ProSoundWeb EXPERT SERIES

SPEC WARS: LOOKING INSIDE LOUDSPEAKER SPL SPECIFICATIONS

Chapter 3 of 4 in the Loudspeaker Expert Series

SPEC WARS: LOOKING INSIDE LOUDSPEAKER SPL SPECIFICATIONS

While it might be possible to attain stated max levels from that box, it'll probably only happen once... and it might catch fire.

by Christopher Grimshaw

The past decade has seen a significant rise in the deployment of active loudspeakers, mostly 2-way designs housed in molded plastic cabinets. With modern processing and plenty of class D power, it's possible to get remarkably good sound quality from these lightweight models.

They will also go surprisingly loud, with manufacturers routinely claiming in excess of 130 dB from a single loudspeaker! With that in mind, let's take a closer look at some of these claims and examine whether they're plausible or indeed possible.

There will also be some tech talk, mostly relating to loudspeaker cones and what happens when feeding several kilowatts into one.

But first, a couple of definitions.

Xmax: a loudspeaker cone's linear travel. Different manufacturers define it in different ways, but it's generally accepted that a given loudspeaker will start sounding bad when driven past Xmax.

Xmech: the mechanical limit of a cone's travel. Permanent damage (torn suspension, smashed voice coil, folded cone, etc) is extremely likely if a loudspeaker sees enough power to hit Xmech.

Current State Of Affairs

There are currently a lot of manufacturers, and they're all competing for your cash. If there's a simple, easy-to-grasp number that makes their product look better than others, they'll try to inflate that number as much as possible to increase sales.

Here's a car analogy: the maximum sound pressure level (SPL) rating of a loudspeaker is similar to the maximum speed of a car. The problem is that it's very easy to measure a car's maximum speed – there's a dial in front of the driver telling him how fast he's going.

THE MAXIMUM SOUND PRESSURE LEVEL (SPL) RATING OF A LOUDSPEAKER IS SIMILAR TO THE MAXIMUM SPEED OF A CAR. THE PROBLEM IS THAT IT'S VERY EASY TO MEASURE A CAR'S MAXIMUM SPEED – THERE'S A DIAL IN FRONT OF THE DRIVER TELLING HIM HOW FAST HE'S GOING.

On the other hand, the maximum output of a loudspeaker is much more difficult to measure because it depends on a significant number of factors, including the test signal itself. Most of the time we tend to trust the manufacturers and don't try to verify performance claims.

What if I told you that Car A has a maximum speed of 160 miles per hour (MPH), and Car B has a maximum speed of 170 MPH? Car B is faster, right? However, would you still want to buy Car B if the engine immediately caught fire when it reached 170 MPH?

This is the sort of thing we're talking about when a standard 12-inch, 2-way loudspeaker has a stated SPL of 136 dB. Indeed, it might be possible to attain that level from that box, but it'll only happen once, and it might catch fire.

THIS IS THE SORT OF THING WE'RE TALKING ABOUT WHEN A STANDARD 12-INCH, 2-WAY LOUDSPEAKER HAS A STATED SPL OF 136 DB. INDEED, IT MIGHT BE POSSIBLE TO ATTAIN THAT LEVEL FROM THAT BOX, BUT IT'LL ONLY HAPPEN ONCE, AND IT MIGHT CATCH FIRE.

In the interest of not naming names (since there are many loudspeaker companies that play this particular game), I'm going to set out an example system that utilizes quality off-the-shelf components, powered with sensibly-sized amplifiers, and then see how it might compare to the specifications produced by the industry at large.

Example System

To help save the environment, I'm not going to do the destructive testing myself. Instead, let's run some simulations.

The 12-inch midbass cone driver I've chosen is a proven unit from a noted manufacturer. It has a 4-inch voice coil and comes with a stated 1,000-watt continuous power rating, 98.5 dB sensitivity, Xmax of 7.3 millimeters (mm) and Xmech of 26.5 mm. It's a very good driver and can be found in top-end active loudspeakers.

The high-frequency portion is a 1.4-inch compression driver with a 3-inch pure titanium diaphragm. It's rated for 110 watts of continuous power, and has 109 dB rated sensitivity when loaded on a 90- by 40-degree horn. We'll choose our amplifier so there's plenty of headroom for short-term peaks, delivering 2 kilowatts (KW) to the cone driver and 220 watts to the compression driver.

How does it stack up? Just based on the sensitivity of each driver and how much power is available for it, the cone driver will produce 131.5 dB and the compression driver will produce 132.5 dB. That's a pretty good match.

We could round it off and say the loudspeaker can do 132 dB across it's bandwidth.

However, let's take a closer look. When we load the cone driver into a ported box (which is what most active loudspeakers use) tuned to 50 Hz, the sensitivity drops to about 94 dB at low frequencies, which means a direct hit on our maximum SPL rating – it drops to 127 dB. That's not good, particularly when competitors are saying their cabinets will do 10 dB more.

It gets worse when we put some hefty bass through the system. Bass ports help drivers over a very narrow bandwidth, where they reduce cone excursion in exchange for air moving in and out of the cabinet. Above the tuning frequency, the driver has to do the work on its own. By 66 Hz, the port action has pretty much stopped, and with 2 KW input, the cone has to move 15 mm one way. While that won't destroy the driver outright, it won't sound good – we're at twice the driver's Xmax.

If we want to remain within the driver's linear region, we can only hit 120 dB, which will present huge problems for the marketing team. There will also be problems with the port itself. Even with generously-sized ports (a pair of triangular ports, 4 inches along the short edges), there will be a lot of port compression, where the driver is generating so much pressure that the air in port itself overloads and begins to experience turbulence.

To avoid port compression, we need to keep the speed of the air in the port below 34 meters per second as a maximum. Here, the air speed will be around three times that – the port will be seriously compressing and making a lot of extraneous noises. This results in the loss of even more SPL at the bottom end.

One last thing, and it's big: all of these figures are derived in half-space, meaning that the loudspeaker is positioned on the floor or against a wall, which provides reinforcement for the lower midrange and bass frequencies.

Once the loudspeaker is placed on a stand, there will be even lower SPL at those frequencies. Exactly how much depends on the loudspeaker's positioning, so for now it's best to table it for now, to be considered another time.

Even without considering the impact at lower frequencies, our example system falls short of the claims made by a good many manufacturers, despite using quality components and plenty of power.

EVEN WITHOUT CONSIDERING THE IMPACT AT LOWER FREQUENCIES, OUR EXAMPLE SYSTEM FALLS SHORT OF THE CLAIMS MADE BY A GOOD MANY MANUFACTURERS, DESPITE USING QUALITY COMPONENTS AND PLENTY OF POWER.

So, how do we get our numbers up? I talked to some manufacturers to find out.

Discussions With Manufacturers

At a recent trade show, I raised this issue with several loudspeaker makers, ranging from smaller entities to larger international ones. Again, I won't name names, but the bigger ones are companies you've heard of.

Manufacturer A is a larger enterprise that was proudly showcasing it's 10-inch-loaded line array element, accompanied by the bold claim that it'll produce 136 dB and reach down below 60 Hz. Naturally, I was interested. There must be some magic going on since our own loudspeaker's top-of-the-line 12-inch cone driver is stuck at a paltry 132 dB.

But no, the chap I spoke to was adamant; apparently that 10-inch box would definitely produce 136 dB, and further, would sound good doing it. I ran the simulation, and the driver would need to move 2 inches one way to produce the stated SPL at 80 Hz (where the port would be inactive). There isn't a 10-inch midbass cone on the planet that can do this, and definitely not this company's driver.

I wasn't getting anywhere, so I moved on. I also reached out to this manufacturer's R&D department regarding this issue but haven't received a response.

Manufacturer B, another fairly large company, proved more sympathetic, admitting there definitely is a specification "war" going on and that they do try to keep their numbers reasonable despite losing potential projects (and sales) over it. Apparently customers often came back around, though, when they realized that competitive products won't do what it's claimed.

The other seven manufacturers I spoke with are mostly smaller companies that share my views on this topic. Most provide sensible numbers with their boxes, such as a 12-inch, 1 KW model with a 127 dB maximum SPL. I checked with the designer of that particular loudspeaker, and he confirmed – 97 dB at 1 watt, and indeed it carries a 1 KW amplifier. Fair enough.

One company representative pointed out that if the loudspeakers made by Manufacturer A could really attain 136 dB, they really ought to be bolted on to every jet aircraft to be used for active noise cancellation. Touché.

ONE COMPANY REPRESENTATIVE POINTED OUT THAT IF THE LOUDSPEAKERS MADE BY MANUFACTURER A COULD REALLY ATTAIN 136 DB, THEY REALLY OUGHT TO BE BOLTED ON TO EVERY JET AIRCRAFT TO BE USED FOR ACTIVE NOISE CANCELLATION.

Later, I dropped by to visit another big company, which was showing a 3-way point source cabinet equipped with a pair of 10-inch midbass cones, an 8-inch midrange in a horn, and a compression driver. The stated SPL spec is 141 dB.

When I raised the issue with a person that really knows his stuff, I was told that it will "technically" produce 141 dB. The test resulting in this number utilizes a very short burst of signal containing all frequencies, and it doesn't matter how much compression or limiting is taking place, the engineering team keeps pushing the power up until the meter reading won't increase any more.

Think about that. Even if one driver started limiting 10 dB ago, they carry on with pushing the fader. If they were to keep that fader position and replace the test signal with music, whichever part was limiting (bass, midrange or treble) would pretty much disappear from the music, and it would sound horrible. This doesn't account for distortion levels at that power level either.

IF THEY WERE TO KEEP THAT FADER POSITION AND REPLACE THE TEST SIGNAL WITH MUSIC, WHICHEVER PART WAS LIMITING (BASS, MIDRANGE OR TREBLE) WOULD PRETTY MUCH DISAPPEAR FROM THE MUSIC, AND IT WOULD SOUND HORRIBLE.

So, we have new information about how we should rate our example system. Let's get back to that.

Revision Of Example System

We'll set aside the problems that occur at low frequencies that drag the specifications down and focus on getting our cabinet to beat the competition (at least, in theory…). It's possible to predict where in the frequency range our loudspeaker will be the loudest. There are some options.

Option 1: find a frequency where the loudspeaker exhibits extremely high sensitivity.

Option 2: use the crossover frequency, where both drivers will be working together to generate more output.

Option 3: try to use both.

Earlier I provided the rated sensitivities of each driver. The assumption there is that, yes, there will be peaks and dips, but they'll average out. Now, we want to make the loudest sound possible with this driver complement, so we're very interested in those peaks. To find them, let's visit the published curves for each driver.

Figure 1 shows the 1.4-inch compression driver's frequency response. We can see there's an elevated region from 1 kHz to 3 kHz, with a bump around 1.5 kHz.

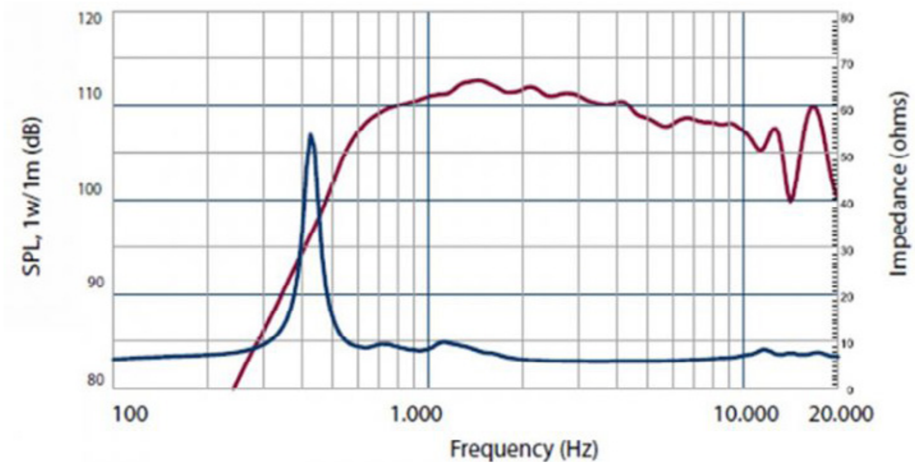

Figure 1: Frequency response and electrical impedance curve of the compression driver mounted on a 90- by 40-degree horn with input signal of 2.83 volts.

Figure 2 provides the 12-inch cone driver's response curve. This is actually measured in a bass reflex cabinet, so we can see the sensitivity drop towards the bass. Around 2 kHz, there's some "peakiness" that represents an area of high sensitivity. This happens to be related to cone break-up, where the cone itself is exhibiting some resonances.

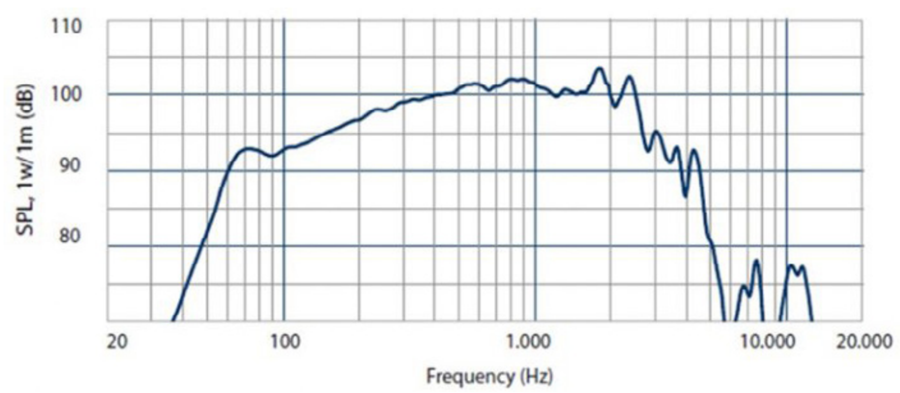

Figure 2: Frequency response of the 12-inch cone driver made in a hemispherical free field. It was mounted in a reflex box with an internal volume of 55 liters and tuned at 60 Hz, applying a sinusoidal signal of 2.83 volts (8 ohms, at 1 meter).

Employing Option 1: the compression driver has it's highest sensitivity around 1.5 kHz, and it comes in at 113 dB. The 220-watt amplifier means a peak SPL of 136.5 dB. The 12-inch cone driver has it's highest sensitivity at 1.8 kHz (a narrow peak indicating cone break-up, but that won't hinder us in the pursuit of the loudest possible sound!), coming in at 104 dB. With 2 KW input, that gives us 137 dB.

Now we're getting somewhere.

Employing Option 2: the crossover frequency is unique because both drivers are contributing equally to the output of the loudspeaker. Temporarily ignoring the peaks and dips discussed above, there are two bands capable of about 132 dB. Put those two together, and we attain 138 dB, an excellent result.

We can go further, though.

Employing Option 3: 1.8 kHz is a good place to start, since the cone driver has it's highest sensitivity there while the compression driver is still around 112 dB. We'll get 137 dB from the cone driver and 135.5 dB from the compression driver. When combined coherently, they'll produce a touch over 142 dB!

(Now that's a number that will sell. We've even beaten Manufacturer A!)

It doesn't matter that our loudspeaker can do 142 dB only at one carefully-chosen frequency, or that both drivers will be showing signs of extreme stress when pushed that hard. The stated sound level can indeed be produced by this loudspeaker (probably without destroying anything) so that's what the marketing team is likely to run with.

THE STATED SOUND LEVEL CAN INDEED BE PRODUCED BY THIS LOUDSPEAKER (PROBABLY WITHOUT DESTROYING ANYTHING) SO THAT'S WHAT THE MARKETING TEAM IS LIKELY TO RUN WITH.

A brief side-note: for the 12-inch cone driver to hit that SPL at it's worst-case frequency, the cone would need to move a little over 3 inches one way, where it would likely turn itself inside-out.

Future & Conclusion

I'd like to see professional audio move towards more sensible numbers. For our example system, we came out with a "peak SPL" rating of 142 dB when the reality would be more like 132 dB, and less when bass is required. That's a huge discrepancy.

Perhaps we could rate it as follows:

- **142 dB LSP** (loudest sound possible) or maybe we could call it WLS (when lightning strikes);
- **132 dB mid-high**, not constrained by cone excursion at low-frequencies, i.e., subwoofers are in use;
- **120 dB full-range**, worst-case scenario where there's a lot of bass content.

Before concluding, I submit this for your consideration: let's say I have a 15-inch subwoofer, housed in a ported box where the response slopes from 97 dB at 1 watt at 100 Hz, down to 93 dB at 40 Hz. The driver also has a cone break-up peak at 1.3 kHz, where sensitivity reaches 103 dB. The amplifier will produce 1 KW.

What's my maximum SPL? You could say 123 dB or 127 dB within the intended frequency range of the product, or perhaps 133 dB if it's run up to 1.3 kHz. Care to guess which number many manufacturers will use?

It's important for potential buyers to be able to compare different loudspeakers and draw meaningful conclusions about whether products are right for them. Currently this can be quite difficult, and at times, pretty much impossible with so many ridiculous claims that are very hard to independently verify.

As a result, we have to make do with hearsay and quick demonstrations, often in sub-optimal conditions. Frankly, we deserve better.

Christopher Grimshaw is a long-time audio professional and the founder/owner of Grimshaw Audio, based in the U.K.

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