MATERION

TRUEXTENT TECH BRIEF

Tuning Forks: Let Your Ears Do The Math!

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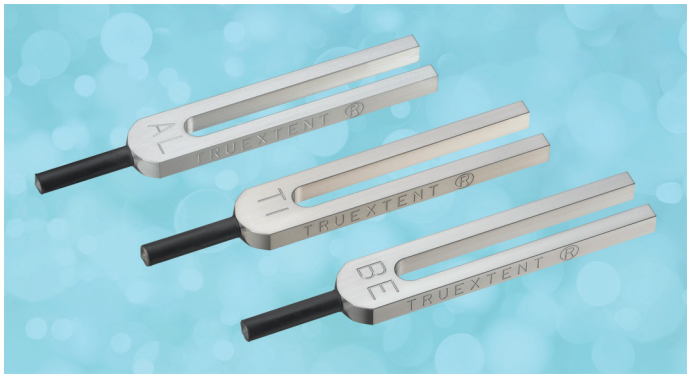
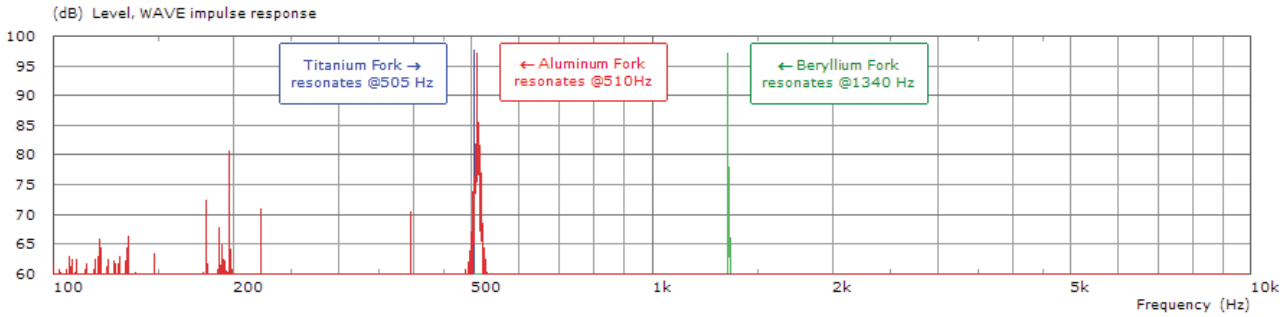
While many audiophiles and engineers are aware that beryllium is the lightest and stiffest metal for electro-acoustic transducers, it is perhaps not easy to grasp the vast performance advantages it has over other common 'lightweight' metals from a theoretical discussion like our white paper [1]. For an easily audible demonstration, we machined three tuning forks to the exact same dimensions; one made of aluminum, one of titanium, and one of beryllium. We hope you had a chance to 'ping' these at a recent trade show demonstration.



The first thing you might notice when picking up the three forks is the difference in weight, with the titanium feeling much heavier in your hands compared to the other two. Titanium, of course, has a relatively high density, at 4.50g/cm^3. The aluminum fork is definitely lighter, at 2.70g/cm^3, and the beryllium fork even lighter than that, only 1.85g/cm^3. The actual masses of our example tuning forks are:

Aluminum Fork = 55.7 g (2.0 oz.)
Titanium Fork = 93.7 g (3.3 oz.)
Beryllium Fork = 38.5 g (1.4 oz.)

The next thing you might notice is that the aluminum and titanium forks ring at nearly the same pitch (roughly C5) when struck on a hard surface, but the beryllium rings at a much higher pitch (roughly E6). Even though titanium is ~1.6x stiffer than aluminum, it is also ~1.7x heavier, giving essentially the same resonant frequency in both materials.



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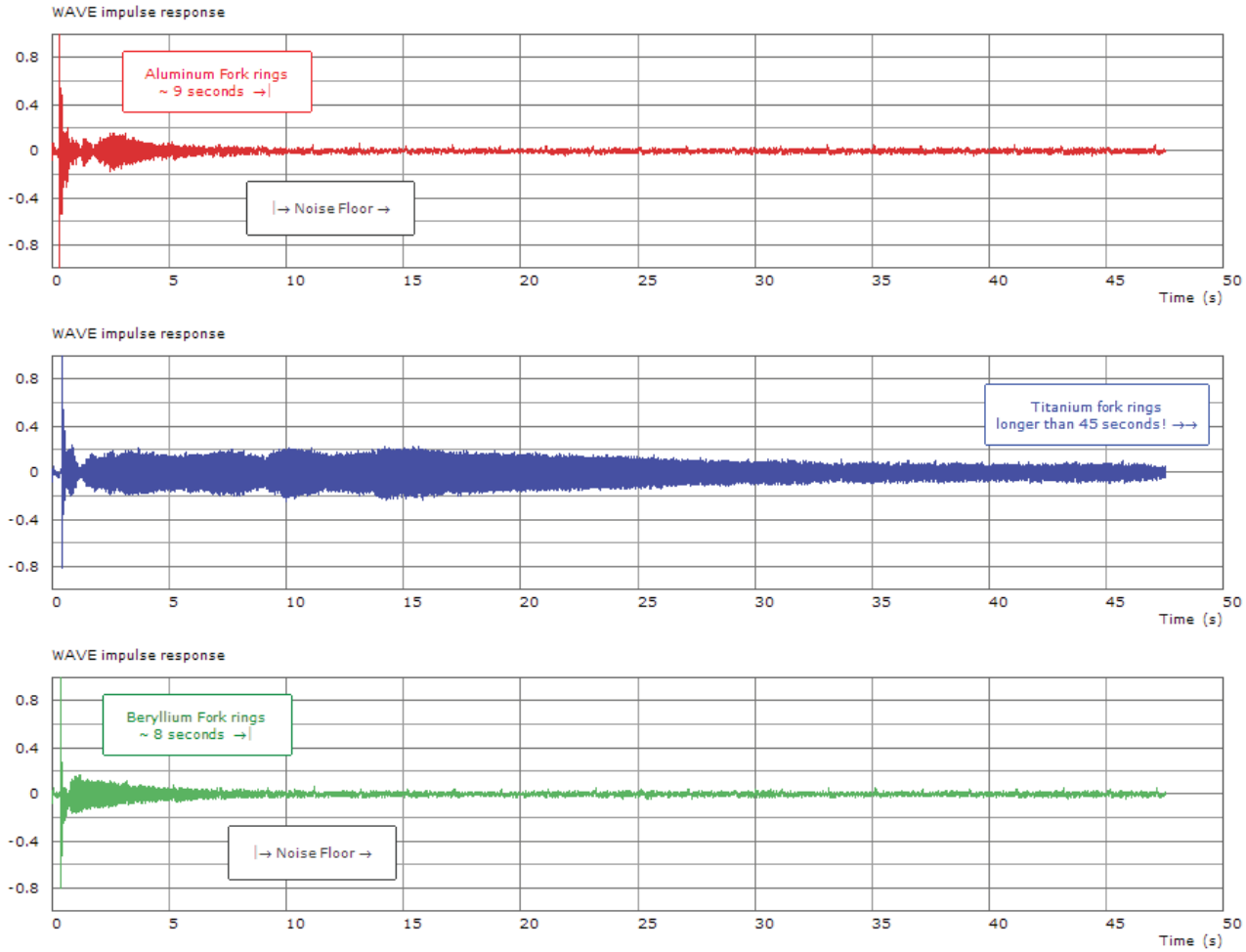
Beryllium, however, is not only ~2.7x stiffer than titanium, it is also ~0.7x as heavy as aluminum, so the resonant frequency is more than an octave above both other metals. (musically speaking, an octave plus a third) This effect is reasonably well predicted in our white paper, which showed beryllium's first bending mode at about 2.4x the frequency of the others (here, it is 2.6x).

But the attentive listener may even hear something further; namely that the three forks ring for significantly different durations. Both the aluminum and beryllium forks die out rather quickly (under 10 seconds), while the titanium fork rings on for a very long time (more than 45 seconds!). This clearly shows the large difference in internal damping between the materials, and hints at how a transducer made of these materials would react to musical signals.



So, even without knowing the physics, it is easy to compare the material properties using these tuning forks. Just ping 'em, your ears will do the math for you!

We hope this simple demonstration clearly shows the vast performance improvements available to you using advanced materials like beryllium in your transducer designs. Beryllium is lighter, stiffer, and faster!

[1] Buck, Andrews, Simmons, and Saye, "Extended Range Beryllium Dome Diaphragm Assembly for Large Format Compression Drivers." Presented at the ALMA Europe Symposium, 9 April, 2011. Available for download at www.truextent.com

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