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Beyond Decibels: Redefining Noise Hazards Using Kurtosis

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Editor's Note: *Thank you to the National Hearing Conservation Association's e-publication , Spectrum, for giving us permission to reprint this article. It touches on a measure of peakedness in a noise spectrum that may be caused by impulse noise such as weapon fire. In addition to measures of energy and time features- two important pieces of data that allow us to establish damage risk criteria- it discusses a measure of kurtosis that provides information on peaks and the possible effect that these may have on damage risk criteria. This is not a new idea (and actually was pointed out by Thiery and Meyer-Bisch in 1988.* (https://doi.org/10.1121/1.396844) *but a measure of the influence of peaks in a noise spectrum is now being studied as one more element that may improve the reliability of damage risk criteria with some "non-gaussian" noise spectra. We will start with the original article and follow with two Q and As that I have posed to the authors.*

Pages 5-13 of the NHCA SPECTRUM Oct. 2025 (Kurtosis article)Download

Q & A

Question 1: Whenever damage risk criteria are used for symphonic musicians (e.g. Russo et al., 2013), there is a good agreement in the higher frequencies but a poorer low frequency agreement-measured hearing loss vs. ISO 1999. Would inclusion of a Kurtosis metric improve the damage risk criteria match especially with percussion? (Reference: Russo, F., Behar, A. Chasin, M., Mosher, S. (2013). "Noise exposure and Hearing loss in classical orchestral musicians". International Journal of Industrial Ergonomics, 43.)

Answer 1: Yes, very likely, particularly for percussion-dominated exposure. Recent analyses of symphonic musicians (e.g., Russo et al., 2013) show that existing damage-risk criteria based on ISO 1999 predict hearing loss reasonably well at high frequencies but tend to underestimate low-frequency hearing loss, particularly in ensembles with prominent percussion. This discrepancy likely reflects the non-Gaussian nature of orchestral noise, where impulsive peaks from percussion and brass instruments yield high waveform kurtosis (?) despite moderate average levels. Incorporating a kurtosis adjustment, such as a ?-adjusted effective level with ? = 6.5 derived from human field data, could improve model agreement by accounting for the additional temporal stress imposed by high-? transients. Applying such a correction would increase predicted risk for percussionists and mixed ensembles, narrow the gap between measured and ISO-predicted threshold shifts, and provide a more realistic framework for musician hearing-conservation programs.

Question 2: How peaky does a spectrum need to be in order to be "peaky"? It is clear that this new measure of Kurtosis may be useful for large peaks such as in gun blasts, but what about more

common sounds such as (1) drum percussion hits, and (2) music in general. Noise has a rather "Gaussian" shape but music (even without percussion) has a larger crest factor than speech or noise- typically RMS to instantaneous peaks of 18 dB vs. speech as 12 dB, and noise at close to 0 dB (if its white noise). Is the 18 dB crest factor for music enough to use a measure of Kurtosis to improve model accuracy, or is this only for blasts such as weapon fire?

Answer 2: Kurtosis becomes meaningful when a signal's peakedness is both *large and frequent enough* to make its amplitude distribution deviate from a normal (Gaussian) shape—typically when the *geometric mean kurtosis (?$_{geo}$)* of 60-s windows exceeds about 4–5. Steady noise (??3) and most speech signals are too Gaussian for kurtosis to matter. Music without percussion, even with an 18 dB crest factor, usually produces ? only slightly above 3–4, so a kurtosis correction would add little value.

However, percussion and transient-rich music (drums, brass, cymbals) often show repeated high peaks that raise ? into the 6–20+ range—similar to some industrial impacts—where kurtosis does improve risk or exposure estimates. Thus, an 18 dB crest factor alone isn't enough; what matters is *repeated impulsive transients*, not isolated peaks. Kurtosis adjustment is essential for weapon fire and impulsive noise, beneficial for percussion-heavy sound, and generally unnecessary for smooth or compressed musical or speech signals.

Bottom line: Weapon fire and industrial impacts almost always require kurtosis. Percussion-heavy music often does. Smooth, non-percussive music: measure ?; don't assume CF=18 dB is sufficient by itself. It's appropriate to include a *kurtosisadjustment* (e.g., , with = 6.5 from human field data) when you measure sound exposure.