

For Whom the Bell Tolls: the dBA - dB SPL war

By Marshall Chasin, AuD

It was a cold winter morning. The troops were unusually quiet, perhaps related to the “party” we had last night. The government had announced that they had discovered yet another digit for pi. For obvious reasons, the celebration went into the small hours of the morning. It was a welcome announcement, as things were not going well.

We were on the front lines. It seemed that, just as we captured another hill, NIOSH or OSHA or some other agency would change their minds. First, it was simply dB; then dB SPL; then dBA; and then back to dB SPL again. From time to time, we had visiting officers from the rear echelons who tried to convince us that we should really be fighting for L_{eq} , or even one guy who suggested that we throw down our calculators and use L_{ex} . Needless to say, he didn’t last long—someone accused him of belonging to Al-Gebra and he was soon arrested for trying to smuggle in weapons of math instruction.

But what are we really fighting for? Our families back home were happy with the decibel; actually my great-grandfather used to call it a Bel, but it was about 10 times too large for our uses so we divided it up in tenths and, using the metric system, called it a deciBel or dB. I recall as a youth we were also quite happy with just using dB SPL and I recall many wonderful bedtime stories where my mom and dad just said dB SPL as I gently fell asleep.

The introduction of dBA was like a knife running through our civic souls. Why introduce another acronym? We were relatively happy, albeit not ecstatic, with dB SPL because we realized its limitations. Every kid did. The dB SPL scale treats all frequencies the same. It is a truly non-discriminatory scale. We can measure 500 Hz and get a measure of the level in dB SPL; we can measure 4000 Hz (my personal favorite) and also get a measure of the level in dB SPL. So why ruin something that seemed to work?

Well, this is where the war started. Actually, the government called it a *conflict*. But for those of us on the front lines, it’s the same thing. Someone had the idea that we should measure noise and music in dBA, a scale that estimates what actually gets through to the cochlea. Low-frequency sounds tend to see a larger obstruction when they impinge upon the eardrum than do mid-frequency sounds. In fact, it takes about 25 dB of low-frequency sound (at 125 Hz) to overcome the eardrum (and middle ear structures) resistance to this sound.

In contrast, the mid and higher frequencies don't see the eardrum as an obstruction. For those who like percentages, the eardrum and middle ear system is only about 66% efficient. This doesn't sound great, but it is. After all, sound needs to travel from the medium of air, to the medium of fluid in the inner ear. Normally, 99.9% of the sound energy would be lost (or 0.001 of the energy gets through) when sound goes from air to water, and for those who like math, $10\log_{10} 0.001$ is 30 dB. Actually, it's still the same thing even if you don't like math! So, a reduction of just 25 dB and only for the lower frequencies is pretty good. The eardrum and middle ear system has done a remarkable, but not a perfect, job of overcoming this sound transmission problem. It gets worse when you present the sound to the ear directly with headphones—then, it takes about 45 dB to be just audible at 125 Hz. The difference is primarily due to vascular noise of the blood running through our blood vessels.

For noise and music spectra that have significant low-frequency energy (below 1000 Hz), there can be a large difference between measurements in dB SPL and dBA, and indeed the dBA value is the way to go. However, for noise/music sources that have little energy below 1000 Hz, then there really is no difference between the two measures. This is quite rare in industrial noise venues but is quite common for music.

A quick switching from the dB SPL scale (also known as the C-scale on many sound-level meters) to the dBA scale can provide a rudimentary estimate of the spectral shape. If there is no difference between the two measures, then there is minimal low-frequency energy in the signal. If there is a substantial difference, then there is significant low-frequency energy below 1000 Hz.

Treble instruments such as the violin, trumpet, and most of the percussion section have substantial mid- to high-frequency sound energy. This is certainly in contrast to a noisy manufacturing facility. While the violin is actually a broadband instrument with significant lower and higher frequency information in its spectrum, like all treble instruments the higher frequency harmonic structure is typically more intense than the lower frequency fundamental energy. For a violin playing A (440 Hz), there is indeed quite a bit of energy at 440 Hz (its fundamental), but this is usually swamped by the higher



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frequency harmonic energy.

Conversely, percussion instruments feature “sudden” blasts of energy. Anything that is “sudden” in the time domain—quickly going from no sound to an intense sound—has a high-frequency spectrum. If you think about the transition to a high level in a short amount of time as one quarter of the entire wavelength (and this is short), then the entire wavelength is short. Short wavelengths (in the time domain) means high-frequency energy when one does a spectral analysis. Neat, eh?

So, the war rages on, and the troops are slowly awakening, but for many musical instruments, there just isn't any big difference between dB SPL and dBA. If one reads a lay publication or hears a public lecture or radio talk show and someone confuses dB SPL and dBA, they may be sloppy, but probably are correct, and it's OK to ignore the difference between the two...at least for music.

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