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IS IT TIME TO TOSS THE SPL METERS?

BY

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Since the mid 1970s, theatre technicians have been using Sound Pressure Level (SPL) meters to set sound levels in movie theatres. BOXOFFICE contributing writer John F. Allen explores the use of these meters and whether they really are the best tool available.

In the last 25 years, the use of SPL meters has become routine when servicing sound systems in motion picture theatres. Technicians have been trained to use pink noise generators, real-time-analyzers and sound-pressure-level meters to ensure proper sound system adjustments. Initially, the pink noise generators were separate plug in units. In recent years, these generators have been built into the cinema processors themselves. Other than that, the audio equipment theatre technicians use and the way they use it hasn't changed much for a very long time.

In a perfect world, all of these pink noise generators would provide the exact same signal level and, because it is related to a specific recording level, technicians could use SPL meters to set the exact same levels in every theatre around the world. That way, every film would play at the correct sound level as long as the fader was set to "7" or 0.0 and there wouldn't be any problems. Unfortunately, it's not that easy. As we all know, if the faders are set to these positions in most theatres, the sound levels will be too loud -- way too loud. In fact, rather than "7", faders are typically set from "4 1/4" to "5 1/4", or 5 to 8 dB below the so called standard settings.

This is because when the technicians calibrated the sound system, they obviously set the levels too high and didn't know it. When pink noise is played in the auditorium, the level for each screen speaker is set to read 85 dB on a C-weighted SPL meter that is set for slow, or longer averaging. This is supposed to match studio practices. So if theatre technicians see 85 dB on their meters, why are the sound levels of the films ending up playing 5 to 8 dB too high in so many theatres? The answer is complicated and though I have written about it before, it's worth some review.

Most sound-pressure-level meters are rather simple things. While they can tell us what the total sound pressure level is, that's about all they can do. They have no way of distinguishing the amplitudes of different frequencies or the bandwidth of the audio spectrum being measured.

> Since it is the dialogue levels that we use to judge movie sound levels, why not simply measure these middle frequencies when setting levels?

This points up one of the main difficulties encountered when relying solely on SPL meters for setting sound levels. Without the ability to include the bandwidth or frequency response in the measurement, SPL meters will indicate that speakers of differing sizes and bandwidths are playing at the same level, when in fact the smaller speakers with less bandwidth are actually playing louder in the critical middle frequencies. To understand why, imagine a three-way loudspeaker with a perfectly flat frequency response, playing pink noise at 85 dB SPL in a 400 seat theatre. If we were to disconnect the woofer, there would be less sound pressure in the room and the SPL meter reading would drop about 3 dB. Though the measured pink noise level is now lower, the level of speech played through the speaker would change very little. The output levels of the middle and high frequencies would not change because we turned off only the woofer. If we then increase the output level of our woofer-less speaker so that our SPL meter would again read 85, we will also increase the speech level by 3 dB. So it's easy to see how loudspeakers with differing low frequency performance can mislead technicians relying on SPL meters.

When we look behind the screens of today's movie theatres, in addition to a thick layer of dust, we find speakers of all shapes, sizes and types. Screen speakers can range from 50 year old two-way systems with combination horn/vented box woofers, to more recent two-way or three-way systems with direct radiator woofers and even three-way as well as four-way fully horn loaded systems. To say that the size of these speakers varies all over the map is an understatement.

Size does matter. But it is the size of the speaker's radiating area that really matters, even more than the size of the box. The radiating area of a loudspeaker is defined as that area that actually acts on the air in the room. In direct radiating speakers, the radiating area is the piston area of the speaker cone(s). This is less than the size of the speaker itself. In other words, a 15 inch diameter woofer driver has an effective radiating area of about 12 inches in diameter, or about .79 square feet. A woofer cabinet with two such drivers would have a radiating area of about 1.57 square feet. The largest direct radiating woofer cabinets with four 15 inch drivers would have a radiating area of about 3.14 square feet.

There are even occasional screen speakers with single 12 inch direct radiating woofer sections. Such speakers have a low frequency radiating area of only .55 square feet.

The radiating area of a horn loaded speaker is not determined by the piston area of the driver cones, but rather the mouth area of the horn itself. It is therefore much larger. The smallest fully horn loaded woofer one is likely to find behind a screen has a radiating area of 4 square feet. The larger horn loaded woofers have a radiating area of 10.25 square feet. If we divide 10.25 by .55, we realize that there is at least an 18.6 times difference in the radiating areas of the woofer sections of various screen speakers. Obviously, the larger the speaker's radiating area, the more air it can move and also (here's the important part) the greater the woofer's contribution to measurements done with SPL meters.

In addition to the size of the speaker, the room's acoustics will also impact the contribution of the lower frequencies to a meter's SPL reading. As we know, the proximity of reflective surfaces as well as the reverberation characteristics of an auditorium can have a significant influence on bass. Unlike dynamic program material, pink noise is sustained and constant. The behavior of subwoofers playing low frequency pink noise is so variable and unpredictable, that measuring subwoofer levels with SPL meters has long been recognized as misguided at best. Indeed, the subwoofer levels are supposed to be set with an analyzer. See Figures 1, 2 and 3.

So how can we rely on SPL meters for accurately setting sound levels in movie theatres when both the loudspeakers and the surrounding acoustics can vary so widely? The simple answer is that we can't. Is there a better way? Yes, there is.

If we think about the reasons for using a real-time-analyzer for setting subwoofer levels, we can also see a better way to measure levels in all the channels. Figure 1 represents the familiar "X" curve. This is how a properly equalized screen channel should "theoretically measure" on an analyzer when playing pink noise. As I have discussed in numerous other articles, there are many problems with the belief that a curve that doesn't really exist can be trusted to tells us much about the sound quality. I will not go into it too much here except to say that the most problematic and inconsistent frequency bands to "measure" this way are those below 400 to 500 Hz as well as those above 2000 Hz. Figure 4 shows the significant variability of pink noise measurements using very high quality loudspeakers built and tuned to produce exceptionally natural tone in rooms the size of movie theatres. In other words, the bass and treble frequency bands as seen on an analyzer measuring pink noise can vary dramatically from theatre to theatre while the tone of real sound remains the same. The important thing to note here is that religiously using steady state pink noise to equalize all behind-the-screen loudspeakers to conform to the response shown in Figure 1, will ruin the sound quality in many of the theatres in which this is

done. This can cause the audience to suffer a sound that is shrill with little to no bass and impaired dialogue intelligibility. Indeed, this is the case in all too many theatres today.

> Someone someday is going to solve the problems of inaccurate and typically excessive sound levels in movie theatres. What are we waiting for?

That being said, there are two important observations that can be seen when looking at Figure 4: The first is that measurements made with SPL meters alone make little sense. The variations in the higher and lower frequency bands will cause SPL meters to give readings that are equally variable -- ***without telling us how loud the sound system will actually operate*****. Secondly, the frequencies between 500 and 2000 Hz are most likely to measure similarly in most theatres.**

This second observation is the key to a better way to set sound levels. If these frequency bands typically measure so consistently from theatre to theatre, as well as speaker to speaker, and since these are also the primary speech frequencies, why not simply measure these middle frequencies when setting levels? After all it is the dialogue levels that we use to judge movie sound levels.

Whether the measurement looks like Figure 1 or Figure 4, when observing an analyzer, one can adjust the overall sound level so that the frequencies from 500 to 2000 Hz are at - or slightly above - 66 dB. This will result in far more reliable dialogue levels when well recorded films are played. In some theatres, a mid-frequency level of 68 dB as seen on an analyzer may be more appropriate. This is not a new technique by any means. I first saw it used in a theatre by a studio engineer some 14 years ago.

To assure proper channel to channel balance, the measurement microphone should be placed symmetrically, which is to say in the center of the seating area. Checking levels by ear with familiar program material will ultimately confirm whether or not the dialogue levels are right. Some adjustment should be expected from time to time especially with different processors.

It is important that the fader be set and left at "7", or 0.0 with SDDS processors, during this entire process. It is also equally important that when finished, the sound levels are adjusted so that films do indeed play at the proper level in all formats when the faders are at these standard positions. A properly calibrated SPL meter set for C-weighting, as well as fast, can be somewhat helpful here. When listening to program material in a theatre, normal dialogue levels will measure with many peaks at about 80 dB SPL, and occasional peaks around 85 dB SPL. Corrections in the levels set to achieve this operating condition are perfectly legitimate and should not be considered out of the ordinary.

As with any measurements of sound levels, this one assumes that the microphone is calibrated. It's sad to say, but with two exceptions, the only technicians I have ever observed with microphone calibrators are those that I have insisted use them, if they were going to service my installations. As I have stated before, I calibrate my own measurement microphone every day before its first use. I recommend the Bruel and Kjaer models 4230 and 4231 microphone calibrators. The 4231 is available directly from the manufacturer in Denmark or by calling Molly McGill in the US office at 1-800-332-2040, extension 6962. The 4231 currently sells for $695.00. The units are shipped directly from Denmark for $38.00 and should arrive in about seven to ten days. No technician should be without one. This will be evident the first time it is used.

Assuming a properly calibrated microphone and a level set to bring the mid frequencies to about 66 dB on an analyzer, we will see SPL readings anywhere from 79 to 86 dB SPL from sound system to sound system as well as theatre to theatre, yet dialogue levels will be much the same.

In addition to different types and sizes of loudspeakers contributing to ambiguous SPL measurements of pink noise, mis-equalization also creates errors. Typically I have found that when sound systems are mis-equalized, the SPL readings are 2 to 4 dB lower than they should be. A technician in this situation reads 85 dB on a SPL meter, but the film will actually play at the equivalent level of 87 to 89 dB SPL, or 2 to 4 dB too loud. Coupled with errors due to speaker sizes and even mis-calibrated microphones, it is easy to see how accumulated errors of as much as 5 to 8 dB can occur and thus force the fader to be lowered by the same amount for normal operations.

Technicians may find that some experimenting with the particular types of surround speakers they use may be needed to determine where the middle frequencies should measure on an analyzer when the surrounds are playing program material at their proper level. A good place to start would be 64 dB. Using an analyzer to set subwoofer levels as shown in Figures 2 and 3 should remain unchanged.

Once a sound system setup is complete and films - in all formats - are playing at their correct levels in the theatres with the faders set to "7" or 0.0, SPL measurements, whatever they may be, can be made and recorded for future reference.

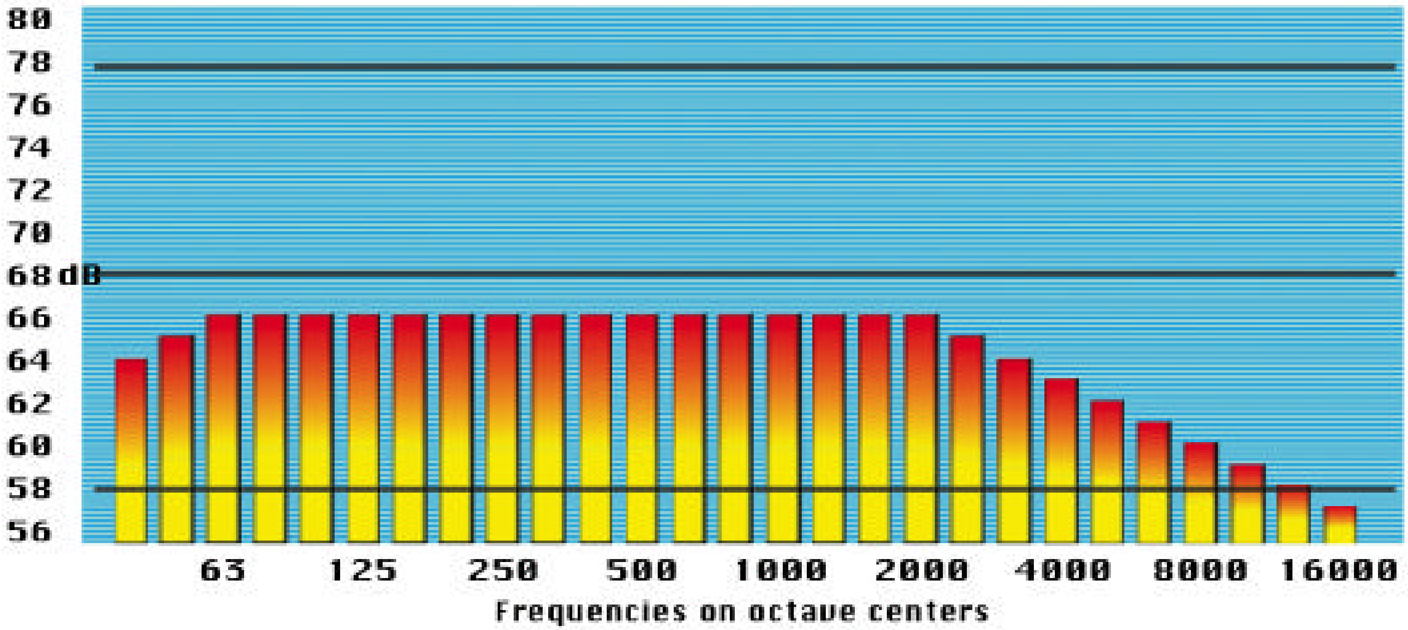
In the future, it might make more sense if the pink noise used for setting levels was limited to just the 1/3 octave bands between 500 and 2000 Hz. It could even be called "J" weighting or "J" noise. ("J" doesn't mean anything. It's just the initial of someone I know.) Limited bandwidth pink noise could be more easily used with SPL meters, as the

higher and lower frequencies that are currently causing so much difficulty, would no longer be there.

Someone someday is going to solve the problems of inaccurate and typically excessive sound levels in movie theatres. What are we waiting for? One day sound technicians will be using a modern method that works for accurately setting and maintaining audio levels in theatres. When they recall how it's been done for these past 2 1/2 decades, they will surely wonder why it took so long for the industry to correct a nagging problem that continues to plague us all.

John F. Allen is the founder and president of High Performance Stereo in Newton, Mass. In addition, he serves as the sound director of the Boston Ballet. He is also the inventor of the HPS-4000® motion picture sound system and in 1984 was the first to bring digital sound to the cinema. John Allen can be reached by E-mail at johnfallen@hps4000.com.

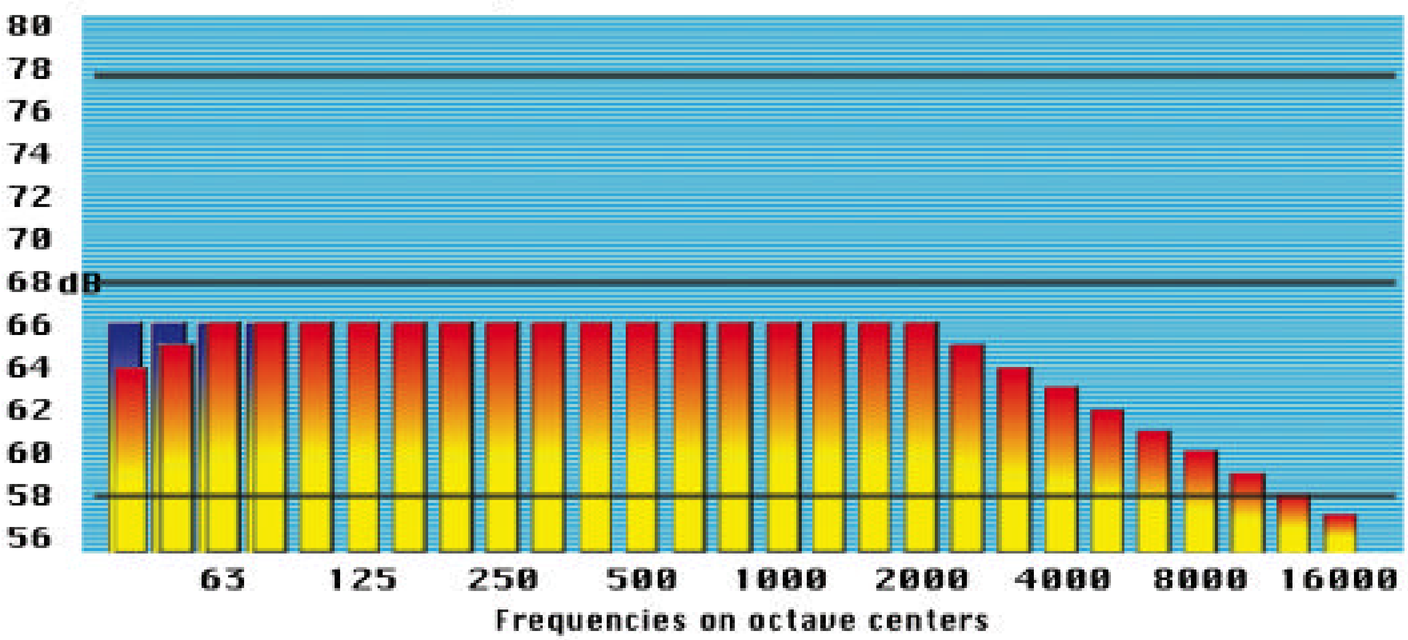
Thoretical "X" Curve



Theoretical frequency response of pink noise played through screen speaker and measured on a real-time-analyzer. The 27 1/3 rd octave levels shown sum to 85 dB SPL.

Figure 1

Optical Subwoofer Response Shown Behind the Theoretical "X" Curve

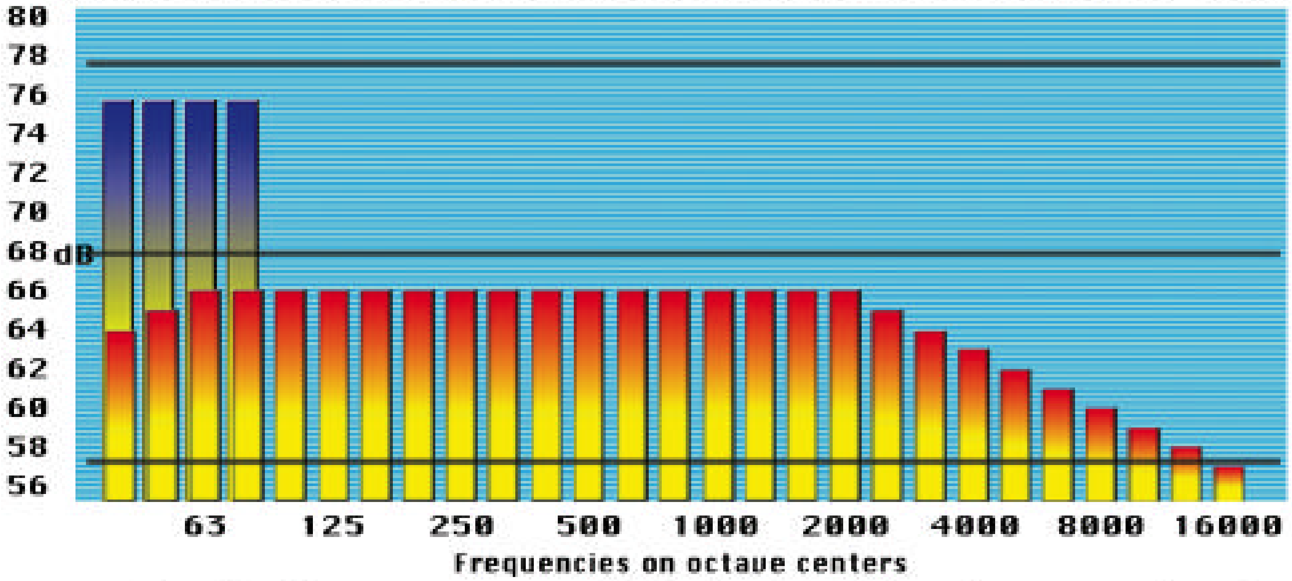


Theoretical frequency response of pink noise played through screen speaker and measured on a real-time-analyzer. The 27 1/3 rd octave levels shown sum to 85 dB SPL.

The subwoofer frequency bands are set to the same amplitude as the middle frequencies.

Figure 2

Digital Subwoofer Response Shown Behind the Theoretical "X" Curve

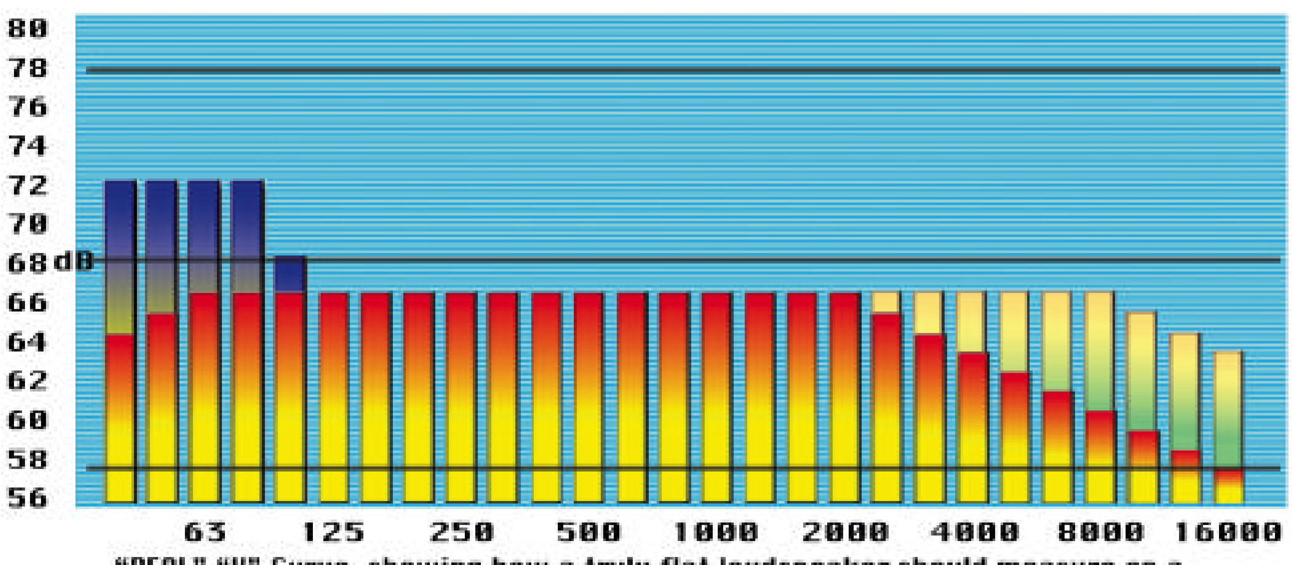


Theoretical frequency response of pink noise played through screen speaker and measured on a real-time-analyzer. The 27 1/3 rd octave levels shown sum to 85 dB SPL.

The subwoofer frequency bands are set 10 dB above the middle frequencies.

Figure 3

"Real" X Curve



"REAL" "X" Curve, showing how a truly flat loudspeaker should measure on a real-time analyzer in a theatre, through a screen, with pink noise playing.

Note the additional low frequency level (in dark blue). This indicates the typical measurement of a modern theatre loudspeaker designed and constructed for full bass response. The amount of this "additional" bass as measured will vary with the size and acoustics of the theatre and does not indicate excessive bass.

The lighter areas above 2 kHz show the difference between the actual frequency response of a speaker with a flat frequency response behind a screen in a theatre and what a real-time analyzer may show. These lighter areas show the potential measurement errors of this measurement system, depending on the size of the theatre being measured.

Figure 4