Subject: Thermal limits vs Excursion Limits
Posted by Wayne Parham on Fri, 22 Jul 2005 17:18:33 GMT
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I'm very excited about this cooling device. It is turning into a very simple and inexpensive option, less than half the cost of the woofer. So we are anticipating being able to increase the power handling enough to represent doubling the number of woofers at a cost of half that of the woofers. That's two times the punch for half the cost!I don't know if you've followed the threads, because I've had discussions here, on the AudioRoundTable.com ProSpeakers forum and on ProSoundWeb. But the amount of heat we've been able to dissipate is significant.I'm still testing, so I'm just leaking information out right now as I get it. We're building a prototype horn now, to test the device as it will be used rather than on a bench. But what we have found out so far is startling.There has been a common misconception that excursion was the primary cause of failure, and that power levels could be increased some four-fold when horn loaded. But that is not true.   While horn-loading increases efficiency, it doesn't do it enough to turn all electrical energy into kinetic energy so heat is still a big problem. In fact, it may be worse because of the confined spaces the drivers are used in and the fact that horns reduce excursion which reduces vent air movement.There has been another common misconception that heat is carried away mostly by air conduction or convection, and that radiation is not significant. The idea seems to be that if the voice coil were hot enough to be radiant, it would be such a problem that this possibility is overlooked. But the fact is that is the way most voice coil heat is transferred, by black body radiation into the pole piece, and not by convection or conduction into the surrounding air. The best thing you can do to remove heat is to conduct it away from the pole piece, so the voice coil is in the coolest environment possible. Of course, keeping the air cool is also important for the same reason.Sure, you can over-extend the driver by feeding it a 20Hz signal at 45 volts, but it will sound like an engine running without oil and it will fail very quickly. When a driver is sent a signal that moves to beyond xmech, it suffers mechanical interference. You're basically beating the driver to a pulp and damage is quick and certain. This can happen from a quick burst of low frequency energy. The solution is high-pass subsonic filtering. As for continuous use at high power levels, the real culprit is heat, not excursion.Thermal limits are less obvious than mechanical limits. A voice coil failure is usually the result of long term exposure to heat. You could fuse the coil by a quick burst of energy, but that's not what usually happens. The normal failure mode is failure of the glue that holds the voice coil in place. Voice coil heat expands the metal and also weakens the glue. Eventually, the over-heated voice coil shifts enough to rub or come undone entirely. Once a part of it moves away, it can fuse or flex break so sometimes it fails that way too.To give you an idea how hot things get, we measured the LAB12 driver in free air, temperature at 72º Fahrenheit. This is a considerably cooler operating environment than a small sealed chamber in a basshorn.We generated a test signal for 20 minutes and then measured temperatures after that period of time. The speaker was presented a 40VRMS, 40Hz signal cycled 15 seconds on, 15 seconds off, ambient temperature of 72º in free air. This is a fairly conservative level, less than 400WRMS when running and plenty of cool down time between signal bursts. But even at this level, there was a noticeable burning smell and a considerable amount of heat produced. The driver is not at its thermal or mechanical limits though, so it is not at risk of failure.The center pole piece measured 165º Fahrenheit under these relatively mild operating conditions. It actually rises a couple of degrees over the course of the 15 second on time, then after the signal shuts off, it quickly rises another two or three degrees to a maximum of about 170º. It then begins to cool, and over the course of the next 15 seconds, it drops about five degrees back to the 165º point.I wouldn't be surprised if you measure the same thing inside a basshorn with a small sealed motor chamber, you'll probably find the pole piece is hot enough to boil water.We considered running at 400WRMS continuous, with no cooldown cycle every 15 seconds but we did not want to risk damaging the woofer. We will do destructive tests later.The cooling system appears to be enormously effective at removing heat from the motor chamber. This is exciting, since having cool air surrounding the voice coil is important. Getting heat out of the pole piece and magnet keeps them from being heat soaked and prevents average voice coil temperatures from continually rising to the point of failure. I'm expecting system power ratings to double, but we'll not know for sure until we've built the prototype horn with the cooling device, so we can test the entire system. We'll find out soon enough.The venting techniques used to cool drivers are good, but it is just as important to keep the metal surrounding the voice coil cool too. Especially in the case of basshorns with small back chambers, doing something to get the heat out of the box is important for long-term high-power use. And the same piece used to conduct heat out of the motor structure might be used as a shorting ring as well, which serves to reduce harmonic distortion. So this is a very exciting concept indeed.