Quick Start Guide for Smaart SPL

Release 1.1

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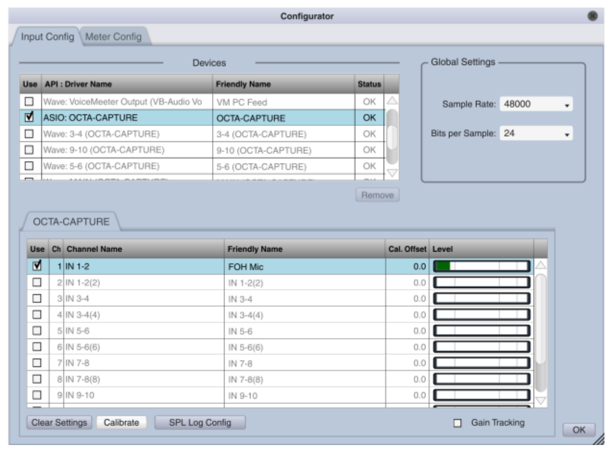
Getting Started with Smaart SPL

This guide will run you through the process of getting Smaart SPL set up to monitor and log sound pressure levels (SPL). For an overview of the basics of SPL measurement, see “What Is SPL?” on page 7.

- First, we’ll need to calibrate an input. If you’re launching Smaart SPL for the first time, the program will display a message stating that no calibrated inputs were detected. Clicking OK brings up the *Input Config* dialog. You can also open it by clicking the Input Config button.

- Check the “Use” box for the device you want to use. The device must be connected and powered on before Smaart SPL is launched in order to be recognized by the application.

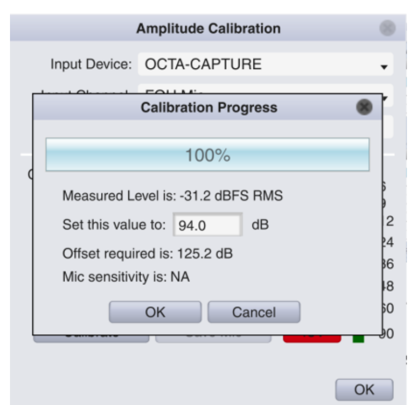


- Check the “Use” box in the lower pane for each input you want you use. We’ve chosen Channel 1, and given it a Friendly Name of “FOH Mic.” This will help reduce confusion if more inputs are added later.

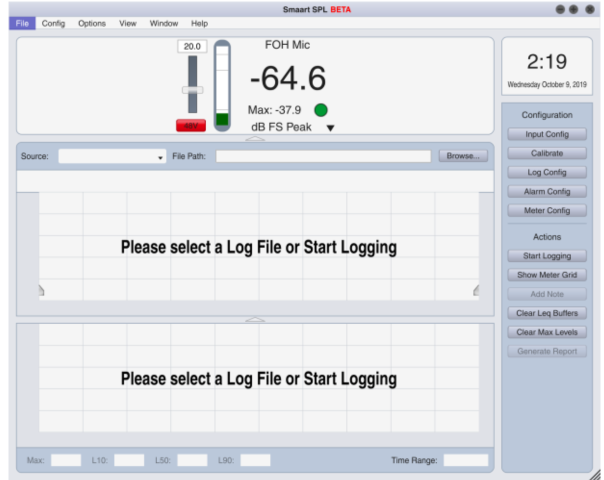
- To measure SPL, an input must be calibrated. Select the input, then click the Calibrate button to open the Amplitude Calibration dialog. Turn on the calibrator and fit it over the microphone, ensuring a snug fit. (Do this slowly so the pressure change doesn’t damage the mic).

- Set the preamp gain to give the desired amount of headroom on the meter. (For example, if your calibrator is producing 110 dB SPL and you want to be able to meter levels up to 130 dB SPL, adjust the preamp level until the meter shows a level of -20 dBFS RMS or lower.) **Make sure to leave enough headroom so the input will not clip during the show!** For concert level measurement, we recommend that your measurement rig be able to accommodate at least 135 – 140 dB peaks.

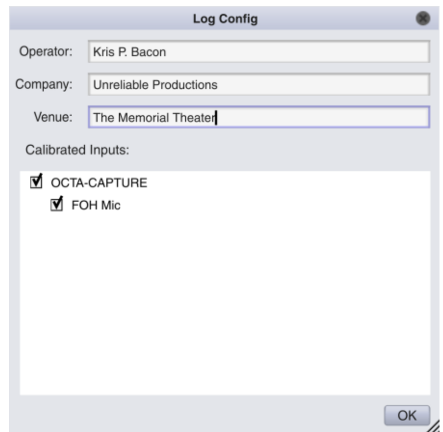
- Click the *Calibrate* button. Once the calibration process completes, enter the level being produced by your calibrator into the “Set this value to:” field and press Enter. Then click OK to close the popup. You may now calibrate another input if desired or click *OK* to close the Amplitude Calibration dialog.



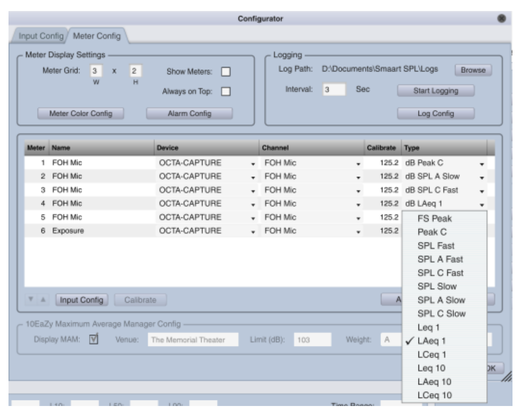
The main program window is divided into three panes with a control bar along the right. The top pane shows the input meters for each selected and calibrated input, along with preamp controls for gain tracking-enabled IO devices. You can click the small triangle below this pane to collapse it.



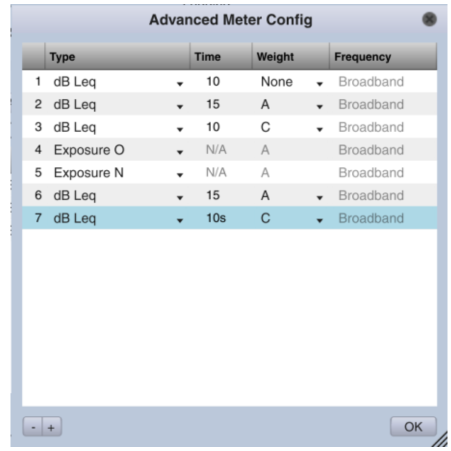
Now, let's get set up for logging. Click the "Log Config" button in the control bar to enter event details to be included in the log file, and choose which inputs are logged if you have multiple enabled.



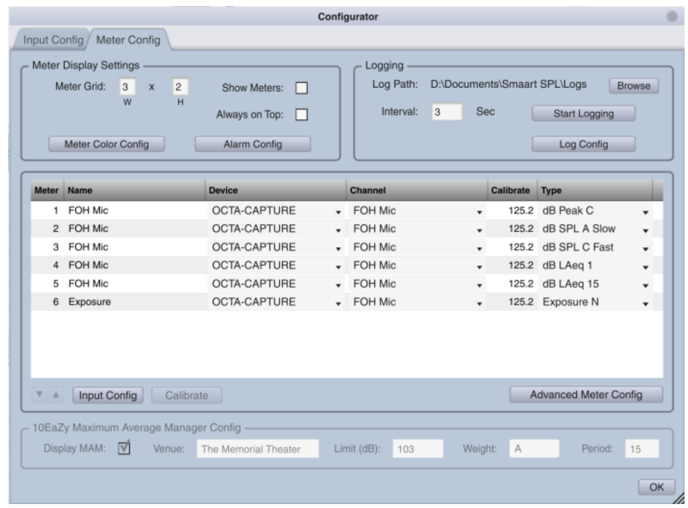
Next step is to configure the meters and metrics we want to log by clicking Meter Config. Here we've configured a 3 x 2 grid to display six meters, and chosen metrics for each with the "Type" dropdown menu. For the last two, let's configure some custom metrics by clicking "Advanced Meter Config."



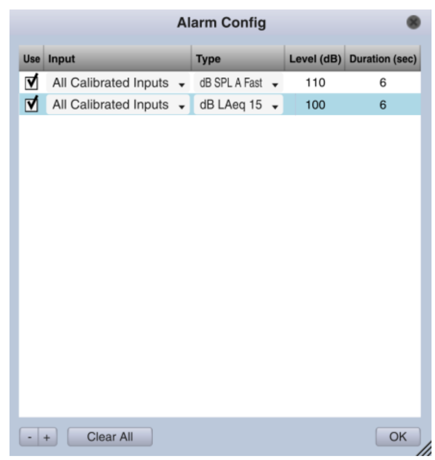
Clicking the + button below the list adds a custom metric. Here we've added an A-weighted Leq 15 and a C-weighted 10 second Leq.



After clicking OK, you can select these new metrics from the Type dropdown in the Meter Config table. You can also give each meter a name if you like – here we've renamed meter 6.

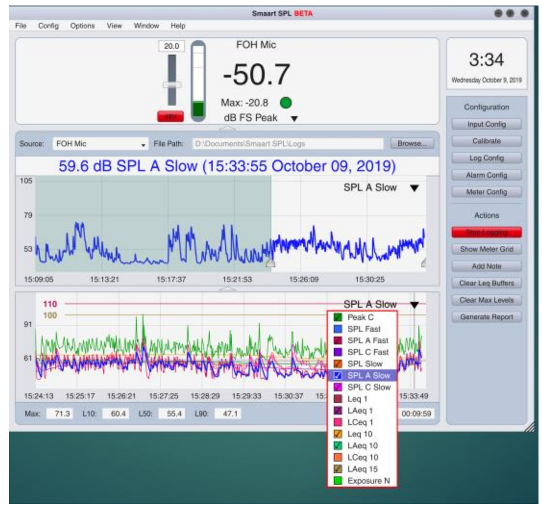


Let's choose Alarm Config next. Here we've added two alarms that will trigger if SPL A Fast exceeds 110 dB, or if LAeq 15 exceeds 100 dB. Alarms can be set to trigger from all calibrated inputs, or specific inputs.



Now we're ready to start logging. Click the Start Logging button to get things rolling. It turns red, and the SPL History plots begin to fill with data.

The top pane is the navigation pane. It shows the entire log duration for the currently selected metric, visible in the upper right-hand corner of the pane. The bottom pane can display multiple metrics at once. Use the [+] and [-] keys to zoom the plot vertically. You can also zoom the bottom pane to a shorter time range by either dragging the arrowhead-shaped widgets in the bottom corners of the upper plot, or entering the desired time range into the Time Range box below the plot.



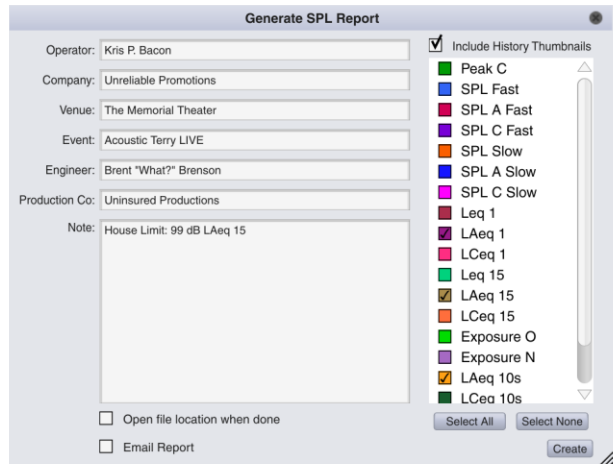
Here we've set the Time Range of the bottom pane to ten minutes, and I've used the metric drop-down list to display additional metrics as well. Change the focused metric, displayed in the top pane, by either selecting it in the drop-down menu or pressing the [Z] key to cycle through visible metrics.

The horizontal lines labeled "110" and "100" represent the alarm thresholds we've configured and are the same color as the metrics they represent. They will hide and show along with their related metrics.

Click "Show Meter Grid" or press [E] to open the meter grid we configured earlier. This is an independent window that you can move and resize freely. Click on the metric name on the bottom of each meter to choose a different one, or in the center of the meter to open Meter Config. Click the circle to reset Max values, and right-click (Ctrl-Click on Mac) for options to reset Exposure and Leq Buffers for the input.

After the event is finished, click Stop Logging, and the File Path bar shows where we can find the log file we just created. By default this is in the Smaart SPL > Logs directory in your Documents folder, but can be changed in the Logging section of the Meter Config tab.

Right-clicking in this filename field allows you to select Open File Location and browse directly to the file using your operating system's file browser.



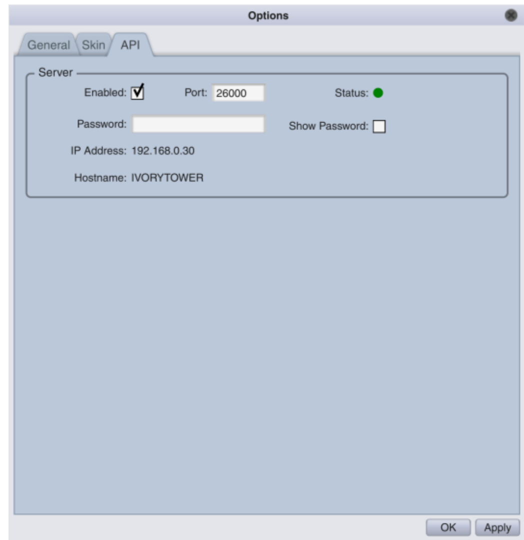
Click Generate Report, enter any desired details, then click OK to prepare an SPL Summary Report for the selected time range. You can choose to include History Thumbnail graphics of any combination of metrics. You can also choose "Open file location when done" to have your operating system open a file browser window showing the generated file, or "Email Report" to open your default mail client with the PDF report attached.

Note that Smaart SPL's logging status is persistent – if you close the program while logging is enabled, it will start logging again next time the program opens. That way, a computer can be configured to boot at a scheduled time and automatically begin logging.

Configuring the Smaart SPL Webserver

Smaart SPL allows remote viewing of the history timeline, meters, and alarms via the web browser of a networked computer. The client computers do not need to have Smaart SPL installed. Here's how to get it running:

1. Configure Smaart SPL as desired, and start logging.
2. Choose "API" from the Options menu.
3. If desired, enter a password. Client machines will be prompted for the password when they connect.
4. Click the "enabled" checkbox to start the webserver. The status indicator should turn green.
5. On client machines, open a web browser and enter either the server IP address or hostname, followed by the port number, as displayed in the API Options tab. For example, you would connect to the server shown here by entering



192.168.0.30:26000

or

IVORYTOWER:26000

If you want to test the webserver on the same computer that's running Smaart SPL, you can also enter "localhost:26000".

Make sure to disable adblocker plugins in your browser, as they can interfere with the API data.

What is SPL?

Sound Pressure Level (SPL) is a measure of the strength of air pressure variations caused by a sound wave. As sound waves travel, they force the air into rapidly alternating states of high and low pressure (*compression* and *rarefaction*), and SPL measures the magnitude of those changes.

SPL measures pressure deviation, not the ambient air pressure itself. If we use the metaphor of a cork floating on the surface of the ocean, we're interested in how much the cork bobs up and down with passing waves, not measuring sea level itself.

We might be tempted to define SPL as "how loud a sound seems," but that's not accurate. SPL is an objective measure of a physical reality, whereas loudness is deeply tied to human perception. Many factors – including SPL – influence perceived loudness, and that's part of the reason an objective measurement is so important: humans are great judges of loudness, but poor judges of SPL. Our ears answer subjective questions like "is this mix comfortably loud", while measurements answer objective questions like "is this sound level dangerous?".

The dB SPL Scale

Reference

SPL is stated in decibels (dB), which means it's a comparative measure: decibels describe how a value compares to a reference. The reference for dB SPL is the threshold of human hearing, or roughly the lowest sound pressure a human can perceive under normal conditions. (For the math nerds, 0 dB SPL is equivalent to a pressure variation of 0.00002 Pascal, or 20 µPa.) The displacement of the eardrum caused by 0 dB SPL sound waves is less than the diameter of a hydrogen atom. At the other extreme, we have the upper limit of human hearing and the threshold of pain, which resides somewhere around 120 – 130 dB SPL. Everything we hear in our day to day lives falls in between these two extremes.

Logarithmic

An important aspect of SPL is that it is a **logarithmic** value. Each 20 dB increase in SPL corresponds to a 10x pressure increase. One of the reasons for using a logarithmic (or "log") scale is that our ears respond to an enormous range of sound pressure – for example, the 120 dB range of human hearing represents a millionfold range of values, analogous to the difference between the length of my driveway and the distance between New York and California. The log scale helpfully compresses that large range of values into smaller, more convenient numbers.

Another basis for the logarithmic scale is that it's a much closer match to our perception, which responds to "percent change." In other words, we perceive a small increase to a low-level signal similarly to how we perceive a large increase to a high-level signal. A good rule of thumb is that a 10 dB increase will be perceived as "twice as loud" to the average listener, but this can depend on many factors, such as source material, spectrum, level, and tone – another reason why it's so important to have an objective reference.

Instantaneous vs Continuous Measurements

SPL measurements fall into two broad categories. An **instantaneous** measurement describes the level at a certain moment in time, like taking a photograph. A **continuous** measurement, on the other hand, is a value integrated over a period of time. (Integrated measurements apply "time weighting," which damps the display's response to sudden changes.) The distinction between the two types of measurements is similar to the difference between peak and program meters on a mixing console.

If you have used a handheld SPL meter, you are familiar with two common integrated measurements: SPL Slow (integration time of 1 second) and SPL Fast (0.125 seconds). If you switch between the two, you'll notice that Fast readings tend to be higher than Slow, because the Slow reading is integrated over a longer time constant and is therefore less affected by short peaks. In addition to Fast and Slow, Smaart SPL offers additional metrics that can be more useful depending on the purpose of the measurement.

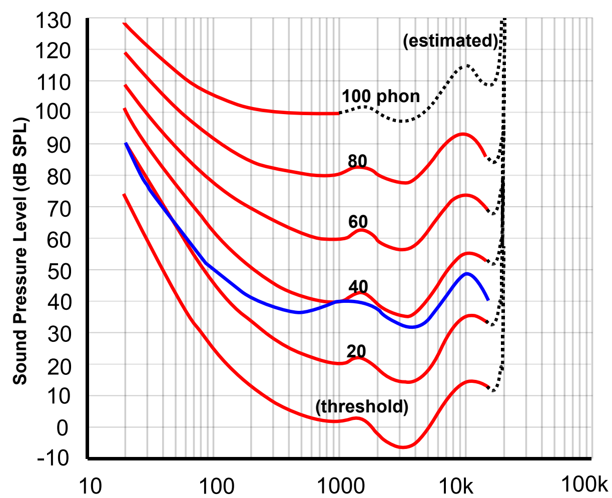
Perception

The human auditory mechanism is wonderfully complex. Our perception is influenced by many factors, both internal (blood pressure, metabolism, fatigue) and external (acoustic environment, intelligibility, source tonality, direct to reverberant ratio, etc), which means that we are quite poorly suited to make objective determinations.

Equal Loudness Contours

A common example is the Equal Loudness Contours, often incorrectly referred to as the Fletcher Munson curves, after Harvey Fletcher and Wilden A. Munson who published the first formalized work on the subject in 1933. (The curves that we often see today, standardized in ISO 226:2003, are actually based on later work by a number of researchers.)

The equal loudness contours describe how our perception of tonal balance changes significantly based on level. At low levels, our hearing is most sensitive to frequencies around 3 kHz and rolls off towards the extremes of the audible spectrum, particularly the low frequency. As level increases, our response flattens out. Thus, we perceive more bass information when the music is louder, providing a scientific basis for the liner notes of the Rolling Stones' 1969 album *Let It Bleed* ("THIS RECORD SHOULD BE PLAYED LOUD").



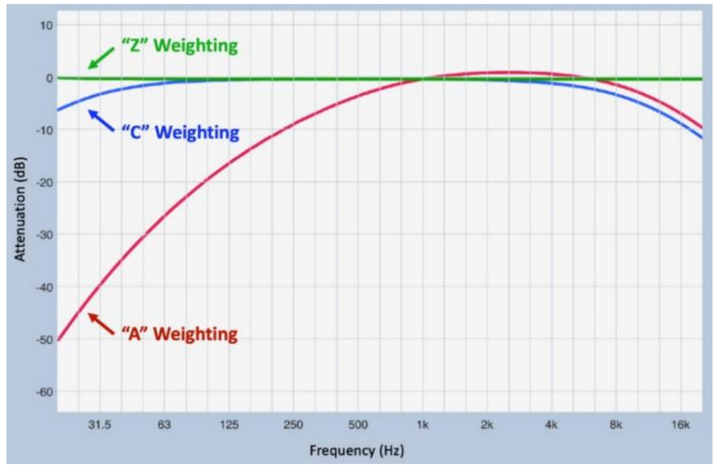
Equal-loudness contours (red) (from ISO 226:2003 revision)
Original ISO standard shown (blue) for 40-phons

Phons

The equal-loudness contours make it quite clear that our loudness perception of a tone varies significantly depending on frequency. Since SPL doesn't necessarily correlate with our loudness perception, we can more directly describe loudness using **phons.** A phon is a unit of loudness that attempts to incorporate the concept of SPL with the equal-loudness contours. Phons use a reference frequency of 1 kHz, and tones falling elsewhere along the equal loudness curve will have the same value as the 1 kHz tone.

Weighting Curves

SPL meters offer several weighting curves which were originally intended to help the meter better match the ear's response at various listening levels, although this approach was flawed in both conception and execution. Most meters offer A and C weighting filters, as those are required by the applicable Standards. Others exist but are not in common usage. Although these curves were originally designed for perceptual reasons (make the measurement "look like it sounds"), they are useful for modern measurement applications that seek to answer objective questions.



A Weighting

The A weighting curve was originally designed to produce a measurement that better correlates with the loudness perception of the ear at lower levels, around 40 dB SPL. Although many noise ordinances designed to prevent nuisance noise specify A weighted measurements, this is a poor choice because it is the low frequencies that are most likely to carry further and generate a noise complaint, and the A weighting curve does not accurately characterize LF information due to the extreme LF rolloff.

Intuitively, it is not immediately obvious why many noise exposure limits are specified in A weighting. The LF rolloff causes the meter to ignore large amounts of LF energy, which is where many loud noise sources (and music) have much of their energy. However, the current audiological consensus is that A Weighted sound level measurements correlate well with statistical data on noise-induced hearing loss, and reasonably approximates the diffuse-to-DRP transfer function of the human hearing mechanism. For this reason, the A Weighting curve is considered by audiological experts to be effective at characterizing sound exposure risk.[1],[2]

However, additional research has shown that LF energy can present a hearing health risk at high levels.[3] For this reason, many sound level limits specific a secondary C-weighted limit (see below).

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[1] https://www.who.int/pbd/deafness/Hearing_loss_due_to_recreational_exposure_to_loud_sounds.pdf
[2] https://www.who.int/activities/making-listening-safe
[3] https://www.aes.org/technical/documents/AESTD1007_1_20_05.pdf

C Weighting

The C weighting curve was originally intended to produce a measurement that better correlates with the loudness perception of the ear at higher levels, around 100 dB SPL. However, The C Weighting curve bears little resemblance to the tonal response of human hearing at concert levels. However, C weighting is effectively broadband for full-bandwidth material such as music and speech, and is useful when we want measurements that include the full sound spectrum.

Z Weighting / Unweighted

Unweighted (also called “Z-weighted”) measurements are taken with a flat response, and so most accurately characterize energy at the frequency extremes (below 30 Hz and above 16 kHz). It is of limited used in concert sound measurement applications, however it is useful for loudspeaker testing applications.

Octave Banded

Smaart SPL offers the ability to meter SPL as octave-wide bands, similar to a traditional RTA (Real Time Analyzer). This is useful when we want to know how the energy is distributed over frequency – for example, looking at levels in the 63 Hz octave band can help indicate whether a level overage occurred as a result of the PA system or a cheering crowd, or how much energy in a certain frequency range is passing across a property line.

Metrics

Smaart SPL comes pre-configured with 15 different metrics – Peak C, SPL Fast in all three weightings (A/C/Z), SPL Slow in all three weightings, a 1-minute Leq in all three weightings, a 10-minute Leq in all three weights, and OSHA and NIOSH sound exposure dose. An unlimited number of additional metrics can be configured as well. All configured metrics are generated and logged (if logging is enabled) regardless of which metrics you choose to view at a given time.

Peak Measurement

Peak C

Peak C shows the maximum instantaneous C-weighted value reached within a measurement period. It is useful for measuring compliance with regulations that seek to protect employees against sudden large peaks, like those created by industrial machines, explosives, and firearms. Peak C is often used as a secondary limit for live music SPL limits to protect the audience from intense broadband pressure peaks.

Additional Peak metrics can be configured in other weightings, including A, Z and Octave Banded.

Integrated Measurements

Integrated measurements use a "time-weighted average" (defined in IEC 61672-1:2013), providing a "smoothed" or "damped" display, similar to the ballistics of the needle on a VU meter.

SPL Fast / SPL A Fast / SPL C Fast

SPL Fast is one of the two metrics commonly found on handheld SPL meters. Technically, is a time-weighted average SPL measurement with a time constant of an eighth of a second (125 ms). Besides the unweighted (Z) metric, Smaart SPL also offers two weighted variants: SPL A Fast and SPL C Fast. Although many mix engineers are familiar with this metric, the time integration period is far too short to offer useful information when it comes to evaluating compliance with noise exposure regulations.

SPL Slow / SPL A Slow / SPL C Slow

SPL Slow is the other metric common on handheld meters. It is a time-weighted average SPL measurement with a time constant of one second. Besides the unweighted (Z) metric, Smaart SPL also offers two weighted variants: SPL A Slow and SPL C Slow. This is probably the measurement that most mix engineers are used to looking at while they mix, so it probably correlates the best with their "mental SPL meter," but as with SPL Fast, it isn't a useful metric for evaluating compliance with noise exposure regulations. "Fast" and "Slow" both decay too quickly to properly characterize longer-term level trends, such as the level of a verse, song, or set.

Equivalent Continuous Sound Level

Leq is a measurement of equivalent continuous sound level, which is a good measure of total energy exposure over a period of time, presented as a single dB value. It can be thought of as "area under the curve." Since live events tend to have high dynamic range and high crest factor, Leq is usually the most useful metric for evaluating level trends (what was the level of the last verse, song, or set?). It is common for a sound level limit at a live event to be a fifteen-minute Leq, which allows the mix engineer to use loud and quiet moments as an artist tool while making sure the long-term levels are compliant and controlled. The number suffix indicates the measurement period in minutes (Leq1, Leq10, etc) and a weighting curve, if used, is indicated after the L (LAeq10, LCeq10, etc). Smaart SPL allows an unlimited number of Leq metrics from 1s to 24h, in Z,A,C or octave weightings.

Leq1 / LAeq1 / LCeq1

Leq1 represents equivalent exposure level over the past minute. Besides the unweighted (Z) metric, Smaart SPL also offers two weighted variances: LAeq1 and LCeq1.

Leq10 / LAeq10 / LCeq10

Leq10 represents equivalent exposure level over the past ten minutes. Besides the unweighted (Z) metric, Smaart SPL also offers two weighted variances: LAeq10 and LCeq10. Leq10 is a good choice for monitoring exposure levels.

Custom Leq Metrics

Although SmaartSPL offers Leq1 and Leq10 metrics by default, you can configure custom Leq metrics with your choice of weighting and integration time by clicking “Advanced Meter Config” on the SPL Config tab of the Configurator. Enter an Leq time in minutes, or use ‘s’ after the number to specify an Leq in seconds or ‘h’ to specify a time in hours.

Exposure

Smaart SPL can model the exposure limits provided by both OSHA’s Permissible Exposure Limits (PEL) and NIOSH’s Recommended Exposure Limits (REL). OSHA exposure is used to establish legal liability, while NIOSH is used to establish hearing health risk.

Exposure O

The Exposure O metric models the OSHA Permissible Exposure Limits. It functions as a dosimeter, and the value is given as a percentage, with 100% constituting a full dose of exposure.

Exposure N

The Exposure N metric models the NIOSH Recommended Exposure Limits. It functions as a dosimeter, and the value is given as a percentage, with 100% constituting a full dose of exposure.

Why is it measured?

Legal

In an increasing number of jurisdictions, some form of SPL metering is necessary because there are restrictions or requirements in place. Noise-related legislation tends to fall into two categories: nuisance and exposure.

Nuisance

The primary goal of many noise ordinance regulations is reducing noise pollution and nuisance to parties outside or adjacent to the event area. Nuisance regulations often require events to keep their levels under a certain limit as measured from the edge of the event area, edge of the property, or outside the venue in which the event is taking place. (A measurement taken at FOH mix position does not necessarily correlate to what the level will be in the far field, as the distance a sound system will carry depends on how it is designed as well as multiple environmental factors.) However, many of these nuisance regulations are poorly written, arbitrary, or specify a limit in dBA, which is ineffective because A weighting is insensitive to LF energy, often the most problematic.

Exposure

Another focus of noise-related legislation is protecting or preserving the hearing of people in the direct presence of the noise source, for example, factory workers or audience and crew members at a concert. In the United States, national noise exposure limits come primarily from two sources: the Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH).

Hearing Health

It is well documented that excessive exposure to high sound pressure levels can cause permanent hearing damage. The ear employs several mechanisms (collectively called the **acoustic reflex**) that desensitize the inner ear in the presence of loud noise to reduce the amount of energy entering the cochlea. This loss of sensitivity is called a **threshold shift** and is familiar to you if you've ever felt like your ears were numb after a loud concert. The excess energy causes stress and fatigue in the hair cells of the inner ear, and if not given a chance to recover, the hearing loss can become permanent. Although loud noises often invoke a sense of discomfort, this is not a good indicator of whether a noise level is safe. People often think that they've "conditioned" their ears to be more resistant to loud noises. Unfortunately, this is not the case – repeated exposure to loud noise can raise the discomfort threshold past the point of harmful level exposure, so you can "feel fine" and still be damaging your hearing.

OSHA PEL	
Sound level (dBA)	**Duration (Hours:Minutes)**
85	16:00
90	8:00
95	4:00
100	2:00
105	1:00
110	0:30
115	0:15
120	0:07

OSHA Permissible Exposure Limit

OSHA's PEL (Permissible Exposure Limit) for noise exposure is 90 dBA for an eight-hour time-weighted average (see Leq, above). The context of the standard is workplace safety, which is the basis for the 8-hour exposure time. The PEL for other durations is determined using a 5 dB **exchange rate**, which means that every 5 dB level increase cuts allowable exposure time in half. This means the PEL for a one-hour concert would be 105 dBA.

The chart at left shows the OSHA PEL for various exposure durations. Maximum level for a given exposure time H in hours can also be determined with the formula ***dB = 105 – 16.6logH.*** It is a common misconception that observing OSHA exposure limits will protect against hearing damage. The OSHA limits are not intended for hearing loss prevention; they indicate the levels at which employers are legally obligated to protect their employees.

NIOSH REL	
Sound level (dBA)	**Duration (Hours:Minutes)**
82	16:00
85	8:00
88	4:00
91	2:00
94	1:00
97	0:30
100	0:15
103	0:07

NIOSH Recommended Exposure Limit

By contrast, the NIOSH REL (Recommended Exposure Limit) aims to protect hearing by reducing the risk of noise-induced hearing loss. The NIOSH limit is 85 dBA for an eight-hour time-weighted average. Unlike OSHA, the NIOSH standard uses an exchange rate of 3 dB, which is consistent with the current scientific consensus. (Since 3 dB represents a doubling of power, it follows that the same exposure limit will be reached in half the time.) The chart at left shows the NIOSH REL for various exposure durations. Maximum level for a given exposure time H in hours can also be determined with the formula ***dB = 94 – 10logH.***

Informational

Even when SPL metering is not legally required, we may choose to measure SPL as a source of technical information for the mixing engineer.

Dynamic Range

An important part of a mixing engineer's job is the use of dynamic range – the contrast of loud and soft moments within the performance – as an artistic tool. A dynamic performance is engaging to the audience, and SPL monitoring can help give the mix engineer feedback on show levels for an effective mix. An SPL meter is an objective check against the normal day-to-day variations of human hearing perception.

Prevention of Listener Fatigue

Exposure to loud sounds can cause a condition known as **auditory fatigue**. Several mechanisms in the middle ear and inner ear act to desensitize the ear's sensitivity to sound. This can create a runaway situation in which the FOH engineer will try to mix even louder to regain the sensation of impact, compounding the problem. The loss of sensitivity causes diminished blood and oxygen supply to the hair cells in the ear, creating stress and fatigue in the listener. SPL metering allows the mix engineer to manage the loud moments of the show to create dramatic impact without tiring out the audience.

Consistency

Night to night consistency is a major component of success on tour, and SPL monitoring offers useful information to the mix engineer to make sure the level of the show doesn't drift over time.

Remote Awareness

It is often necessary to monitor levels in remote locations, or multiple locations at once, for example, the production team being able to monitor levels during a multi-stage music festival without leaving the production office. (Smaart SPL allows remote connections via a web browser to allow remote users to view meters, alarms, and history plots.)

Intentional vs Unintentional Exposure

Another aspect of noise exposure to consider is that of intentional (willing) vs unintentional (unwilling) exposure. By choosing to attend a concert, you are willingly placing yourself in a loud environment. However, for stage crew, security, vendors, and other individuals working at or near the venue, exposure to loud noise is an unavoidable aspect of employment, and exposure regulations remain in effect to protect these individuals, despite the fact that concert attendees may "opt in" to the exposure or consider themselves exempt from regulation. Additionally, it is becoming increasingly common for venues to provide hearing protection to the audience.

How is it measured?

As with all measurement tools, an SPL meter can only be expected to provide an answer to a specific question, and we might be asking the wrong question.

For example, suppose we decide to use SPL metering at an event to make sure we are not causing hearing damage to the audience. Leaning over the console with a handheld SPL meter might look official, but it gives us very little actionable data if our concern is protecting people – as discussed above, the familiar “Fast” and “Slow” metrics on most handheld meters don’t offer much meaningful information about exposure.

For that, we need to know how much energy the ear is exposed to over a longer period of time, information supplied by an Leq measurement, commonly Leq10 or Leq15. We will want to use an unweighted (Z weighted) Leq metric in this case, because we are concerned with the actual energy levels at the ear, not perceived loudness.

Conversely, we may need additional or alternative metrics, depending on the exact wording of the directive we need to comply with. If a regulation is in effect, it is important to get a technically complete specification. This image illustrates why: it’s the same raw SPL measurement data, expressed via all of Smaart SPL’s 13 default metrics. As you can see, we have 13 different answers to the question “How loud is it?”

Comments from venue management such as “keep it under 100 dB” are too technically vague to be actionable, given the enormous difference between, say, 100 dB Peak C measured next to the snare drum and 100 dB LAeq 15 measured outside the venue. In these cases, it is necessary to ask for clarification regarding time constant, weighting curve, and measurement location. Without this information, any measurement we take will be arbitrary, but don’t be surprised when those questions produce blank stares.

Calibration

The importance of calibration can be illustrated by comparing the results from multiple handheld SPL meters or smartphone apps. It is unlikely that they will all agree – an informal study of 6 handheld meters showed a variance of almost 10 dB. More rigorous studies have shown that smartphone meters are highly variable when using internal microphones.[4],[5]

Calibration is a critical step in setting up a Smaart SPL measurement system. Sound waves at the mic diaphragm cause the mic to create an output voltage, which is then amplified by the preamp in the

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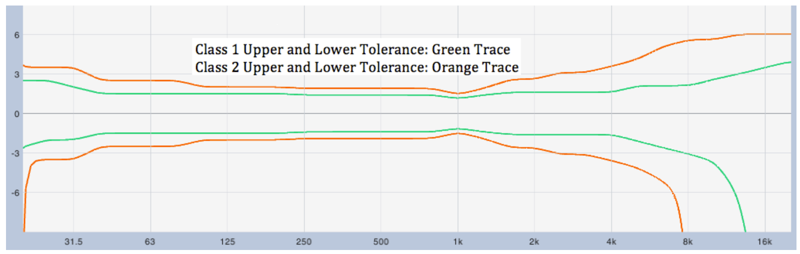
[4] https://blogs.cdc.gov/niosh-science-blog/2014/04/09/sound-apps/
[5] https://asa.scitation.org/doi/full/10.1121/1.4964639

audio interface and converted to a digital value. Calibration allows Smaart SPL to translate those digital values into meaningful SPL data by teaching the software about how a certain digital value relates to a certain pressure at the microphone. (Class-compliant systems such as 10EaZy come calibrated from the factory, but may require periodic checks as determined by the relevant regulations in your region.) A microphone calibrator is used to create a known pressure at the mic (usually either 94 dB SPL or 110 dB SPL @ 1 kHz). Smaart SPL's calibration function can then correlate that reference SPL to the incoming signal level. Since this calibration takes into account the sensitivity of the microphone itself as well as the preamp gain, changing either will change the value seen by Smaart SPL and thus calibration will need to be repeated.

Accuracy



How accurate does the measurement have to be? The answer depends heavily on the goal of the measurement. A FOH engineer simply looking for night-to-night consistency doesn't need an accurate calibration at all – hitting the same numbers every night is enough.

On the other end of the spectrum, exposure measurements require the highest accuracy possible – consider that a calibration error of 3 dB equates to a 100% error in NIOSH exposure, leaving audiences with twice the intended noise dose. That is to say that with a 3 dB error, a one-hour event that appears to be at a safe level can become unsafe after 30 minutes. Our recommendation is that for critical measurement applications such as compliance or sound exposure, accuracy should be within 1 dB tolerances.

Standards

The IEC standard 61672-1 sets forth two categories for sound level meters, Class 1 and Class 2, with Class 1 being the more stringent specification. The standard dictates a variety of performance specifications covering every part of the metering and logging process, from mic tolerances and windscreens all the way through to data logging format and how the interface presents measurement data to the user. Probably the most relevant difference is the frequency response tolerances of the microphones used for logging. They are quite similar for most of the audible band, but a Class 1 microphone must fall within more stringent tolerances at the extremes of the spectrum.

Compliance

In the context of SPL metering, we use the term "compliance" to describe being in accordance with established standards. Given the rather serious consequences of error – hearing damage and potential legal trouble, to start – we need to make sure that we can trust the data we are collecting. It's important to note that compliance is not strictly a question of accuracy – it is conceivable that a smartphone app could give results just as accurate as a professional-quality calibrated metering system. Likewise, a high-quality measurement mic, connected to Smaart SPL via a high-quality audio interface, and calibrated with a high-quality calibrator, will certainly provide an accurate measurement. It is not, however, a legally verifiable measurement.

By contrast, class-compliant systems such as the 10EaZy system are “closed” measurement chains – the hardware is designed to comply with IEC 61672-1 standards, manufacturer-calibrated, and cannot be altered or tampered with in the field. The resulting logfiles therefore have sufficient integrity to be admissible as legal evidence as to whether a noise ordinance was violated.

In many jurisdictions, violations can carry hefty fines, so it is important to consider whether your SPL metering needs would be better met with class-compliant hardware, along with whether you want to leave the determination in the hands of a well-meaning local official with a handheld meter. In these situations, a good (class-compliant) offense can be the best (legal) defense.

Logging

Smaart SPL logs all configured sound level metrics, independent of what is currently displayed in a timeline or meter. This way, when the data is reviewed, you are not limited to the metrics that were selected during logging. In addition, the following information is logged:

Date/Time

Each line entry in the log starts with the date and the time the data interval was logged. The default logging interval is three seconds and can be changed in the SPL Config tab of the Configurator. An accurate date and timestamp allows us to reconstruct the timeline and figure out exactly when a certain event occurred.

Alarms

Smaart SPL allows you to configure up to two alarms, which will visually alert the user when an individual input exceeds a set threshold, and will enter the alarm event in the log. Alarms are useful as a “warning” to allow the mix engineer time to respond and readjust before a noise regulation is breached.

Overloads

In an overload condition, the sound pressure exceeds the maximum capability of the measurement system as configured, so we no longer have an accurate record of the levels reached. This is an undesirable occurrence, as it invalidates all our exposure-related measurements. When an overload condition occurs, all Leq buffers are flushed and will start refilling once the overload condition passes. Asterisks appear next to the Max Leq values in the log file to indicate that the value is unreliable due to an overload condition.

Concerns

Dynamic Range

When choosing and calibrating a measurement system, it is important to consider the system's dynamic range – the difference between the highest and lowest levels the system can accommodate. We want the signal to be high enough above the noise floor of the system to ensure a clean, accurate measurement, while still allowing enough headroom for loud parts of the performance and audience noises without overloading the system and invalidating the data.

Verifying Compliance

All class-compliant hardware can be serviced and recertified periodically to ensure that its accuracy does not drift over time. Be sure to observe the manufacturer's recommendations regarding how often the equipment should be recertified, and also be aware that any noise regulations in effect may also include requirements for recertification frequency.

For non-class compliant systems, you may choose to re-check calibration at the end of a logging session to ensure that it was not changed or tampered with, and that the logged data is trustworthy.