of an OEHS professional.

Which Settings to Use

It is possible to use an SLM to collect instantaneous measurements or to integrate (i.e., average) measurements over a period of time. The ability for some devices to average measurements over time gives rise to the distinction between "Basic" and Integrating SLMs. For basic SLMs, there are several settings that can be adjusted on the SLM, including the response time, weighting scale, and octave band filter. For integrating SLMs, there are additional settings and mirroring dosimeter settings (AIHA, 2024) such as the criterion duration, criterion level, exchange rate, and threshold.

Response Times – The response time indicates how long a period is used to create an average sound measurement. The most common options for response time are slow (S), fast (F), and impact/impulse (I). Impact is generally the shortest measurement duration that the meter can achieve; it is as close as the meter can come to providing a peak measurement. Fast response usually provides a measurement every 1/8th of a second (125 ms). Slow response provides a measurement every second. In the absence of logging capabilities, it is easier to use a slow response while performing sound level surveys.

Weighting Scale - Sound level meter frequency weightings (A-weighting, C-weighting, and Z-weighting) are digital filters applied to SLMs. Each weighting reflects different aspects of human auditory perception: A-weighting is the most commonly used filter, designed to approximate the human ear's sensitivity to different frequencies. C-weighting emphasizes low frequencies and is used for peak measurements. Z-weighting is a flat filter that provides an unweighted measurement and is primarily used for detailed frequency analysis, such as in 1/3-octave bands.

Octave Bands – Most SLMs combine the noise levels from all frequency ranges into a single number, typically the A-weighted decibel (dBA). More advanced SLMs feature octave band analyzers that enable the user to measure the sound level for several small frequency bands (octaves) simultaneously. There are 1/1 octave bands and 1/3 octave bands. Octave band analysis is typically used when trying to identify the specific frequency of noise that contributes the most to the total sound level. The *AIHA Noise Manual* provides a more in-depth discussion on octave band analysis.

Generally, these settings can be specified directly on the device or through the software provided with the SLM. Below are some recommended settings for typical situations that an OEHS professional may encounter when measuring occupational noise.

- General sound level survey
  - Slow Response
  - A-Weighting
- Identifying the most effective engineering controls
  - Type 2 Octave Band Analyzer
  - Z-weighting

Sound Level Meter Availability and Options

The wide array of manufacturers and SLM models available today can make choosing an SLM a challenging process. Like other OEHS instruments, it is important for whatever device is chosen to be "fit for purpose." The first consideration should be the type of measurement the device will be used for. While it may be tempting to choose a basic, low-end (e.g., cheaper) device based on current needs, it is important to consider that it may be necessary to conduct more sophisticated measurements in the future. Another consideration is whether one is already using a certain model of device and is generally happy with the product and support from the manufacturer. Finally, ensure that the computer and/or smart device software accompanying the SLM is up to date and allows for exporting data in a non-proprietary format, such as a text file or comma-separated value (.csv) file. Thus, if a decision is made to change platforms, steps can be taken to minimize the loss of access to historical monitoring data. Beyond these important factors, Table 1 lists commonly available features of modern SLMs. It is important to note that different SLMs may be offered for occupational and environmental noise measurements, with the latter including lower measurement ranges.

When deciding which specific SLM to purchase or rent, it is helpful to consider the following questions:

1. Is the SLM exclusively for occupational noise versus environmental noise, or both?
2. Is a Type 1 or Type 2 SLM needed?
3. Does the SLM need to measure multiple different noise criteria simultaneously?
4. What choices of logging intervals are desired?
    a. What metrics are desired to be logged?
    b. What memory size is needed given the number of data points logged per interval, frequency of intervals, and total run time (e.g., continuous or sum of event times) that might be logged?
5. Is dosimetry a feature needed?
6. Does the SLM allow the setting of the needed criteria, exchange rate, and threshold (more details below)?
7. Is a 1/1 or 1/3 Octave frequency spectrum display desired?
8. Will an octave-based Real-Time Analyzer frequency spectrum display be desired?
9. Will a Fast Fourier Transform (FFT) frequency spectrum display be desired?
10. What data communication modes are needed or desired?
11. Is the use of a smart device in conjunction with the SLM of interest, as some line-specific apps provide purpose-specific control and analysis software for the SLM?
12. Is the GPS of interest to log location with sound measurement and metrics? Does the GPS feature provide sufficient accuracy with respect to the location of noise sources and the measurement?
13. Is an audio recording of sound events desirable? Is making audio notes desirable?
14. Is measurement into low-noise ranges (e.g., threshold lower than 70) needed?

SLM Function
>1 virtual meter running on different settings
Dosimetry tools
Selectable thresholds & criteria for dosimetry
Summary data logging
Time-history data logging
Variable logging intervals
Different on-board memory options
Data logging, long-term
Fast logging of certain parameters
Automatic event detection/triggers
Picture event triggering with an app on the phone
Spectrum analysis
1/1 Octave filters
1/3 Octave filter
1/1 Octave-based Real Time Analyzer
1/3 Octave-based Real Time Analyzer
FFT analysis
Communication: wired download, or:
WIFI
Bluetooth
Cellular
GPS

Table 1. List of common features available on modern SLMs.

Calibration and Sampling Procedure

Field calibration is crucial to ensuring the device operates properly. Every SLM model requires a slightly different calibration procedure; therefore, it is essential to consult the device's manual. Generally, calibration should be conducted before and after each use, with a calibrator that generates a tone at 1000 Hz with an intensity of 94 or 114 dB. The reading on the SLM should be adjusted to be within +/- 0.5 dB of the calibration intensity. If the reading cannot be within the 0.5 dB range, select another SLM for the survey. If a post-survey calibration check reveals that the SLM is outside the 0.5 dB range, this should be recorded alongside the measurements. Record the results, as well as the SLM and calibrator serial number.

Please see the Dosimeter Fact Sheet for a detailed walk-through of the calibration process. Users should also refer to the manual for specific instructions on calibrating their devices.

A factory calibration should be performed as per the manufacturer's manual and recommendations.

Positioning of the Sound Level Meter: The meter should be free from impediments to the measurement such that it is taken in the open air around the SLM. The SLM is positioned within 12 inches (30 cm) of the employee's head at ear level and an appropriate height depending on the task. Wind screens should be used and are available in most kits. They are used to correct errors introduced by wind (in the outdoors) or airflow indoors (e.g., ventilation systems).

The sample duration depends on the type of survey being conducted and the length of time the noise is generated. Full-shift measurements are best collected by a noise dosimeter (AIHA, 2024). For an area survey, ensure enough sample time (at least 30 seconds) to capture the loudest noise levels and establish the pattern of noise in the area (NIOSH, 2023). Take enough measurements to ensure that there is sufficient data to evaluate the sound levels of the area adequately.

Results and Interpretation

SLMs can be used to conduct area surveys or measure personal exposure.

The area noise survey may be conducted comprehensively or in phases. Upon identification of areas where sound levels exceed 85 dBA, appropriate signage should be installed to indicate that hearing protection is recommended due to potential exposure to hazardous noise levels. Area surveys can also be used to develop noise maps, which can assist in hazard identification and planning. Like all exposure measurements, it is important to consider the role that variability can play. There is no guarantee that the sound level measured at one point in time will be the same a day or even an hour later. Even when sufficient measurements are collected to account for variability, it is best practice to periodically repeat the noise survey to ensure that the data in the survey is still relevant. Figure 2 provides an example of the general SLM components, including the standard display information.

Figure 2. Typical sound level meter and display screen.
Note: Photo by Don McInnes

An SLM can also be used to assess an employee's noise exposure, and is best used if they are stationary for a known timeframe, or most of their work shift, or task-based exposure assessments. If possible, this is best done using a noise dosimeter, as it is far less cumbersome. But if a noise dosimeter is not available, an SLM can be used for this purpose. To use an SLM for this determination, an OEHS professional needs to accompany the employee for their entire shift, or a representative portion of that shift. The noise levels need to be taken within the "hearing zone" of the employee (OSHA, 2022), which is near one of the ears (ideally an area near the collarbone or upper shoulder), without disturbing the worker or blocking the source of sound. While collecting measurements, it is important that the OEHS professional collects notes on the sources and tasks associated with the exposure.

Please refer to Chapters 3 and 9 of the *AIHA Noise Manual* for more information on calculations.

Definitions

Extensive sound glossaries may be found at https://www.acoustic-glossary.co.uk/ and at https://www.electropedia.org/iev/iev.nsf/index?openform&part=801 and can be consulted for all terms not listed here.

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 duration - the length of exposure used to calculate dose. For occupational exposures, the typical duration is 8 hours (480 minutes).

Criterion level - a 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). The criterion level for the OSHA and MSHA PELs is 90 dBA. The current NIOSH and ACGIH criterion level is 85 dB. (Larson Davis, 2023)

Decibel (dB) - a unit of sound level. The dB is expressed on a logarithmic scale. (CCOHS, 2023)

Exchange rate (ER) - the quantity of sound needed to halve or double the exposure duration. OSHA currently employs an ER of 5 dB, almost all other agencies use a 3 dB ER (e.g., NIOSH, ACGIH, DoD, ISO, EU, etc.).

Fast Fourier Transform (FFT) - a digital signal processing technique that converts a time record into a narrow band constant bandwidth filtered Fourier spectrum. Measurements are defined by specifying the frequency span and a number of lines (or filters). (https://www.acoustic-glossary.co.uk/)

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} – the equivalent continuous A-weighted sound pressure level, which is the constant noise level that would result in the same total sound energy being produced over a given period.

Noise dose - the 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 the selected threshold level, the criterion level, and the 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. (AIHA, 2024)

Octave band filter - a bandpass filter that divides the audible spectrum into smaller segments called octaves. Typically, OEHS professionals use full octaves or 1/3 octaves.

Peak sound level (IEC 801-22-15) - greatest instantaneous value of a standard-frequency-weighted sound pressure level, within a stated time interval, also known as the peak frequency-weighted sound pressure level. (https://www.acoustic-glossary.co.uk/)

Sound pressure level (SPL) - the level of sound pressure measured in decibels (dB). It represents the intensity of the sound wave.

Threshold level - the sound level at which the device integrates the exposure into the noise dose. (OSHA, 2022)

Time-weighted average (TWA) sound level - 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)

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