An Online Conference
NOISE-CON 2020
Week of November 16, 2020

Tutorial on Sound Level Meters: Choosing a Sound Level Meter

Tyler Dare
Applied Research Laboratory
The Pennsylvania State University
PO Box 30
State College, PA 16803
tpdare@psu.edu

ABSTRACT
Deciding what sound level meter to purchase can be an intimidating task. Features can vary widely, and prices often span orders of magnitude. In this tutorial, we will offer practical tips on choosing a sound level meter. First, features common to most sound level meters are briefly discussed, such as calibration and storage. Then, different optional features are discussed, including octave band analysis, time history logging, multiple channels, and analysis types useful to noise control engineering. Differences between Class 1 and Class 2 meters are highlighted, as well as alternatives to sound level meters, such as smart phones and data acquisition systems. *Note: this paper is part of a series of tutorial papers on sound level meters.*

1 INTRODUCTION
Sound level meters must meet a host of requirements for accuracy and robustness to electrical and envorinmental factors. However, in terms of features, the only major requirements of IEC 61672-1[1] are that a sound level meter must be capable of displaying the result of an A-weighted sound measurement and it must be possible to calibrate the meter. It is easy to become overwhelmed with all of the different options of various meters, especially with the costs of meters spanning orders of magnitude. The goal of this paper is to provide a brief description of the different options and features of sound level meters so that the most appropriate meter can be selected with confidence.

2 PERFORMANCE CATEGORIES
IEC 61672-1 describes two categories of performance for sound level meters, class 1 and class 2. In general, class 1 requires better accuracy and performance than class 2. Aside from the accuracy, there are some additional performance requirements for class 1 meters and features that may be of interest, depending on the application:

- Class 1 meters must be accurate to $\pm$1.0 dB at most frequencies, compared to $\pm$1.5 dB for class 2 meters.
- In addition to A-weighting, class 1 meters must also have a C-weighting option.
- Class 1 meters are required to have a wider frequency range (16 Hz to 16 kHz one-third octave bands) than class 2 meters (20 Hz to 8 kHz one-third octave bands).
- Class 1 meters are required to give more accurate results for transient sounds than class 2 meters.

- Class 1 meters are required to have less drift in measured levels over time and have less sensitivity to changes in supply voltage and atmospheric conditions compared to class 2 meters.

Some standards require the use of a class 1 meter, especially for measurements typically conducted in a laboratory setting. The wider frequency range of class 1 meters may be needed for sources dominated by low frequencies, such as wind turbines, or high frequencies, such as motor controllers. For surveys of occupational noise or where the interest is mainly in whether or not noise regulations have been met, a less expensive class 2 meter may suffice.

Both the specification sheet and the body of the meter will indicate what standards the meter meets, including the meter's class. If there are no standard markings present, there is no guarantee that the unit in question is suitable for noise measurements, and a different meter should be selected.

3 KINDS OF SOUND LEVEL METERS

There are three kinds of sound level meters described in IEC 61672-1, categorized on the type of results that are calculated and displayed.

- **Time-weighting sound level meters** must include F (fast) time weighting. Many meters also include S (slow) time weighting.
- **Integrating-averaging sound level meters** must measure time-averaged sound levels.
- **Integrating sound level meters** must measure sound exposure levels. Note that it is simple to convert between time-averaged sound level to sound exposure level by adding or subtracting $10\log_{10}\left(\frac{T_e}{1\ s}\right)$ dB, where T_e is the exposure time in seconds.

Many meters include a combination of these features. If the interest is only in assessing compliance with noise regulations, an integrating or integrating-averaging sound level meter may be appropriate. However, if assessing sources of noise and investigating potential noise mitigation strategies is of interest as well, a time-weighing sound level meter is useful.

ANSI S1.13-2005[2], "Measurement of Sound Pressure Levels in Air", establishes requirements for when to use the different kinds of meters or different settings on a given meter, depending on the characteristics of the sound being measured. In general, time-averaged sound levels or sound exposure levels are used to describe the average sound over time from steady or intermittent sources, but time-weighted levels are used to describe fluctuations in sound and can be used for statistical descriptions of sound over time. A meter that can perform both time-weighted and time-averaged measurements is preferred.

4 ADDITIONAL FEATURES

After selecting the class of meter most appropriate for your situation, it is helpful to consider what additional features might be useful. These features are generally not necessary for a unit to be labeled as a sound level meter under various standards, but they may be useful or even necessary in certain noise control applications.

Note that some vendors include various features as additional software licenses, which may require an additional cost. It is best to establish what features are needed or desired ahead of time, and then request quotes from multiple vendors for units that meet these needs.

4.1 Octave band and one-third octave band analysis

The ability to measure noise in octave bands and one-third octave bands can be useful and often necessary. Knowing the frequency content of a sound can be used to establish the sound's source.

Additionally, spectral analysis can be used to determine what source is dominating the total sound field, so cost-effective recommendations can be made.

Some meters can also output narrow-band (sometimes called "FFT") spectra. Narrow-band spectra can be used to establish the precise frequency of a tone. For example, when investigating machinery noise, tones at multiples of a machines rotation rate can indicate problems with gears or fan blades.

4.2 Wider frequency range

Though class 1 meters must function between 16 Hz and 16 kHz, some meters include an even wider range. For most industrial noise applications, a wider range is not necessary. For wind turbine noise, however, there is often significant interest in the infrasound range (below 20 Hz). Conversely, when monitoring noise from motors, pulse width modulation switching frequencies are often above 16 kHz and may be of interest.

4.3 Wider level range or auto range

Older analog meters commonly have a level range setting or dial. The meter can only measure sound within a given range of levels (for example, 20 dB) at a time. If the range is set incorrectly, the meter can be overloaded or may not measure any sound at all (under-ranged). Many modern digital meters do not have a user-selectable range settting, so there is less opportunity for error.

4.4 Time history recording

It can be valuable to be able to store the sound recorded from a meter. The sound can be played back for the client or used for future analysis. Those experienced and comfortable with signal analysis will find this feature invaluable. Uncompressed file formats (such as .wav) are preferred. Additional storage space in the meter may be needed to support long recordings.

Meters capable of time history recordings commonly also include a Z-weighting option, in addition to the required A-weighting. Using Z-weighting, the unfiltered time histories can be recorded.

4.5 Recording of time-weighted values

Some statistical measures of noise, such as L_{90} or $L_{\max}$, require that time-weighted (F or S) values be stored over the length of the recording. These metrics are common in environmental noise monitoring situations.

4.6 Simultaneous measurements

With so many recording settings available on high-end meters, it can be difficult to choose the most appropriate one for any given situation. A useful option available on some meters is the ability to record and display multiple metrics simultaneously. For example, it is often useful to calculate both the A-weighted time-averaged sound level and the C-weighted peak level to describe transient events. Showing the current time-weighted level along with the time-averaged level since the beginning of the measurement is also useful. For meters that can record time histories, it can be useful to record the Z-weighted time history while watching a real-time display of the A-weighted levels.

4.7 Calibration features

All meters must be calibrated both at the factory and in the field. Many meters have the ability to detect the calibration tone and its nominal level, especially for calibrators sold in a kit with the meter. Another important feature is the ability to store a history of calibration values over time. Aside from making record-keeping easier, it can be useful to watch a slow drift of calibration values over weeks or months to get a warning of when the meter might need additional factory calibration or service.

4.8 Calculation of additional metrics

Some meters are able to calculate standard metrics for outdoor and building acoustics. For example, some meters are able to calculate reverberation time and noise criterion (NC) curves. Though these metrics can be calculated through post processing of time histories or octave band levels back in the office or laboratory, it can be useful to get real-time information in the field. If you will be relying on included software for calculating results and report generation, it is worth choosing a meter that includes software that will work for your application and systems.

4.9 Water resistance

For outdoor measurements and especially long-term environmental monitoring, a water-resistant meter is necessary. Such meters are labeled with an ingress protection (IP) code, for example IP54, where the numbers indicate the level of protection[3]. Note that in many situations, the microphone it not part of the IP rating. A weather-resistant windscreen can be used so that measurements can continue even in the rain. A meter that includes an optional microphone extension cable can be useful for long-term experiments so that the meter can be secured while the microphone stays at the monitoring location.

4.10 Multiple channels

All sound level meters will include a microphone, but some also include inputs for additional microphones or other sensors. For example, an accelerometer can be used to measure the vibration of a machine to assess isolation mount performance. If an accelerometer and microphone are sampled simultaneously, correlation analysis can be used to determine whether a vibrating component is radiating sound. Sound intensity measurements are possible with two microphones and can be used to identify the source of sound and calculate its sound power.

5 ASSEMBLED METERS

We typically think of sound level meters as being a self-contained unit, but it is possible to assemble a sound level meter from components, as long as the assembled system meets the requirements. For those that already own general-purpose data acquisition systems, it may be more cost effective to add the necessary components to make a complete sound level meter. However, given that there are many additional requirements for sound level meters beyond those mentioned in this overview, it may be difficult to prove that an assembled system does indeed meet all of IEC 61672-1 without an investment in equipment greater than that of simply purchasing a stand-alone meter.

6 APP-BASED "METERS"

Searching for "sound level meter" in the iOS or Android app store yields hundreds of options for smart-phone-based sound level measurement options. However, a 2018 study of sound level meter apps[4] concluded that "Many sound measuring apps exist on the market for various mobile platforms, but only a fraction of these apps achieves sufficient accuracy for assessing noise levels, let alone be used as a replacement for professional sound level measuring instruments." However, one app, available on iOS only, has been shown to meet the accuracy requirement for a Class 2 meter when used with an external microphone. The app is available in the Apple app store as "NIOSH Sound Level Meter" and can be used for a "first glance" evaluation of noise to determine if a more detailed evaluation is required. It is important to note that the NIOSH app and external microphone combination was not evaluated on many of the other requirements of IEC 61672-1, and so should not be used in a setting where aherence to standards is strictly required.

7 PERSONAL PREFERENCE

Once you have decided on what class of meter and features you need, it is also important to consider how easy a meter's interface is to use, how good the display is, and how quickly you can find the features you want. When possible, visit an exhibition with multiple sound level meter vendors to try out as many as you can. It will be helpful to write down a list of "must-have" and "nice-to-have" features so you can more easily compare your choices on an equal basis. While you try out the meters, also ask about warranty and factory calibration options to get an idea of the level of service each vendor provides. Select a meter that you can use confidently that you will enjoy using for years to come.

8 REFERENCES

1. *Electroacoustics – Sound level meters – Part 1: Specificaions*, International Standard IEC 61672-1: 2013-09 (International Electrotechnical Commission, Geneva, Switzerland, 2013).
2. *Measurement of Sound Pressure Levels in Air,* American National Standard ANSI S1.13-2005 (American National Standards Institute, Inc., Melville, NY, 2005).
3. *Degrees of protection provided by enclosures (IP Code)*, International Standard IEC 60529: 1989 (International Electrotechnical Commission, Geneva, Switzerland, 2013).
4. Celestina, M., Hrovat, J., and Kardous, C. A., "Smartphone-based sound level measurement apps: Evaluation of compliance with international sound level meter standards," *Applied Acoustics* **139**, 119–128, 2018.