Vibro-Acoustic Consultants Series on Vibration and Noise Control Issues – February 2012

Bandwidth in Spectral Data

Byron Davis of Vibro-Acoustic Consultants offers a tasty look at why measurement bandwidth is such an important part of spectral data and criterion expressions.

Looking at the two photos below, how many red candies are in the photo on the left? How many red jellybeans are in the photo to the right?


Before we start counting red jellybeans, we have some thinking to do.

It's easy to count red candies in the photo on the left. They only come in five different colors, and there is no confusing one color for another: 17 individual red candies are visible.

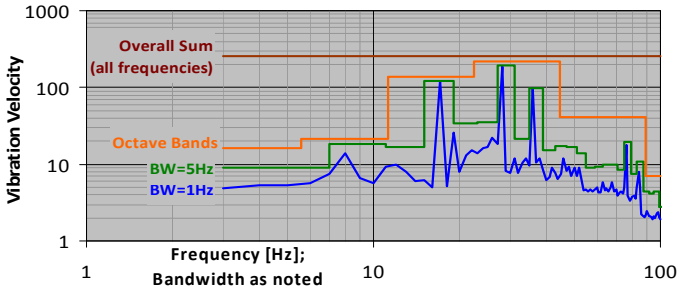
The jellybeans on the right present a conundrum: what do we mean by "red"? Some are dark red, but what about the orange-red ones? Do they count? What about the pink ones? Are they "red"? In truth, it is up to you to define what you mean by "red". Maybe you want to pick out the cherry-flavored jellybeans, in which case you'll have a restrictive definition. Alternatively, if you're allergic to red food coloring, then you'll use a broader metric that defines anything with even a hint of crimson to be "red". The only requirement is that you tell us your definition so that we correctly interpret the result, because *the broader the definition, the higher the count.*

Detailed vibration and noise data are communicated as spectra instead of single-number values: unlike an overall number, a spectrum provides insight into how much energy there is at different frequencies. In terms of jellybeans, the purpose is to tell us more than the overall number of jellybeans; it also tells us how many we have of each color. But before we start counting, we have to agree on what we mean by color. *This definition of color is analogous to "bandwidth".*

When communicating spectra, bandwidth is a critical part of the discussion. It is just as vital as the units themselves; in fact, the bandwidth is actually *part of the units:* it's how we define the different "colors". For vibration and noise data, bandwidth is part of the definition of frequency. Imagine that you want to know how much sound there is at 100Hz. Before we perform the measurement, we need agree on what you mean by "100Hz". Do you mean 99.9~100.1Hz? Or 99~101? How about 90~110? Just like with the jellybeans, the answer depends on *why* you want to know.

Bandwidth is important because the magnitude of the spectrum depends on it, just like the magnitude depends on the units. The answer to the question of "how many red jellybeans are in the photo" depends crucially on the *definition of red.* The energy in a vibration signal comes at different frequencies, just like jellybeans come in different colors. The amount of energy we record at each frequency in a spectrum is like the number of jellybeans we count at each color. For both, a broader definition results in a higher count.

The plot below shows four curves, all based on the same data. The measurement was done with a bandwidth of 1Hz; this roughly means that "9Hz" is defined as "everything from 8.5~9.5Hz". For a bandwidth of 5Hz, we have to add up those 1Hz-wide points from 7~11Hz to get the magnitude at "9Hz". See how it's higher? The octave bands are defined more broadly yet. The "overall sum" is based on *all* of the frequencies. It's the broadest – and therefore highest – measure:



It's all the same data, but the more broadly we define each frequency, the higher the result.

In practice, things are a bit more complicated. Narrowband spectra are calculated using a mathematical "window" that can influence bandwidth. There are other subtleties, but the overall point is that *a spectrum without a bandwidth is incomplete*: we need to know the bandwidth so that we can properly interpret the meaning. Not knowing bandwidth is just as bad as not knowing whether we're talking about inches or centimeters.

Next time someone gives you a spectrum but doesn't tell you the bandwidth, give them some jellybeans and ask them to start counting the red ones. It won't take long for them to scratch their head and ask, "What do you mean by red?"

Vibro-Acoustic Consultants specializes in vibration and noise design in demanding settings, serving clients around the world. Contact Byron by visiting www.va-consult.com

VACC, Inc. DBA
Vibro-Acoustic Consultants

490 Post St. #1427 • San Francisco 94102 • USA
(+1) 415-693-0424 • http://www.va-consult.com